MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

# Irrigation Management

## Learning Objectives

At the end of this unit, the student will be able to:

- Describe issues around Colorado's (western) water situation.
- Describe design criteria for efficient landscape irrigation.
- Describe maintenance criteria for efficient landscape irrigation.
- Describe management criteria for efficient landscape irrigation.
- Perform a lawn irrigation check-up.
- Set a controller for efficient landscape irrigation.

## Reference /Additional Reading

### CMG GardenNotes

#260 Irrigation Management: References and Review Questions
#261 Colorado's Water Situation
#262 Water Movement Through the Landscape
#263 Understanding Irrigation Management Factors
#264 Irrigation Equipment
#265 Methods to Schedule Home Lawn Irrigation
#266 Converting Inches to Minutes
#267 Watering Efficiently
#268 Worksheet: Home Lawn Irrigation Check-Up

### CSU Extension Fact Sheets and *PlantTalk Colorado*

- Automatic Sprinkler System Overview – Planttalk #2201
- Drip Irrigation for Home Gardens – Fact Sheet #4.702
- Efficient Irrigation – Planttalk #1903
- Graywater Reuse and Rainwater Harvesting – Fact Sheet #6.702
- Irrigation: Inspecting and Correcting Turf Irrigation Systems – Fact Sheet #4.722
- Water Conservation In and Around the Home – Fact Sheet #9.952
- Watering Colorado Soils – Planttalk #1621
- Watering Established Lawns – Fact Sheet #7.199

### Websites

- Colorado Springs Utility: http://et.csu.org/
- Denver Water: www.denverwater.org
- Northern Colorado Water Conservancy District: www.ncwcd.org

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Curriculum developed by David Whiting (CSU Extension, retired), Carl Wilson, (CSU Extension, retired), and Catherine Moravec (Colorado Springs Utilities.
Revision: Kurt M. Jones, Chaffee County Extension Director (9/2017).



Revised September, 2017

# Review Questions

Colorado's Water Situation

1. Describe the western water rights doctrine of "prior appropriation" or "first-in-time, first-in-right." How does it differ from the "riparian" water rights system used in eastern states?

2. What percent of Colorado's water supply is used for landscape irrigation?

3. During the summer irrigation season, what percent of a community's water supply is typically used for landscape irrigation?

4. On a community-wide basis, what percent of the water used for landscape irrigation is wasted due to poor design, maintenance, and management of the irrigation systems?

5. Explain how landscape irrigation affects a community's water infrastructure? What is the primary purpose behind community water schedules, such as every third day or every other day?

6. What is the typical multi-year drought cycle in Colorado's climate?

7. How does population growth play into Colorado's water situation?

Water Movement Through the Landscape

8. List how water enters the landscape. Explain how water is stored in the landscape. List how water leaves the landscape.

9. What is ET? What factors influence ET rates?

Understanding Irrigation Management

10. Describe how these factors influence irrigation management:

    a. Location of soil moisture
    b. Type of soil
    c. Water holding capacity
    d. ET
    e. Rooting depth

11. How does improving a sandy soil with organic matter influence irrigation management? How does improving a clayey soil with organic matter influence irrigation management?

12. Define *water holding capacity*, *saturation*, *field capacity*, *permanent wilting point*, and *available water*.

13. Compare the historical ET for a lawn in spring, summer, and fall.

14. Based on a soil's typical water-holding capacity, describe the amount of water to apply and frequency of irrigation for sandy, sandy loam and loamy/clayey soils with a six-inch, 12-inch and 24-inch rooting depth in the spring, summer and fall.

15. Describe the textbook amount of water to apply if a lawn required water every two, three, four, or five days in the typical summer.

16. Describe how these factors influence irrigation management:

    a. Exposure
    b. Previous irrigation pattern
    c. Stage of growth

17. Give examples of mechanisms that plants use to tolerant/escape drought.

Irrigation Equipment

18. Explain basic components of an in-ground sprinkler system, including the following:

    - Point of connection
    - Pressure regulator
    - Backflow prevention device
    - Supply line
    - Valve box
    - Valves
    - Secondary lines
    - Controller

- Winter drainage

19. Describe the advantages and limitations of pop-up spray heads and rotor heads.
20. Describe the strengths and weaknesses of an in-ground sprinkler system.

21. Describe basic components of a drip system, including the following:

    - In-line filter
    - Pressure regulator
    - Half-inch tubing
    - Quarter-inch microtubing
    - Drip emitters
    - In-line drip tubing
    - Micro-sprayers

22. Describe a drip system made with soaker hose or soaker tubing.

23. Describe the strengths and weaknesses of drip irrigation.

24. Describe the strengths and weaknesses of hose-end, hand watering

<u>Methods to Schedule Irrigation</u>

25. Describe irrigation scheduling by the <u>Type of Sprinkler Method.</u>

26. Describe irrigation by the <u>Precipitation Rate Method</u>. Explain how to do a Precipitation Rate (Catch Can) Test.

27. What is the purpose of cycle and soak? Explain how to add cycle and soak to an irrigation scheduling method.

28. What is an ET controller? What is a soil moisture sensor?

29. Explain how to fine-tune an irrigation schedule.

<u>Watering Efficiently</u>

30. Of the seven principles of water wise gardening, why does watering efficiently have the greatest potential for water conservation in the typical home landscape?

31. With attention to irrigation design, maintenance, and management, what is the potential water savings for a typical home landscape?

32. List factors to consider with irrigation zones.

33. Describe <u>design criteria</u> for uniform water distribution.

34. Describe <u>maintenance techniques</u> for water wise irrigation management.

35. Describe <u>management techniques</u> for water wise irrigation management.

<u>Irrigation Check-Up</u>

36. What is the purpose of an irrigation check-up?

*CMG GardenNotes #261*

# Colorado's Water Situation



## Western Water Rights – *Doctrine of Prior Appropriations*

In Colorado and other western states, water rights are based on the ***Doctrine of Prior Appropriation*** or "first-in- time, first-in-right". Rights are established when water is put to beneficial use.

A water right is a property right to use a specified quantity of the state's water for a specified purpose. As a property right, water rights can be sold, leased, or rented (like other personal properties such as a home, apartment, or car). With the *prior appropriation doctrine* used in western states, a property owner does not own the water that rains, snows, or flows across or is adjacent to his/her property.

By contrast, eastern states follow some form of "riparian" water right (i.e., water rights belong to landowners bordering the water source). Without an understanding of the *doctrine of prior appropriation*, newcomers and residents may fail to realize that the purchase of land does not necessarily include the rights to irrigation water.

Under the *prior appropriation doctrine*, water rights are established by putting the water into ***beneficial use***. The person or organization putting the water to beneficial use requests the ***water courts*** to legally recognize the right with a ***decree***.

In the establishment of water rights, the water judge decrees the location at which the water will be withdrawn, the amount to be withdrawn, the use of the water, and assigns a ***priority date***. Claims with earlier priority dates have ***senior rights***; claims with more recent priority dates have ***junior rights***.

During times of reduced rainfall or drought, *senior rights* (water rights established in early years) take precedence over *junior rights* (water rights established in recent years). Water use will be cut off for junior rights, protecting senior rights.

When a water use is changed, the water courts reissue the decree amending the owner, location, amount, or use. The priority date will be based on the previous priority date. Since Colorado's water supply fluctuates continually and the typical available water in a river basin is already owned with established water rights, issues of senior and junior rights become very complex in drought scenarios.

**Colorado's water future** – *"As Colorado's water consumption reaches the limits of its allotment under interstate compacts and treaties, intensive water management will become even more critical. Water management decisions will involve examinations of all options. Conversation will become indispensable…. Inevitably, as each generation must learn, the land and the waters will instruct us in the ways of community."* (Citizen's Guide to Colorado Water Law)

### Administration

In Colorado, the Office of the State Engineer, Colorado Division of Water Resources, administers water rights. It monitors the amount of water being taken from surface and underground sources, and oversees distribution based on the priority of water rights.

Interstate water rights are set in federal agreements based on stream flows for the Platt, Colorado, and Arkansas River basins.

## Water Quality Terminology

Regulated by the EPA, ***drinking water*** or ***potable water*** is water of sufficiently high quality for safe human consumption. The drinking water in many Colorado communities is of higher quality than most bottled water. Over large parts of the world, humans have inadequate access to potable water, and use sources contaminated with unsafe levels of dissolved chemicals, suspended soils, disease vectors, and pathogens.

***Nonpotable water*** refers to water not processed to drinking-water standards. ***Raw water*** refers to untreated water taken directly from rivers and lakes.

***Wastewater*** is any water that has been adversely affected in quality by human activities. This includes domestic, municipal, or industrial liquid waste products disposed of by flushing them with water through a pipe system. ***Sewage*** technically refers to wastewater contaminated with feces and urine. However, in popular usage, sewage refers to wastewater. ***Gray water*** refers to water from the bath/shower and washing machine. ***Black water*** refers to water with feces and urine (from the toilet).

***Reclaimed water*** or ***recycled water*** is former wastewater (sewage) that has been treated to removed solids and certain impurities. In most situations, it is returned to the river system, being the non-consumptive use portion of water rights. That is, the reclaimed water returned to stream flow becomes someone's water right downstream. In Colorado, some parks, golf courses, and industrial properties are irrigated with reclaimed water. Reclaimed water may be high in salt, limiting its use for landscape irrigation.

## Sources of Landscape Irrigation Water

In many communities, most landscape irrigation is done with potable, drinking water purchased from the city or community water provider (who owns the water right or purchases the water wholesale). The source of water may be stream flow (from snowmelt with storage in the reservoir system) or wells. During the summer irrigation season, this puts a high demand on the water treatment facilities. To deal with this, many communities aggressively market landscape water conservation.

In the west, many larger landscape sites (golf courses, parks, and industrial sites) are irrigated with nonpotable water or raw water. In some western communities, homes have a waterline for drinking water and a second, nonpotable waterline for irrigation. This creates significant savings in water treatment costs.

### Wells

For rural homes, a common water source is groundwater (wells). The Colorado Division of Water Resources also regulates the drilling and use of groundwater. In the past, the lack of strict regulations caused a significant drop in the water table in some communities, creating problems for well users. Today the use of wells is regulated, limiting the amount of water that can be withdrawn. In recent years, new domestic well permits have been very restrictive, prohibiting outdoor irrigation. Folks moving to their rural ranchette are often shocked when they learn that they may not irrigate the landscape with their well water.

On the high plains of eastern Douglas and El Paso Counties, the community water source is non-renewable groundwater (wells). This water supply is not refilled with annual rain and snowmelt. Conservation is extremely critical.

### Rain Water and Gray Water

Landscape design can be creative in reducing the surface runoff of rain and snowmelt (reducing pollution of surface water). However, in Colorado state law prohibits the intentional interception and diversion of rain and snowmelt (that is, the collection of the water in a retention system for later use), including rain barrels. This is an issue of water rights, as the water already belongs to someone downstream. Collection of rain and snowmelt could interfere with another’s water right.

A new exception which went into effect August 1, 2016 allows rain barrels to be installed at single-family households and multi-family households with four (4) or fewer units. A maximum of two (2) rain barrels can be used at each household and the combined storage of the 2 rain barrels cannot exceed 110 gallons. Rain barrels can only be used to capture rainwater from rooftop downspouts and the captured rainwater must be used on the same property from which the rainwater was captured, for only outdoor purposes, including to water outdoor lawns, plants and/or gardens. Rain barrel water cannot be used for drinking or other indoor water uses.

Colorado House Bill 13-1044, which was passed and signed during the 2013 legislative session, provides municipalities, counties, and groundwater management districts the authority to authorize graywater use and enforce ordinances. Under HB-13- 1044, graywater can be used to flush toilets and irrigate landscapes at residential, multi-residential and commercial locations. As of the 2017 revision of this publication, only the City and County of Denver has permitted graywater uses for irrigation, and only for sub-surface or drip irrigation of non-food crops.

For additional information on using gray water and harvesting rainwater in Colorado, refer to CSU Extension fact sheet #6.702, *Graywater Reuse and Rainwater Harvesting*, and the *Rainwater Harvesting in* Colorado fact sheet number 6.707, available on the CSU web site at http://extension.colostate.edu

## Colorado's Water Use

Eighty percent of Colorado's water supply falls on the Western Slope. With the high population along the Front Range and major agriculture in northeastern Colorado, 80% of the water use (that is 80% of the water rights) is along the Front Range and High Plains. Table 1 gives the breakdown of water use in a typical year.

**Table 1. Where does Colorado's water go?**

| | |
|---|---|
| Agriculture | 86% |
| Domestic/municipal | 7% |
| Recreation and fisheries | 3% |
| Industrial and commercial | 2% |
| Augmentation | 1% |
| Recharge | 1% |

Source: Colorado State Engineer's Office, 2004

**Production agriculture** is the primary user of Colorado's water supply, using 85 to 90% for food production. To grow the typical American meal it takes 500 to 2,000 gallons of water. On an annual basis, it takes 1.6 million gallons of water to grow the food for the typical American diet of 2,000 calories per day. (Source: Michigan State University Institute of Water Research)

Although the individual farmer can be rather inefficient in use, the runoff water returning to the system is used repeatedly by other farmers down the line, resulting in a 90% system-wide efficiency.

**Landscape irrigation** – Depending on the year, approximately 7 to 10% of Colorado's water supply is used for landscape irrigation, including home lawns and yards, public and commercial landscapes, parks, and golf courses. During the summer irrigation season, 50 to 75% of a community's water use may be for landscape irrigation. Because it is highly visible, landscape irrigation is often targeted for conservation.

Based on community water use, the average landscape receives twice the amount of irrigation water that plants actually need. This is due to poor irrigation system design, maintenance, and management. In research of actual yard-by-yard comparisons, most gardeners are rather efficient; however, others may be applying 5 to 10 times the amount of water actually needed!

With the rapid growth in Colorado's population, some farmers have sold, leased, or rented water rights to communities. This creates a significant shift in water use during periods of drought and creates long-term dynamics between agriculture and urbanization.

**Other demands** on water flows come with power generation, recreational use, and wildlife habitats. As an important side issue, during periods of drought (decreased stream flow), hydroelectric power generation will also decrease.

A standard unit for measuring large quantities of water is the ***acre-foot***. An acre-foot is the amount of water needed to cover an acre of land to a depth of one foot, or 325,851 gallons. The standard unit of measuring water flow is cubic feet per second, or cfs. One cfs equals 7.48 gallons per second or 448.83 gallons per minute.

## Community Water Infrastructure

A community typically invests $30,000 to $60,000 per new household for the water and sewer treatment infrastructure. Due to landscape irrigation, Colorado communities typically experience 10 to 15 days per year when water use greatly exceeds average use. Because peak demand actually occurs only a few days a year, developing the water processing and delivery infrastructure to adequately meet water needs during these few peak days is very expensive. One Colorado community, for example, is facing a $35 million expansion to its water-processing infrastructure to meet peak demand for just five days a year!

The high cost of meeting peak water demand is why communities often adopt irrigation schedules based on address (like odd/even days or other set irrigation day programs). <u>Schedules are designed to spread the water demand more evenly over the week.</u> Just imagine the water infrastructure that would be required if most residents decided to water the lawn on a Saturday morning during a hot week!

Odd/even or set watering day water restrictions do not effectively reduce total water usage. An underlying fear with gardeners is that they cannot hold off irrigation until their next turn, so the lawn is watered just because it is their turn. Irrigation restrictions that allow for no irrigation on some days of the week more effectively conserve water.

## Population Growth and Water Conservation

Colorado's rapid population growth creates growing pains for Colorado's water supply. Due to planning by forefathers, some communities have good water resources, including senior rights. Other communities seriously lack sufficient water rights to support growth. Residents who do not understand western water rights may have strong values and opinions about where water should and should not be used during shortages. Under western water rights, market price to purchase water rights will determine who has water. What are you willing to pay?

Water conservation, both indoors and outdoors, is essential for communities to meet the water demands for growth. Some communities with limited water resources have put restrictions on new building permits. This could be viewed as a form of discrimination aimed at keeping newcomers out of the "white" community.

Other communities, with limited water resources, have allowed for growth by purchasing "surplus" water from water rights holders (such as other communities or farmers). Some of the extreme water restrictions during the drought of 2002 are examples of what happens in years when "surplus" water is not available for purchase.

With growth, water conservation is also critical even for those communities with senior water rights. For example, Denver Water and Colorado Springs Utilities, two of the state's larger water providers, are running out of water resources to support continued growth at current usage rates. Conservation is essential.

Water for growth must come from water conservation. This will be through voluntary conservation and aggressive pricing structures to push conservation. Since Colorado's climate typically has a multi-year drought about every 20 years, water conservation is important to all residents.

## CMG GardenNotes on Irrigation Management

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*CMG GardenNotes #262*

# Water Movement through the Landscape



## Soil-Plant-Water System

Water constantly moves in and out of landscapes. Scientists use the concept of the soil–plant–water system to explain the complex ways water moves in landscapes. The ***soil–plant–water system*** describes water entries, storage and exits in a landscape from the plant's perspective. Understanding how water moves through a landscape is important when designing or using an irrigation system.

Most plants constantly use water, but store little in their tissues. Therefore, plants rely on the soil water reserves being periodically replenished through entries of water into the soil–plant–water system.

### Water Entries

Water enters the landscape in several ways. First, water enters through **precipitation**, such as rain or snow. Second, gardeners may add water through **irrigation**. Third, water may run over the surface of the landscape from a neighboring area (**run-on**). Fourth, water may enter as **seepage** from groundwater.

In different landscapes, some entry methods are more important than others. For example, in a wet climate most water enters through precipitation. Alternatively, in dry climates like many areas of Colorado and the West, most water enters via irrigation. If a landscape is located below a heavily irrigated property or below a melting snowfield, run-on or seepage may be the most important entry. Taking water entries into account helps gardeners determine how much water must be added through irrigation to keep plants healthy.

### Water Storage

In most landscapes, soil is the major water storage site for plants. Once water has entered the landscape through precipitation, irrigation, run-on, or seepage, water penetrates the soil surface through **infiltration**.

Water infiltrates into sandy soils much more quickly than into clayey soils. For example, a sandy soil may take in 4 inches per hour, but a clayey soil may take in only 0.5 inches of water per hour—8 times more slowly. To prevent water waste via runoff, gardeners should take the soil's infiltration rate into account when scheduling landscape irrigation.

Once water infiltrates the soil surface, it **percolates** downward and sideways through the soil profile. Water moves rapidly through large soil pores, and slowly through small pores. Therefore, sandy soils with primarily large pores will accept and release water readily, holding little. On the other hand, clayey soils with primarily small pores will wet and dry slowly.

After water percolates through the soil profile, some of the water will be stored in small pores, and a water films surrounding soil particles. Plants can use some of the stored water (called plant**-available water)** by extracting it with their roots. However, some of the water is held so tightly by small pores or particle surfaces that plant roots cannot extract it. This water is **unavailable** to plants.

When plants need more water than is available in the soil, they experience **water stress**. Because water is a component of photosynthates, photosynthesis stops and growth stops. Furthermore, water stress compromises plant defense systems, making them more susceptible to abiotic stress factors as well as insect and disease problems.

Some soils store more water than others. The amount of water held in the soil and available to plant depends on the following factors:

- Clay content (the amount of small pore space) to hold water.
- Soil organic content – Organic matter holds ten times more water than sand.
- Rooting depth – Plants with deeper roots reach a larger water supply.

## Water Exits

Water eventually leaves the landscape. Water may exit by running over the land surface (**runoff**). It may leave the system through **off-target application**, such as sprinklers that apply water to the sidewalk rather than the soil. Sometimes, water percolates below the plant's root zone (**leaching**).

Water **evaporates** from the soil surface, causing soils to dry from the top downwards. Mulches help ameliorate water loss by reducing evaporation from the soil surface. Mulches also improve plant growth by helping to maintain moisture in the top layer of soil, thereby stabilizing soil moisture around roots.

Some water is taken up by plant roots, transported through plant tissues and used in photosynthesis for plant growth. Most of the water taken up by plants is **transpired** out leaf surfaces. Because evaporation and transpiration are often the two most important water exits in landscapes, scientists combine these two pathways into one term called *evapotranspiration*.

**Evapotranspiration** (abbreviated as **ET**) is a measurement of water use combining water used by plants for transpiration, photosynthesis, and growth, plus water lost from the soil surface evaporation. It is most often defined as a rate of water loss, such as 1/4 inch per day. In this example, an ET of 1/4 inch per day means that a 1/4 inch depth of water was lost from the soil–plant–water system through evaporation and transpiration.

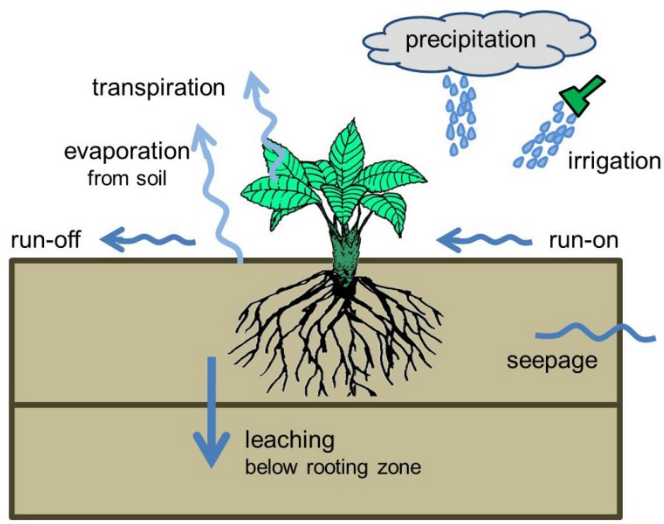
ET measurements help gardeners make informed decisions about how much irrigation water to add. In some Colorado communities, ET rates are available on-line through weather stations or water utilities.

ET rates change daily through the growing season. High ET rates occur when there is 1) bright sunshine, 2) high wind, 3) high temperature, and/or 4) low humidity.

## Summary

Water entries and exits are summarized in Figure 1. In order to maximize plant health in dry climates of Colorado and the West, gardeners can take two approaches. First, they can apply soil management practices to increase soil water storage. This helps ensure adequate water supplies for plants when needed. Second, gardeners can use effective irrigation management practices to ensure that irrigation water is made available to plants and not wasted.

Figure 1: Typical water entries and exits in the soil – plant – water system.





Authors: Catherine Moravec, Colorado Springs Utilities and David Whiting, Colorado State University Extension (retired). Artwork by David Whiting; used by permission.
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*CMG GardenNotes #263*

# Understanding Irrigation Management Factors



Poor watering practices lead to many common landscape problems, including iron chlorosis, low plant vigor, foliar diseases, root rots, and water pollution. On a community-wide basis, landscape irrigation typically uses twice the amount of water that the plants actually need.

Several complex factors work together in irrigation management, including the following:

- The soil's ***water-holding capacity*** (the quantity of water held by the soil)
- ***Evapotranspiration, ET,*** (a measurement of actual water use by the plant and lost from the soil by evaporation). ET is a factor of weather (temperature, wind, humidity, and solar radiation) and plant growth.
- Rooting depth.
- The plant's ability to extract water from the soil.
- The plant's water need.

## Location of Soil Moisture

Following dry winters or summer droughts, soils may be dry in the top layers with moisture only in deeper layers. Following extended drought, it is possible that soils may be dry in deep layers and wet only in the top few inches following a light rain or irrigation.

Dry soils tend to resist wetting. Alternating irrigation applications with shutoffs to allow water to soak in (cycle and soak irrigation) may be necessary to wet a dry soil profile.

Irrigation management is basically applying the correct amount of water at the correct frequency to supply water needs of the plants. Additional water would be wasted as it would leach below the rooting zone.

## Type of Soil

Soil texture, structure and organic matter content determine the water-holding capacity and water movement of a soil. Water coats the soil particles and organic matter, and is held in small pore space by cohesion (chemical forces by which water molecules stick together). Air fills the large pore space.

In large pore space, water readily moves downward by ***gravitational pull***. In small spore space, water moves slowly in all directions by ***capillary action***. Figure 1 illustrated water movement in a sandy soil with large pore space and clayey soil with small pore space. [Figure 1]

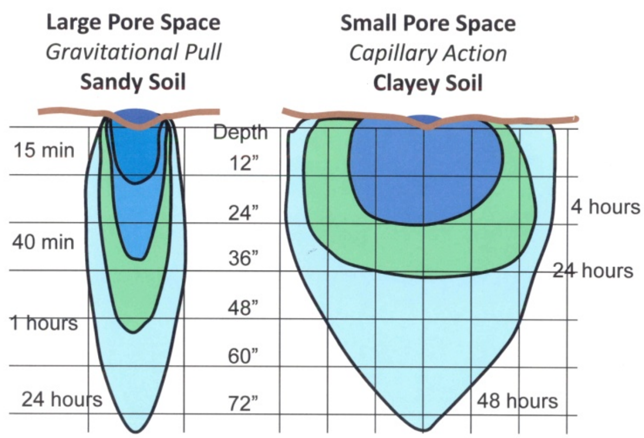



Figure 1. Comparative movement of water in sandy and clayey soils

**Sandy Soil** – Large pore space dominate sandy soil, giving it rapid drainage. Thus, surface runoff of irrigation water is generally not a concern with sandy soil. Water movement is primarily in a downward direction by gravitational pull in the large pore space with limited sideward and upward movement by capillary action in the small pore space. Thus, in drip irrigation the emitters must be placed closer together than in clayey soils.

Sandy soils have a low water-holding capacity due to the lack of small pore space. Organic matter, which holds ten times more water than sand, significantly improves the water-holding capacity of sandy soils.

As a point of clarification, plants on sandy soils do not use more water than plants on clayey soils. **With the limited water holding capacity, sandy soils simply need lighter and more frequent irrigations than clayey soils.** Water readily moves below the rooting zone when too much is applied at a time.

**Clayey Soil** – Small pore space dominates clayey soil, giving it high water-holding capacity. However, the lack of large pore space greatly limits water movement. Water is slow to infiltrate into clayey soil, often leading to surface run-off problems. Cycle and soak irrigation is appropriate on clayey soils to slow application rates and reduce surface runoff.

In clayey soils, soil *structure* (creating secondary large pore space) also directly influences water movement and soil oxygen levels. Compaction (a reduction in pore space) further limits water movement and reduces soil oxygen levels, resulting in a shallow rooting depth. The total water supply available to plants is reduced by the shallower rooting.

**With higher water-holding capacity but limited drainage, clayey soils need heavier, but less frequent irrigations than sandy soils.** Watering too often can aggravate low soil oxygen levels. Because water moves slowly in all directions by capillary action, drip emitters may be placed further apart than in sandy soils.

For additional discussion on texture, structure and pore space, refer to CMG GardenNotes #213, *Managing Soil Tilth*.

## Water-Holding Capacity

The terms, *saturation*, *field capacity*, *wilting point*, and *available water* describe the amount of water held in a soil. [Figure 2]

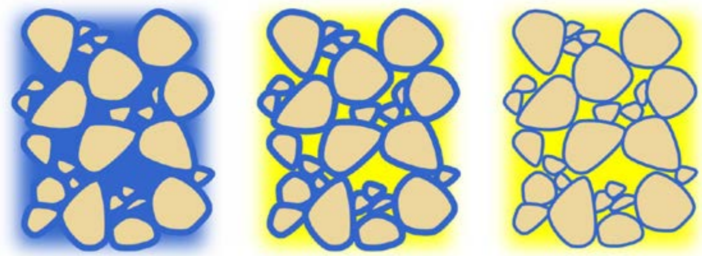



Figure 2. At ***saturation*** water fills the pore spaces. **At *field capacity*** air occupies the large pore spaces while water fills the small pore spaces. At the ***wilting point***, plants cannot extract additional water from the soil.

***Saturation*** refers to the situation when water fills both the large and small pore spaces. With water replacing air in the large pore spaces, root functions temporarily stop (since roots require oxygen for water and nutrient uptake).

Prolonged periods without root oxygen will cause most plants to wilt (due to a lack of water uptake), to show general symptoms of stress, to decline (due to a lack of root function) and to die (due to root dieback). During summer flooding of the Mississippi River in Iowa and Illinois it was observed that healthy trees were somewhat tolerant of a short-term flooding period, whereas trees under stress or in a state of decline were very intolerant.

***Field capacity*** refers to the situation when excess water has drained out by gravitational pull. Air occupies the large pore space. Water coats the soil particles and organic matter and fills the small pore space. A handful of soil at or above field capacity will glisten in the sunlight. In clayey and/or compacted soils, the lack of large pore space slows or prohibits water movement down through the soil profile, keeping soils above field capacity for a longer period of time and limiting plant growth.

***Permanent wilting point*** refers to the situation when a plant wilts beyond recovery due to a lack of water in the soil. At this point the soil feels dry to the touch. However, it still holds about half of its water; the plant just does not have the ability to extract it. Plants vary in their ability to extract water from the soil.

***Available water*** is the amount of the water held in a soil between *field capacity* and the *permanent wilting point*. This represents the quantity of water "available" or usable by the plant. Note from the illustration below that the amount of *available water* is low in a sandy soil. Loamy soils have the largest amount of *available water*. In clayey soils, the amount of *available water* decreases slightly as capillary action holds the water so tightly that plants cannot extract it. [Figure 3]

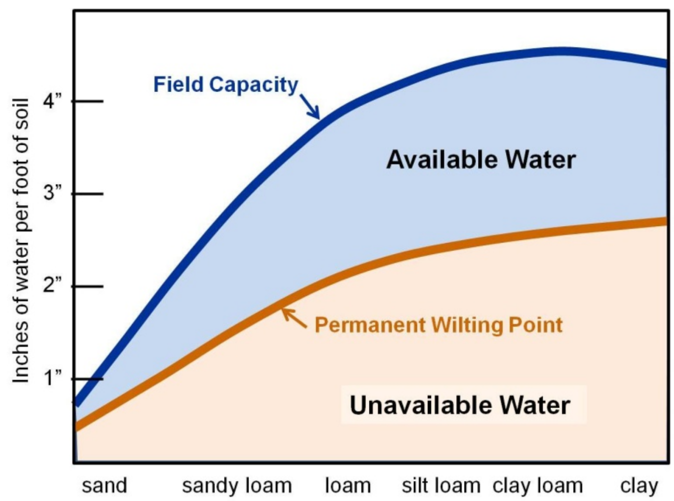



Figure 3. Relationship between soil texture and available water

## Evapotranspiration, ET

***Evapotranspiration, ET,*** is the rate at which a crop uses water for transpiration and growth plus evaporation from the soil surface. Primary influences on ET include weather factors (temperature, wind, humidity, and solar radiation) and the stage of plant growth.

On hot, dry, windy days, ET will be higher. On cool, humid days, ET will be lower. In the summer, ET changes significantly from day to day. To illustrate seasonal variations, the typical irrigation requirement for cool season turf in Colorado is given in Table 1. [Table 1]

Table 1.
**Weekly Water Requirement for Cool Season Lawns in Colorado**

Inches of water (irrigation and rain) per week

| Late April | May | June | July | August | September | Early October |
|---|---|---|---|---|---|---|
| 0.75" | 1.0" | 1.0" | 1.5" | 1.5" | 1.0" | 0.75" |

## Rooting Depth

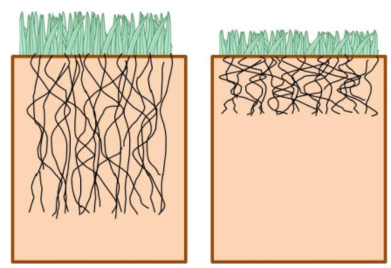
Irrigation management should be taken into account the rooting depth, adding water to the actual root area. Root systems may be contained or spreading. Annual plants tend to have contained root systems, whereas woody trees and shrubs have more wide-reaching roots.

A newly planted annual flower or shallow-rooted plant cannot obtain water from deeper soil depths. Deep watering of these plants is wasteful.

Roots only grow where there are adequate levels of soil oxygen. In clayey or compacted soils, where a lack of large pore space restricts oxygen levels, roots will be shallow. Plants with a shallow rooting depth simply have a smaller profile of soil water to use. [Figure 4]

A plant with deeper roots will need less frequent but heavier irrigation than the same plant with shallow roots. This, however, should not be interpreted as necessarily using less water. For example, turf-type fall fescue may root more deeply than Kentucky bluegrass (if soil oxygen levels allow). With deeper rooting, it requires less frequent irrigations, but irrigations must be heavier to recharge the rooting zone. Actual water-use rates of Kentucky bluegrass and tall fescue are similar.

Figure 4. Plants with a deeper rooting systems reach a larger supply of water and can go longer between irrigations. With deeper rooting, irrigations will be less frequent but heavier to recharge the larger rooting zone. In compacted or clayey soils, low levels of soil oxygen limit rooting depth, thus reducing the supply of available water.



## Irrigation: How Much? How Often?

Table 2 illustrates the relationship of the soil water-holding capacity, ET and rooting depth.

These textbook figures make a good starting point for understanding irrigation management. Most automatic sprinkler systems are set to keep the lawn green in the summer. (i.e., set for the higher summer water need). Without seasonal adjustments on the irrigation controller the lawn will be over-irrigated in the spring and fall by about 40%. This springtime over-irrigation is a primary contributing factor to iron chlorosis.

**Table 2. Irrigation Summary of a Textbook Soil**

| | Soil Type | | |
|---|---|---|---|
| | **Sandy** | **Sandy Loam** | **Loamy & Clayey** |
| **Available water per foot of soil** | 0.5” | 0.75” | 1” |
| **<u>6-inch rooting depths</u>** | | | |
| Inches of available water and<br>**Inches of water to apply per irrigation**<br>(Additional amounts would leach below the rooting zone.) | **0.25”** | **0.38”** | **0.5”** |
| Typical days between lawn irrigation | | | |
| Spring/Fall (at 1.0 inches/week) | 1.8 days | 2.7 days | 3.6 days |
| Summer (at 1.5 inches/week) | 1.2 days | 1.8 days | 2.4 days |
| **<u>12-inch rooting depth</u>** | | | |
| Inches of available water, and<br>**Inches of water to apply per irrigation**<br>(Additional amounts would leach below the rooting zone.) | **0.5”** | **0.75”** | **1”** |
| Typical days between lawn irrigation | | | |
| Spring/Fall (at 1.0 inches/week) | 3.6 days | 5.3 days | 7.1 days |
| Summer (at 1.5 inches/week) | 2.4 days | 3.6 days | 4.8 days |
| **<u>24-inch rooting depth</u>** | | | |
| Inches available water and<br>**Inches of water to apply per irrigation**<br>(Additional amounts would leach below the rooting zone.) | **1”** | **1.5”** | **2”** |
| Typical days between lawn irrigation | | | |
| Spring/Fall (at 1.0 inches/week) | 7.1 days | 10.7 days | 14.2 days |
| Summer (at 1. 5 inches/week) | 4.8 days | 7.1days | 9.5days |

## Fine-Tuning for the Site

**The textbook figures are a good starting point to understand irrigation management. When coupled with careful observations, a gardener can quickly fine-tune his/her irrigation schedule to the site-specific irrigation demands.**

On a typical July day, if the lawn is using an average of 0.20 inch per day, you can estimate the water-holding capacity and rooting depth by observing irrigation needs. For example:

- **<u>If the lawn will go five days on one-inch of water</u>**, and additional water won’t extend the interval between required irrigations, the water-holding capacity (for this soil and rooting depth) is 1 inch. <u>One inch would be the maximum amount of water to apply per irrigation, as additional amounts would leach below the rooting zone.</u> The ideal irrigation would be 1 inch of water every 5 days.

- **<u>If the lawn will go four days on 0.80 inch of water</u>**, and additional water won't extend the interval between required irrigations, the water-holding capacity (for this soil and rooting depth) is 0.80 inch. <u>This would be the maximum amount of water to apply per irrigation, as additional amounts would leach below the rooting zone.</u> The ideal irrigation would be 0.8 inches of water every 4 days.

- **<u>If the lawn will go two days on 0.40 inch of water</u>**, and additional water won't extend the interval between required irrigations, the water-holding capacity (for this soil and rooting depth) is 0.40 inch. <u>This would be the maximum amount of water to apply per irrigation, as additional amounts would leach below the rooting zone</u>. Irrigation options include the following: The ideal irrigation would be 0.4 inches of water every 2 days.

These textbooks figures don't take into account exposure, wind or irrigation system efficiency. They make a good start point, **but will need adjustments to fine-tune it to the specific site.** For example:

- In full shade (not under large trees), water use could be 30% lower.
- In unusually hot weather or in open, windy sites, water use could be 20% to over 50% higher.
- In the rooting area of large trees, water use could be 30% to 50% higher (as the tree is pulling water as well as the plants in the shade under the tree).

For examples, in the author's landscape, the front lawn (open site with constant summer wind) uses 20% more water than the normal ET. While the back lawn (sheltered from the wind by the house and wood fence) uses the normal ET.

So the trick for efficient irrigation is to start with the textbook numbers then fine tune them based on observation. **Based on actual observations for each zone, adjust the run time up/down in 10% increment to fine-tune the irrigation.**

These examples are based on typical July weather. <u>For cooler spring and fall seasons, the amount of water to apply generally remains the same, with a longer interval between irrigations.</u>

## Other Factors Influencing Irrigation Management

Other factors also have a direct influence on the <u>actual</u> water-holding capacity and irrigation demands, for example:

- **Exposure** – The plant's exposures greatly influences water demand. Sun, heat and wind increase water demand. Shade decreases water demand. Water use for a lawn on a windy, southwest-facing slope could be double the water use of a lawn in full sun but sheltered from wind and extreme heat.

- **Soil organic matter content** – Since organic matter holds over ten times more water than sand, a sandy soil with good organic content (around 4 to 5%) will hold more water than indicated in the table above. Over time, clayey soils with good organic content may have an improved soil structure, supporting a deeper rooting depth.

- **Previous irrigation pattern** – Plants adjust rooting depth (to the extent that soil oxygen levels allow) to where soil water is available. Frequent irrigation eliminates the need for plants to develop a deep rooting system. A shallow rooting system makes the plant less resilient to hot, dry weather.

- **Stage of growth** – The stage of growth also influences ET. Water needs increase as a plant grows in size during the season and peaks during flowering and fruit development.

  Compared to the rooting system of a mature plant, newly planted or seeded crops don't have the root systems to explore a large volume of soil for water. Recently planted and seeded crops will require frequent, light irrigations. In our dry climate, even "xeric" plants generally need regular irrigation to establish.

  Confusion about plant water requirements can arise from changing needs as plants move through their life cycles. For example, newly planted trees are extremely intolerant of water stress. Established trees in good health are rather tolerant of short-term water stress. Older trees in decline are intolerant of water stress. General statements about the ability of trees to tolerate dry situations need to take into account life-cycle stages.

- **Water demand of a plant** – Plants vary greatly in the demand for water to 1) support growth, and 2) survive dry spells. (Note that the two are not necessarily related.)

- **Ability to extract water** – Plants vary in their ability to extract water from the soil. For most plants, the *available water* is about 50% of the soil's total water supply before reaching the *permanent wilting point*. Onions are an example of a crop that can only extract about 40%.

- **Drought mechanism** – A similar, <u>but unrelated</u>, issue is the plant's ability to survive on dry soil. Plants have evolved with a variety of drought mechanisms, for example:

  - Small leaves, waxy leaves, hairy leaves, and light-colored leaves are characteristics of many plants with lower water requirements.
  - Some plants, like cacti, have internal water storage supplies and waxy coatings.
  - Many plants, like impatiens, readily wilt as an internal water conservation measure.
  - Trees close the stomata in the leaves, shutting down photosynthesis, during water stress.
  - Some plants, like Kentucky bluegrass, can go dormant under water stress.
  - Kentucky bluegrass slows growth as soils begin to dry down. (Does your irrigation management capitalize on this dry-down, also reducing your mowing?)
  - Tall fescue is an example of plants that survive short-term dry soil conditions by rooting more deeply (if soil conditions allow) to reach a larger water supply. But tall fescue can't go dormant.

## Tools to Evaluate Soil Moisture

Gardeners have a number of tools available to evaluate the amount of moisture in their soil.

**Plant observation** is a good guide to soil moisture. Look for color change and wilting. For example, Kentucky bluegrass will change from a blue-green to gray-blue with water stress. Footprints in the lawn that do not rebound within 60 minutes are another symptom to watch for. Use of an indicator plant in a perennial flower bed is also useful. Certain perennials such as *Ligularia stenocephala* 'The Rocket' and *Eupatorium rugosum* (White Snakeroot) often wilt before other perennial flowers, indicating irrigation will shortly be required.

The **hand feel method** used when digging in soil is more evidence of moisture content. Is the soil powder dry, medium moist or even muddy?

The ease with which a **probe** can be inserted can be telling. A screwdriver will punch into the soil more easily when wet than when dry. However, this can be very misleading, as a clayey soil may be difficult when wet and impossible when dry. A sandy soil may be easy when dry and easier when wet.

**Soil moisture meters** are available. A simple, houseplant water meter can be used outdoors. Although the exact number reading may give little information, the overall indication of wet or dry is useful. It will read on the wet side when the soil has high nutrients or salts, and on the dry side when the soil is low in nutrients and salt. Permanently buried soil moisture sensors are available to automatically activate irrigation systems when the soil has dried.

## CMG GardenNotes on Irrigation Management

#260 Irrigation Management: References and Review Questions
#261 Colorado's Water Situation
#262 Water Movement Through the Landscape
#263 Understanding Irrigation Management Factors
#264 Irrigation Equipment
#265 Methods to Schedule Home Lawn Irrigation
#266 Converting Inches to Minutes
#267 Watering Efficiently
#268 Home Lawn Irrigation Check-Up

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Authors: David Whiting (CSU Extension, retired), with Carl Wilson (CSU Extension, retired). Artwork by David Whiting; used by permission.
Revision: Kurt M. Jones, Chaffee County Extension Director (9/2017).



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MASTER GARDENER
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*CMG GardenNotes #264*

# Irrigation Equipment

Outline:


Equipment for delivery of landscape irrigation water ranges from automated in-ground sprinkler systems and drip irrigation systems to hose-end watering. A basic outline of each with their strengths and limitations follows.

## In-Ground Sprinklers

Different types of irrigation equipment are most effective to water various types of planting in the home landscape. For lawns, sprinkler irrigation with pop-up spray heads and rotor heads are generally used. Because each type of sprinkler delivers water at a different rate, do not mix sprinkler types in a zone.

All sprinkler systems must comply with local building codes, requiring building permits and inspection. In-ground sprinkler systems have the following basic components.

**Point of Connection –** The system starts at the point of connection where the supply line connects to the water supply. This is in the basement of the typical house. The size of the pipe and water pressure determine water flow and thus influence design of the system (how many heads can run at one time).

A **pressure regulator** provides uniform, lower water pressure for uniform water delivery. This is typically found just before the point of connection. It should be set at 30 to 40 psi for the landscape irrigation system and household water use. Sprinkler systems have maintenance problems and values may fail to shut off when the pressure is above 80 psi. Pressure regulators are typically not found in older homes. Due to increased uniformity of water delivery, adding a pressure regulator may result in significant water savings in landscape irrigation.

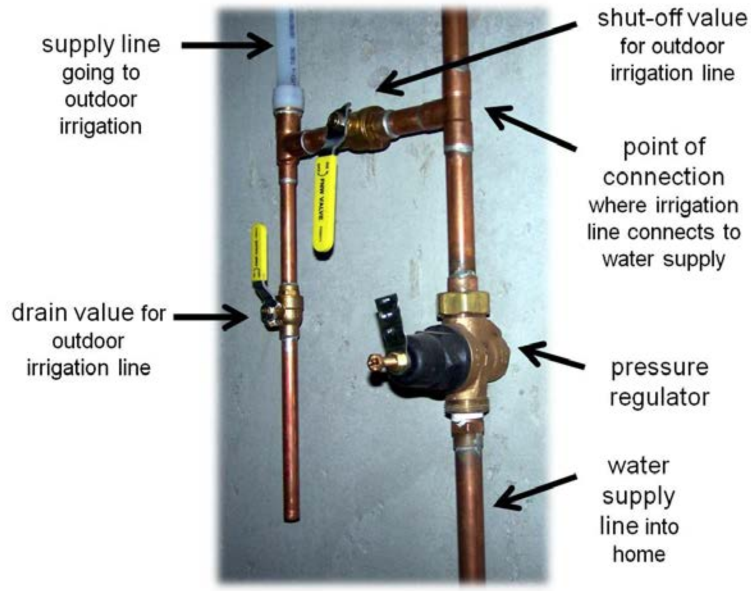



Figure 1. Point of connection with pressure regulator, shut-off value for outdoor line and drain valve that drains the outdoor line to the backflow prevention device (located just outside the house).

Local building codes require a **backflow prevention device** to protect the community's water supply. This is typically placed where the water line comes out of the house. Some valves have a backflow prevention device build into the value. The type to use depends on the local building code. [Figure 2]

Figure 2. Required by local building codes, backflow prevention devices are typically located where the line comes outside from the house.

The main **supply line** (water line holding water under pressure throughout the summer) splits in a **valve box** to a **valve** for each zone. To minimize maintenance headaches, use Schedule 40 PVC pipe for below-ground supply lines and copper pipe for any above-ground pipe. PVC fitting are connected with special glue. Copper pipefittings are soldered. [Figure 3]

Figure 3. Valve box with two zone valves.

Beyond the valve, **secondary lines** (lines that have water only when the zone is running) go to sprinkler heads.  Being easy to work with, these are generally made of flexible black poly pipe.  Connect poly pipe fitting with pinch clamps.

The size of the pipe and the water pressure determine the number of sprinkler heads that can be used per zone.  Various brands of sprinkler equipment have planning booklets with specific details for their product lines.

A **controller** (timer) runs the system from a central location (typically in the garage).  In the home garden market, there are many styles of controllers with a variety of features.  [Figure 4]


Figure 4.  Controller – Many brands offer a variety of features.

In climates where the soil freezes, the lines need to be **drained** in the winter.  This starts by turning off the water with the valve near the point of connection and opening the internal drain line.  This drains the line to the backflow prevention valve (which is outdoors at the high point in the system).

Depending on how the system was designed, there are several methods to drain the supply line and secondary lines.  Some systems are “blown out” by connecting an air compressor.  Other systems have valves that are manually opened, allowing for drainage by gravity.  In some systems, secondary lines have self-draining valves that automatically drain the line each time the water is turned off.

## <u>Pop-Up Spray Heads</u>

This is a generic name for sprinklers that automatically “pop up” with a fan-shaped spray pattern and do not rotate when running.  The head retracts by spring action when the water is turned off.  [Figure 5]

Figure 5.  Pop-up spray heads are used for small areas, 15 feet wide and less.

**<u>Delivery pattern</u>** – Pop-ups spray heads are best suited for small to moderate sized home lawn areas (larger than seven to ten feet wide up to 30 to 45 feet wide) and irregular or curvilinear areas.

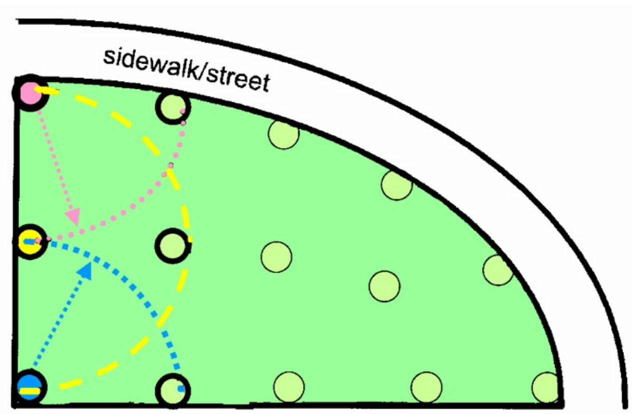
Pop-up spray nozzles are most common with 15, 12, 10, and 8 foot radii.  The radius can usually be adjusted down about 30%, using the nozzle’s adjustment screw.  Therefore, a commonly available ten-foot nozzle can be reasonably adjusted down to seven feet. Any greater adjustment would significantly distort the pattern, resulting in poor application efficiency.

The spray pattern of a pop-up spray head depends on choosing nozzles to water quarter circles, half circles, or full circles. Some manufacturers offer adjustable arch nozzles that can be set at any angle. However, do not use adjustable nozzles where a fixed nozzle would work, as the uniformity of water delivery is not as high.

Some specialty patterns to handle narrow, rectangular turf areas are available (often called "end-strip," "center-strip" or "side-strip" nozzles). However, nozzle performance is not as uniform compared to quarter-circle, half-circle, or full-circle nozzles.

Within any given brand, spray nozzles have "match precipitation rates." That is, a half-circle head uses half the amount of water per hour as a full-circle head. With match precipitation rates, full, half and quarter circles may be used in the same zone. It is also acceptable to mix a combination of nozzle radii in a zone.

Figure 6. For uniform water distribution, the spray head needs to release water above the grass height.




**Pop-up height** – For uniform water distribution, the sprinkler heads should rise above the grass height, making the 4-inch pop-up style most popular. High pop-up heads, with a 12-inch rise, are suitable for ground-cover areas and lower flowerbeds. [Figure 6]

**Pressure** – Pop-up spray heads work best with water pressure around 30-40 psi. The water pressure at some homes may be significantly higher, and an in-line pressure regulator will be needed in these cases. A sprinkler producing a "mist cloud" around the head is a common symptom of excessive pressure. This gives a distorted distribution pattern (significantly increasing water use) and leads to increased maintenance problems.

In addition, a grade change of more than eight vertical feet on a single zone will result in significantly higher pressure at the lower end, creating distribution problems.

**Small Areas** – Small areas less than seven to ten feet wide are difficult to sprinkle irrigate efficiently with pop-up spray heads. Consider landscape alternatives. For example, that small side yard between houses may be an excellent site for a low maintenance, non-planted, non-irrigated mulch area. Alternatively, the small area could be a shrub/flower bed watered with drip irrigation. A narrow lawn strip may be watered efficiently with the new sub-surface drip for lawns.

**Precipitation rate** – Pop-up spray heads have a high water delivery rate (***precipitation rate***) of 1 to 2½ inches per hour. At the typical rate of 1½ inches per hour, the zone would apply 1/2 inch of water in just 20 minutes.

## Rotor Head

Rotor heads mechanically rotate to distribute the spray of water. Impact and gear-driven heads are two common types in the home garden trade. [Figures 7 and 8]

Rotor heads in the home garden trade are best suited for larger lawn areas, generally 18 to 24 foot radius and greater. Some rotor-type heads in the commercial line have a radius of 30 to 90 feet.

Figure 7. Impact or impulse heads rotate as the water stream coming from the nozzle hits a spring-loaded arm. Impact heads tend to experience fewer problems with marginal (dirty) water quality.

Figure 8. Gear-driven heads use the flowing water to turn a series of gears that rotate the head. Gear-driven heads are quieter to operate than impact heads.

The spray pattern depends on the head. Most can be set at any angle from 15º up to a full circle. Some are adjusted at 15º increments. Others are designed for a quarter-circle, half-circle or full-circle spray pattern.

In rotor head design, do not mix quarter, half and full circle patterns in the same zone. The water flow is the same for each head, but the area covered will be different. For example, a full circle (covering twice the area of a half circle) will have half the precipitation rate of a half circle. The full circle will need to run twice as long to apply the same amount of water as the half circle.

**Pressure** – Rotor heads typically operate at 30 to 90 psi, 30 to 40 psi being most common for heads in the home garden trade. Better quality heads have built-in pressure regulators.

**Precipitation rate** – Rotors are more uniform in water distribution than pop-up spray heads and take much longer to water. As a rule of thumb, rotor heads deliver water at a rate of ¼ to ¾ inch per hour. At the typical precipitation rate of ½ inch per hour, it would take 60 minutes to apply ½ inch of water. The slower precipitation rate can be an advantage on clayey or compacted soils where water infiltration rates are slow.

### Multi-Stream Rotors

The newer multi-trajectory rotating streams, provide unmatched uniformity in water distribution for significant water savings. They have a lower application rate, reducing runoff on compacted, clayey soils and slopes. The streams of water are large enough to resist wind disturbance, so they reduce the amount of water blowing onto driveways, sidewalks, and roads.

Several manufacturers offer multi-stream rotors in today's market, including Hunter MP Rotator, Toro Precision Series, Rainbird R-VAN, and others. Generally used by landscape contractors, multi-stream rotors are less common in the home garden trade. For the home gardener, they may be found online.

Almost any type of sprinkler head can be retrofitted with an MP Rotator® sprinkler, including spray heads and traditional rotors. MP Rotators® can apply water to distances ranging from four to 30 feet. They can also be used to water narrow planting strips, which are often difficult to water effectively with traditional sprinkler heads.

Depending on the head, they perform best at 30 to 40 psi. With matched precipitation rates, quarter, half and full heads may be mixed in a zone.

### Strengths and Weaknesses of In-Ground Sprinklers

**Strengths** of in-ground sprinklers include the following:

- Convenience
- Time savings
- Usefulness for irrigating small areas
- Very efficient if well-designed, maintained and managed according to plant water needs (ET).

**Weaknesses** of in-ground sprinklers are that they can be very inefficient if poorly designed, maintained, or managed. Being "too" convenient, many gardeners give them little attention, significantly wasting water.

## Bubblers

Small groupings of flowers and other small plants can be efficiently watered with bubblers, which flood an area and rely on the natural wicking action of the soil to spread the water.

They are ideal for level shrub and ground cover areas. Heads are typically placed at three to five feet intervals or placed by individual plants for spot watering. Stream bubblers are directional and come in a variety of spray patterns.

Bubblers deliver water faster than drip emitters and are used to water trees and shrubs. Refer to manufacturers' literature for design and management criteria related to various models.

## Drip Systems

For flower and shrub beds, small fruits and vegetable gardens, drip emitters, drip lines, micro-sprayers, and soaker hoses are popular.

Water use rates, weed seed germination, and foliar disease problems are reduced in drip systems that do not spray water into the air and over the plants and the soil surface. As a rule of thumb, a drip system coupled with mulch can reduce water needs by 50%.

Drip emitters, micro-sprayers, and drip lines require clean water, which is relatively free of soil particles, algae, and salts. In-line filters are part of the system. Water quality is generally not a problem when using potable water sources. However, with non-potable water sources, the filtering system required may be expensive and high-maintenance, making drip impractical.

Drip systems work with lower pressures (typically around 20 psi), generally using **in-line pressure regulators**. The system snaps together with small fittings. No gluing or bands are required. It is much easier to work with if the tubing has been warmed by the sun for an hour. [Figure 9]


Figure 9. In-line filter and pressure regulator going to drip line poly tubing.

The system is put together with half-inch and quarter-inch poly tubing, fittings and emitters. For the main line and branch lines, **half-inch poly tubing** is used. The **quarter-inch micro-tubing** serves as feeder line to individual drippers or micro-sprinklers. Ideally, the tubing is on the soil surface under the mulch.

- **<u>Drip emitters</u>** deliver water at a slow, consistent rate, such as one-half gallon, one gallon, or two gallons per <u>hour</u>. Emitters can connect to the branch line or extend on micro-tubing out to individual plants or pots. Small annuals and perennials typically have one emitter per plant. Several would be used spaced around larger perennials, shrubs, and small trees. [Figure 10]

Figure 10.  Drip emitter on ½" poly tubing

As a point of clarification, some gardeners mistakenly think that using half, one, and two gallon per hour drippers is an effective method to manage differing water needs.  Although this works to a small degree, the concept is basically flawed.  The two-gallon per hour drippers will have significantly larger wetting zones than the half-gallon per hour dripper.  However, plants with the higher water needs (two-gallon/hour drippers) do not necessarily have a larger root spread.  Likewise, plants with lower water needs (half-gallon/hour dripper) will not necessarily have a smaller root spread (in fact, a large root spread is what makes some plants more xeric).  The factor missing here is irrigation frequency to match the water needs.

- **In-line drip tubing** is a quarter-inch micro-tubing with built-in emitters spaced at six, 12, or 24 inch intervals.  The 12-inch spacing is readily available in the home garden trade.  These are great for snaking through a bed area.  For sandy soils, spacing of the tubing should be at 12 inches.  For clayey soils, spacing may be at 18 to 24 inches for perennial beds.

- **Micro-sprayers**, often held up on a spike, cover a radius of two to 13 feet.  Delivery rates vary from 0.1 to 10 inches per hour, depending on the head selected.  Because water is sprayed in the air, drift and water waste in wind resembles sprinklers more than ground-applied drip.  Micro-sprayers work with a very small droplet size that readily evaporates.  For this reason, their efficiency in Colorado's low humidity is questionable.

Specifications on design and management vary among manufacturers and types selected.  Refer to the manufacturer's literature for details.  Typical run times are 60 to 90 minutes.

Drip systems are easy to automate by connecting the zones to valves and a controller (like an in-ground system for a lawn).  For ease of programming to the specific watering needs of the drip system, use a dedicated controller for multiple drip zones.  In small yards, a single zone or two could be added to the controller used for the lawn, but they would run on a different program than the lawn to match the different watering needs.

When connected to the garden hose, the zone can be automated with single-zone controllers that connect with hose-end fittings at the tap.  Some simple models turn the water off after a set number of minutes or gallons.  More elaborate battery-operated models turn the water on and off at the day and time interval set by the gardener. [Figure 13]

Like any irrigation system, drip systems require routine maintenance. They are not an install-and-forget type of system.

For additional information on drip irrigation, refer to CSU Extension Fact Sheet #4.702, *Drip Irrigation for Home Grounds.*

## Soaker Hose and Soaker Tubing

The **soaker hose** is a different type of drip system that allows water to seep out the entire length of a porous hose. They are great for raised bed gardens and flower beds. In sandy soils, space runs at 12 inches. For flower and shrubs beds on clayey soil, space runs at 18-24 inches. In a raised bed vegetable garden (where uniform delivery to small vegetables is important), make three to four runs up and down a four-foot wide bed. Typical run time is 10 to 20 minutes.

- **Quarter-inch Soaker Tubing –** Quarter-inch soaker tubing is availble in the drip irrigation section at garden stores. Cut the soaker tubing to desired length and connect with drip system components. An in-line pressure regulator (Figure 10) is required; otherwise, the fitting may pop or leak.

- **Half-Inch Soaker Hose** – Some brands (like *Swans Soaker Hose*) are a ½-inch hose that connect with a standard hose fitting. These are found in the garden hose section. It can be cut to any length and connected with garden hose fittings.

  A small plastic disc fits inside the female hose connection as a flow regulator. To adequately water the garden with the reduced water flow, it may need to run for around an hour. For better performance, use the pressure regulators with hose-end fittings found with the drip irrigation supplies (Figure 11). To adequately water the garden with this type of regulator, the drip line runs 10 to 20 minutes. Without a pressure regulator of some type, the soaker hose tends to rupture, sending out steams of water at spots rather than dripping along the line. [Figure 11]

Figure 11. Tap, pressure regulator (with hose connections) and half-inch drip hose in raised bed garden.

This half-inch hose style is more tolerant of small amounts of dirt, algae, or salts in the water than other types of drip systems and may be successful on some non-potable water sources. Periodically, open up the end of the hose and flush out soil deposits.

Because the soaker tubing has a higher delivery rate, it cannot be on the same zone as other in-line drip tubing, button emitters, or bubblers.

### Strengths and Weaknesses of Drip Irrigation

- **Strengths** of drip irrigation include the following:
  - Convenience.
  - Water saving.
  - Operates with low water pressure.
  - Easy to change when the plantings change.
  - Does not require trenches for installation.
  - Readily automated on a multi-zone controller or single-zone controllers that connect to the faucet.

- **Weaknesses** of drip irrigation include the following:
  - Require good-quality water and filtration.
  - Maintenance difficulty in seeing if systems are operating and need to check water delivery to individual plants.
  - Cost: for large areas, the cost will be significantly higher than a sprinkler system.
  - Unsuitable for watering large trees.

## Subsurface Drip

Subsurface drip is a relatively new way to water lawns and flowerbeds. Tubes are permanently buried below ground. Water soaks upward and laterally so subsurface drip works in clay-containing soils, but not well in sands.

Generally installed by a trained and experienced professional, subsurface drip requires very exact installation depth and spacing. Without proper attention to installation, the lawn becomes striped with green and dry strips. Studies being conducted by the Northern Colorado Water Conservation District find that water use is similar to a well-designed sprinkler system.

**Strengths** of subsurface drip include:

- Convenience.
- Operation at low pressure.
- Equipment located out of sight, where it is less prone to damage.
- Easy to water anytime day or night, even when the lawn is being used.
- Application of water directly to the root zone.
- Easy to automate with soil moisture sensors.
- Potential to inject fertilizers with the irrigation water.

**Weaknesses** of subsurface drip include:

- Requires high-quality water.
- Inability to see if it is operating correctly and need to dig it up if it is not.
- Prohibition of inserting stakes in the ground.

- Requires professional installation.
- Relatively high cost.
- Evolving technology that has not stood the test of time.

## Hose-End and Hand Watering

Hose-end watering devices include various types of spray heads, water wands and water breakers, soaker hoses, and soil needles. Such devices are commonly used for temporary situations and where permanent installations are impractical or not desired.

Hose-end watering is very inefficient in uniformity of water delivery, resulting in high water use. However, significant water savings may occur because gardeners generally do not water until the lawn/garden show signs of being dry.

A common problem with hand-held water wands is that folks tend to only water the surface, rather than deep watering of the root system. Avoid soil needles because they apply the water below the primary root system of trees, shrubs, and flowers.

A hand-moved sprinkler can be automated with single-zone controllers that connect with hose-end fittings at the tap. Some simple models turn the water off after a set number of minutes or gallons. More elaborate battery-operated models turn the water on and off at the day and time interval set by the gardener. [Figure 12]


Figure 12. Single-zone controllers connect to the hose line. Left: This style is manually turned on and automatically turns off after a set number of minutes. Right: This battery powered controller turns water on and off at the day and time intervals set by the gardener.

### Strengths and Weaknesses of Hose-End Watering

**Strengths** of hose-end and hand watering include the following:

- Relative low cost of equipment.
- Ability to water plants differently and usefulness for spot watering.
- Allows for close observation that may result in more timely care of plants.

- Being outside in the yard encourages neighborhood relationships.

**Weaknesses** of hose-end hand watering include the following:

- Time-consuming.
- Poor uniformity of water distribution with hand-placed sprinklers, leading to high water use.
- Hand-held watering often leads to surface watering rather than effectively watering the root zone.
- Wasting water by allowing it to run too long.

## Summary

Any type of irrigation system (in-ground sprinklers, drip, or hand watering) can be very efficient with attention to detail. Likewise, any type of irrigation can be inefficient, wasting water. What makes a system efficient or inefficient is not the equipment, but rather the attention given by the gardener.

## CMG GardenNotes on Irrigation Management

#260 Irrigation Management: References and Review Questions
#261 Colorado's Water Situation
#262 Water Movement Through the Landscape
#263 Understanding Irrigation Management Factors
#264 Irrigation Equipment
#265 Methods to Schedule Home Lawn Irrigation
#266 Converting Inches to Minutes
#267 Watering Efficiently
#268 Home Lawn Irrigation Check-Up

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Revised by Kurt M. Jones, Chaffee County Extension Director


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MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

*CMG GardenNotes #265*

# Methods to Schedule Home Lawn Irrigation

Outline:


## Irrigation Scheduling

In many areas of the semiarid West, gardeners cannot count on natural precipitation to deliver moisture at the right times or in sufficient amounts to grow most introduced landscape plants. Supplemental irrigation is necessary unless the plant pallet is limited to species tolerant of natural precipitation levels. Due to limited precipitation and periodic droughts that limit available water supplies, using efficient irrigation is of interest to all.

Scheduling landscape irrigation is a critical part of lawn and garden care. When irrigating, gardeners have two goals: 1) water enough to keep plants healthy, and 2) minimize water waste.

Irrigation management comes down to two basic questions: 1) how much, and 2) how often. Gardeners often hear recommendations such as "water deeply and infrequently" or "water to adequate depth without runoff." Such advice is usually too broad to translate into effective irrigation management practices.

Rather than using broad generalizations, this *CMG GardenNotes* looks at several management approaches with differences in the time investment and potential water savings. **The textbook figures will need to be fine-tuned to the specific site needs, taking into account soils, exposure, heat, wind, and other water-use factors.**

Methods focus on cool-season turf, such as Kentucky bluegrass and turf-type tall fescue. Xeric and dry-land plants may need significantly less water.

## Sprinkler-Type Method

One of the easiest ways to schedule an irrigation system is based on sprinkler type. Different types of sprinklers deliver very different amounts of water in the same amount of time. By considering sprinkler type, gardeners can begin to match their watering practices to the lawn's water needs.

Pop-up spray heads typically apply 1-2½ inches of water per hour, whereas rotor heads only deliver ¼ to ¾ inch of water per hour. Therefore, zones that have pop-up spray heads can run for a short time, while zones with rotors will need to run longer to deliver the same amount of water.

A gardener could estimate that a zone with pop-up spray heads applies 1¾ inches of water per hour, and zones with rotor head apply about ½ inch per hour on average. Table 1 estimates run time (based on historical water use). The typical Colorado soil requires that this be split between a couple of irrigations.

Table 1.
**Estimated Sprinkler Run Time Based on Sprinkler Type for Cool-Season Lawns**

| | Late April | May & June | July & August | September | Early October |
|---|---|---|---|---|---|
| **Inches of water per week** (irrigation plus rain) | 0.75" | 1.0" | 1.5" | 1.0" | 0.75" |

| **Run Time** (minutes/week) | Late April | May & June | July & August | September | Early October |
|---|---|---|---|---|---|
| **Pop-up Spray Head**[1] | | | | | |
| **Irrigated 1 time per week**[3] | **26** | **34** | **52** | **34** | **26** |
| **Irrigated 2 times per week**[4] | **13** | **17** | **26** | **17** | **13** |
| Irrigated 3 times per week | 9 | 11 | 17 | 11 | 9 |
| Irrigated every 6 days | 22 | 29 | 45 | 29 | 22 |
| Irrigated every 5 days | 19 | 24 | 37 | 24 | 19 |
| Irrigated every 4 days | 15 | 19 | 30 | 19 | 15 |
| Irrigated every 3 days | 11 | 15 | 22 | 15 | 11 |
| Irrigated every 2 days | 7 | 10 | 15 | 10 | 7 |
| **Rotor Head**[2] | | | | | |
| **Irrigated 1 time per week**[3] | **90** | **120** | **180** | **120** | **90** |
| **Irrigated 2 times per week**[4] | **45** | **60** | **90** | **60** | **45** |
| Irrigated 3 times per week | 30 | 40 | 60 | 40 | 30 |
| Irrigated every 6 days | 77 | 103 | 154 | 103 | 77 |
| Irrigated every 5 days | 64 | 86 | 129 | 86 | 64 |
| Irrigated every 4 days | 51 | 69 | 103 | 69 | 51 |
| Irrigated every 3 days | 39 | 51 | 77 | 51 | 39 |
| Irrigated every 2 days | 26 | 34 | 51 | 34 | 26 |
| **Percent of July/August** | **50%** | **67%** | **100%** | **67%** | **50%** |

[1] Pop-up spray head estimated at 1 ¾" per hour.
[2] Rotor head estimated at ½" per hour.
[3] Recommended for most Colorado soils in the spring and fall
[4] Recommended for most Colorado soils in the summer

An easy tool for making seasonal adjustments is the **Percent Key** found on most controllers. The controller would be set for the July/August irrigation schedule. The percent key would be set at 50%, 67% or 100%, based on the season.

**The method will need fine-tuning as described below to match the actual water need for the site based on soil, exposure, heat, wind, etc**.

Although this method outlines a starting point for gardeners who want an easy approach, it does not factor in the <u>actual</u> water application rates for <u>each zone</u>.

## Precipitation Rate Method

A far better approach is to do a ***Precipitation Rate (Catch Can) Test*** on each zone to determine the actual water delivery rate (know as ***precipitation rate***). The actual precipitation rate is determined by the sprinkler type and brand, water pressure and head spacing. It is generally slightly different for each zone.

To do the calculations you will need six identical, straight-sided, flat-bottomed cans such as soup, fruit, or vegetable cans. (Do not use short cans like tuna cans as they are too shallow, and water may splash out.) You will need a ruler, a watch and paper/pen to record your findings. Many water providers and sod growers have calibrated plastic cups specifically designed for this test. Again, six are needed.

### <u>Precipitation Rate (Catch Can) Test</u>

Step 1. Place six identical, straight-sided, flat-bottomed cans randomly around the area between sprinkler heads in the zone.

Step 2. Turn on the sprinklers for exactly ten minutes.

Step 3. Pour all the water into one can.

Step 4. With a ruler, measure the depth of the water in the can. This is your **<u>precipitation rate in inches per hour</u>**. Write it down for future reference.

Step 5. Repeat steps 1 and 2 for each irrigation zone.

Step 6. Use Tables 2 & 3 to calculate the run time for each zone.

Note: if the amount of water in some containers is significantly more or less than others, the system is poorly designed or head(s) are malfunctioning.

In many lawn sections, one zone waters the area from the left while another zone waters the same area from the right. In this situation, cut run times for zones in half, so that each applies half of the needed water.

An easy way to make seasonal adjustments is with the **Percent Key** found on most controllers. The controller would be set for the July/August irrigation schedule. The percent key would be set at 50%, 67% or 100% based on the season.

**The method will need fine-tuning as described below to match the actual water need for the site based on soil, exposure, heat, wind, etc**.

Table 2.
**Minutes to Run Sprinklers PER WEEK Based on Precipitation Rates**
**For Cool-Season Turf in Colorado**

| | Late | May & | July & | | Early |
|---|---|---|---|---|---|

| | April | June | August | September | October |
|---|---|---|---|---|---|
| **Inches of water per week** (irrigation plus rain) | **0.75”** | **1.0”** | **1.5”** | **1.0”** | **0.75”** |
| **Precipitation Rate** | | | | | |
| **1/4** | 180 | 240 | 360 | 240 | 180 |
| **3/8** | 120 | 160 | 240 | 160 | 120 |
| **1/2** | 90 | 120 | 180 | 120 | 90 |
| **5/8** | 72 | 96 | 144 | 96 | 72 |
| **3/4** | 60 | 80 | 120 | 80 | 60 |
| **7/8** | 52 | 69 | 103 | 69 | 52 |
| **1** | 45 | 60 | 90 | 60 | 45 |
| **1 1/8** | 40 | 53 | 80 | 53 | 40 |
| **1 1/4** | 36 | 48 | 72 | 48 | 36 |
| **1 3/8** | 33 | 44 | 65 | 44 | 33 |
| **1 1/2** | 30 | 40 | 60 | 40 | 30 |
| **1 5/8** | 28 | 37 | 55 | 37 | 28 |
| **1 3/4** | 26 | 34 | 51 | 34 | 26 |
| **1 7/8** | 24 | 32 | 48 | 32 | 24 |
| **2** | 23 | 30 | 45 | 30 | 23 |
| **2 1/8** | 22 | 28 | 42 | 28 | 22 |
| **2 1/4** | 20 | 27 | 40 | 27 | 20 |
| **2 3/8** | 19 | 25 | 38 | 35 | 19 |
| **2 1/2** | 18 | 24 | 36 | 24 | 18 |
| **2 5/8** | 17 | 23 | 34 | 23 | 17 |
| **2 3/4** | 16 | 22 | 33 | 22 | 16 |
| **2 7/8** | 16 | 21 | 31 | 21 | 16 |
| **3** | 15 | 20 | 30 | 20 | 15 |
| **Percent of July/August** | **50%** | **67%** | **100%** | **67%** | **50%** |

Table 3.
**Conversion of Run time PER WEEK to Run Time PER IRRIGATION**

| Irrigations Per Week | Conversion to Run Time Per Irrigation |
|---|---|
| 1 time per week[1] | minutes per week |
| 2 times per week[2] | minutes per week / 2 |
| 3 times per week | minutes per week / 3 |
| Every 6 days | minutes per week X 0.86 |
| Every 5 days | minutes per week X 0.71 |
| Every 4 days | minutes per week X 0.57 |
| Every 3 days | minutes per week X 0.43 |
| Every 2 days | minutes per week X 0.29 |

[3] Recommended for most Colorado soils in the spring and fall
[4] Recommended for most Colorado soils in the summer

Determining the number of irrigations per week becomes complex as soil water-holding capacity and rooting depth are factored in. For details, refer to CMG GardenNotes #263, *Understanding Irrigation Management Factors*.

However, many gardeners know by experience how often they need to irrigate. For the majority of Colorado soils, irrigating once per week works in the spring and fall, and twice a week works in the summer. Watering as infrequently and deeply as the soil allows gives better resilience during hot spells and helps reduce many weed species.

## Adding Cycle and Soak Features

On slopes or compacted, clayey soils, water is generally applied faster than it can soak into the soil, resulting in water being wasted as it runs off-site. The ***cycle and soak*** approach cuts the irrigation period into multiple short runs with soak-in time in between. Programming a controller for cycle and soak is simply a matter of using multiple start times.

**Adding Cycle and Soak**

Step 1. From the methods discussed above, calculate the total run time for the irrigation.

Step 2. Using Table 4, figure the number of cycles and soaks desired.

For example, if the run time is 26 minutes, three cycles are suggested.

Step 3. Divide the run time per irrigation by the number of cycles to get the run time per cycle.

For example, if the run time is 26 minutes and three cycles will be used, run time per cycle is nine minutes (26 / 3 = 8.67, rounded to 9).

Step 4. Set program with multiple start times, as needed. Generally, the controller is set to cycle again after all the zones have run. If the controller only has a few zones, start times need to be at least one hour apart.

Table 4.
**Estimated Number of Cycles to Reduce Surface Runoff**

| Type of Sprinklers | Run Time Per Irrigation | Number of Cycles |
|---|---|---|
| **Pop-up Spray Heads** | Greater than 16 minutes | 2 |
| | Greater than 24 minutes | 3 |
| **Rotor Heads** | Greater than 48 | 2 |
| | Greater than 72 | 3 |

## Observation and Manual Control Method

A simple method to manage lawn irrigation and conserve water is to manually activate the controller as needed. With careful attention, this method can maximize plant health and water savings since the gardener continually adjusts the irrigation system to actual weather and lawn needs. The downside of this method is that it takes daily attention to the lawn's water needs.

Run times on the controller are set as previously described. The difference is that the controller is turned to the "off" position. It is manually activated when the lawn shows signs of water stress (color change from bluish-green to grayish-blue and footprints are still visible an hour or more later). After the zones run through, the controller is turned back to "off".

## Using Emerging Technology

Advances in irrigation technology have led to several innovations. ET Controllers and soil-moisture sensors are examples. Even though they may be more expensive or require professional installation, these products can be used to further improve water delivery to a landscape. Because they automate the irrigation controller, they can potentially reduce the amount of effort needed to water effectively.

### ET Controllers

The ET controller is a relatively new piece of equipment that automatically adjusts the irrigation to the daily ET. ET controllers are designed to water only enough to fulfill the lawn's water need, thereby reducing over and under watering.

Some models use "Historical ET," which is a multi-year average for the day. With these, dry spots will pop up with extreme heat over multiple days. They do not take into account actual rain received locally.

For a small annual fee, other models connect by cell phone, Wi-Fi, or satellite communication networks to download actual ET and rainfall from a local weather station system. On a day-by-day basis, they adjust the irrigation to match actual water need.

For additional information on ET controllers and the use of ET in irrigation management, refer to the *Northern Colorado Water Conservancy District* website at www.ncwcd.org.

### Soil-Moisture Sensors

Soil-moisture sensors measure the water content of the soil, allowing the controller to run only when soil dries down to a threshold level. One of the advantages of a soil-moisture sensor is that it uses on-site soil conditions to control the irrigation system. Usually one sensor is buried in the home landscape in a "representative" area. Run times for reduced irrigation zones or shady zones are programmed into the controller relative to the representative zone.

### Rain Shut-off Sensors

Rain shut-off devices, also known as rain sensors, interrupt the schedule of an irrigation controller when a specific amount of rain has fallen. They are wired into the irrigation controller and placed in an open area where they are exposed to rainfall. They save water by preventing an irrigation system from running during moderate and heavy rains. Many states, but not Colorado, require rain shut-off sensors on automated systems.

## Fine-Tuning Any Scheduling Method

**Any scheduling method will need fine-tuning to match the actual water need of the site based on soil type, exposure, wind, heat, rooting depth, etc**. This is done by careful observation of the lawn.

**<u>When adjusting all zones</u>**, the **Percent Key** on most controllers provides an easy method to fine-tune for the actual site by adjusting the percentage up/down in 10% increments, as needed. It can also be adjusted by increasing/decreasing the run time for each zone in 10% increments, as needed.

**<u>When adjusting a single zone</u>**, adjust the run times for that zone up/down in 10% increments, as needed.

In typical summer weather, if the lawn starts to become dry between irrigations, increase the run time in 10% increments, as needed. By trial and error, it is easy to fine-tune each irrigation zone. On multiple days of unusually hot weather, dry spots should pop up if the controller is precisely fine-tuned. In unusually hot weather, if dry spots do not pop up, the lawn is being over-watered. Cut back the time in 10% increments, as needed, to fine-tune each zone.

Many water providers encourage homeowners to water their yards between 9 p.m. and 9 a.m. Winds are typically less at night, and evaporation loss will be lower.

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Revision: Kurt M. Jones, Chaffee County Extension Director (9/2017).



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# Converting Inches to Minutes



Most gardeners realize that temperatures affect the water needs of lawns and gardens. The difficulty is that water is usually measured in inches while the irrigation controller (timer) works in minutes. The challenge is to make minutes equal to inches so that the correct amount of water is applied to the lawn or garden. It's easy to make the conversion. First calculate the precipitation rate for each irrigation zone. Then convert inches to minutes using the formula or the table.

## Calculate the Precipitation Rate

The following steps need to be done for each irrigation zone (or each location you placed the sprinkler if you're a "hose dragger"). To do the calculations you will need 6 identical straight-sided, flat-bottomed cans or cups such as soup, fruit or vegetable cans. (Do not use short cans like tuna cans as they are too shallow, and water will splash out.) You will need a ruler, a watch, and paper/pen to record your findings. Many sod growers and local water providers give out small rain gauges with a ruler on the side for this measurement. You will need 6 of the same type.

**Steps**

1. Place six identical, straight-sided, flat-bottomed cans between sprinkler heads in the zone.
2. Turn on the sprinklers for exactly ten minutes.
3. Pour all the water into one can.
4. With a ruler, measure the depth of the water in the can. This is your precipitation rate in inches per hour.
5. Write down the number near your controller for future reference.
6. Repeat steps 1-5 for each irrigation zone.

**Table 1. Conversion of fractions to decimals**

| | | | | | |
|---|---|---|---|---|---|
| 1/16 | = | .06 | 9/16 | = | .56 |
| 1/8 | = | .13 | 5/8 | = | .63 |
| 3/16 | = | .19 | 11/16 | = | .69 |
| 1/4 | = | .25 | 3/4 | = | .75 |
| 5/16 | = | .31 | 13/16 | = | .81 |
| 3/8 | = | .38 | 7/8 | = | .88 |
| 7/16 | = | .44 | 15/16 | = | .94 |
| 1/2 | = | .50 | | | |

## Convert Inches to Minutes

Once you know the precipitation rate for each zone, you can look up the run time in the table or calculate it by using the following formula:

$$\textbf{Run Time}\text{ (minutes)} = \frac{\textbf{Water to apply}\text{ (inches)}}{\textbf{Precipitation rate}\text{ (inches/hour)}} \times \textbf{60 minutes/hr}$$

**Example:** You have done the above steps and calculated that this sprinkler zone has a precipitation rate of 1.5 inches per hour. You desire to apply one-half inch of water.

$$\text{Run Time} = \frac{0.5\text{ inches}}{1.5\text{ inches/hr.}} \times 60\text{ minutes/hr} = 20\text{ minutes}$$

You need to calculate this for each zone. Don’t make the common mistake of assuming that all zones are the same. In the typical yard, they are not!

**Table 2. Sprinkler Run Time Table (in minutes) – by 1/8th inch**

| **Precipitation Rate** (inches per hour) | **Water to be Applied** (inches) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** | **1.0** | **1.1** | **1.2** | **1.3** | **1.4** | **1.5** |
| **1/4** | 48 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 | 264 | 288 | 312 | 336 | 360 |
| **3/8** | 32 | 48 | 64 | 80 | 96 | 112 | 128 | 144 | 160 | 176 | 192 | 208 | 224 | 240 |
| **1/2** | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 | 132 | 144 | 156 | 168 | 180 |
| **5/8** | 19 | 29 | 38 | 48 | 58 | 67 | 77 | 86 | 96 | 106 | 115 | 125 | 134 | 144 |
| **3/4** | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 | 104 | 112 | 120 |
| **7/8** | 14 | 21 | 27 | 34 | 41 | 48 | 55 | 62 | 69 | 75 | 82 | 89 | 96 | 103 |
| **1** | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 | 78 | 84 | 90 |
| **1 1/8** | 11 | 16 | 21 | 27 | 32 | 37 | 43 | 48 | 53 | 59 | 64 | 69 | 75 | 80 |
| **1 1/4** | 10 | 14 | 19 | 24 | 29 | 34 | 38 | 43 | 48 | 53 | 58 | 62 | 67 | 72 |
| **1 3/8** | 9 | 13 | 17 | 22 | 26 | 31 | 35 | 39 | 44 | 48 | 52 | 57 | 61 | 65 |
| **1 1/2** | 8 | 12 | 16 | **20** | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 |
| **1 5/8** | 7 | 11 | 15 | 18 | 22 | 26 | 30 | 33 | 37 | 41 | 44 | 48 | 52 | 55 |
| **1 3/4** | 7 | 10 | 14 | 17 | 21 | 24 | 27 | 31 | 34 | 38 | 41 | 45 | 48 | 51 |
| **1 7/8** | 6 | 10 | 13 | 16 | 19 | 22 | 26 | 29 | 32 | 35 | 38 | 42 | 45 | 48 |
| **2** | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 |
| **2 1/8** | 6 | 8 | 11 | 14 | 17 | 20 | 23 | 25 | 28 | 31 | 34 | 37 | 40 | 42 |
| **2 1/4** | 5 | 8 | 11 | 13 | 16 | 19 | 21 | 24 | 27 | 29 | 32 | 35 | 37 | 40 |
| **2 3/8** | 5 | 8 | 10 | 13 | 15 | 18 | 20 | 23 | 25 | 28 | 30 | 33 | 35 | 38 |
| **2 1/2** | 5 | 7 | 10 | 12 | 14 | 17 | 19 | 22 | 24 | 26 | 29 | 31 | 34 | 36 |
| **2 5/8** | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 21 | 23 | 25 | 27 | 30 | 32 | 34 |
| **2 3/4** | 4 | 7 | 9 | 11 | 13 | 15 | 17 | 20 | 22 | 24 | 26 | 28 | 31 | 33 |
| **2 7/8** | 4 | 6 | 8 | 10 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 |
| **3** | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |

Select the precipitation rate of your sprinkler zone along the left column and move right until you are in the column of the amount of water to be applied. This is the number of minutes to run your sprinkler.
Example: Your sprinkler applies water at 1 1/2 inches per hour and you want to apply 0.5 inch, it takes 20 minutes.

## Table 3. Sprinkler Run Time Table (in minutes) – by 1/10th inch

| Precipitation Rate (inches per hour) | Water to Be bpplied (inches) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** | **1.0** | **1.1** | **1.2** | **1.3** | **1.4** | **1.5** |
| **0.20** | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | 360 | 390 | 420 | 450 |
| **0.30** | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 |
| **0.40** | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 | 195 | 210 | 225 |
| **0.50** | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 | 132 | 144 | 156 | 168 | 180 |
| **0.60** | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 |
| **0.70** | 17 | 26 | 34 | 43 | 51 | 60 | 69 | 77 | 86 | 94 | 103 | 111 | 120 | 129 |
| **0.80** | 15 | 22 | 30 | 37 | 45 | 52 | 60 | 67 | 75 | 82 | 90 | 97 | 105 | 113 |
| **0.90** | 13 | 20 | 27 | 33 | 40 | 47 | 53 | 60 | 67 | 73 | 80 | 87 | 93 | 100 |
| **1.00** | 12 | 18 | 24 | 30 | 36 | 72 | 48 | 54 | 60 | 66 | 72 | 78 | 81 | 90 |
| **1.10** | 11 | 16 | 22 | 27 | 33 | 38 | 44 | 49 | 55 | 60 | 66 | 71 | 76 | 82 |
| **1.20** | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 76 | 75 |
| **1.30** | 9 | 14 | 18 | 23 | 28 | 32 | 37 | 42 | 46 | 51 | 55 | 60 | 65 | 69 |
| **1.40** | 9 | 12 | 17 | 21 | 26 | 30 | 34 | 39 | 43 | 47 | 51 | 56 | 60 | 64 |
| **1.50** | 8 | 12 | 16 | **20** | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 |
| **1.60** | 8 | 11 | 15 | 19 | 22 | 26 | 30 | 34 | 37 | 41 | 45 | 49 | 52 | 56 |
| **1.70** | 7 | 11 | 14 | 18 | 21 | 25 | 28 | 32 | 35 | 39 | 42 | 46 | 49 | 53 |
| **1.80** | 7 | 10 | 13 | 17 | 20 | 23 | 27 | 30 | 33 | 37 | 40 | 43 | 47 | 50 |
| **1.90** | 7 | 9 | 13 | 16 | 19 | 22 | 25 | 28 | 32 | 35 | 38 | 41 | 44 | 47 |
| **2.00** | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 |
| **2.10** | 6 | 9 | 11 | 14 | 17 | 20 | 23 | 26 | 29 | 31 | 34 | 37 | 40 | 43 |
| **2.20** | 6 | 8 | 11 | 14 | 16 | 19 | 22 | 25 | 27 | 30 | 33 | 35 | 38 | 41 |
| **2.30** | 5 | 8 | 10 | 13 | 16 | 18 | 21 | 23 | 26 | 29 | 31 | 34 | 37 | 39 |
| **2.40** | 5 | 7 | 10 | 12 | 15 | 17 | 20 | 22 | 25 | 27 | 30 | 32 | 35 | 37 |
| **2.50** | 5 | 7 | 10 | 12 | 14 | 17 | 19 | 22 | 24 | 26 | 29 | 31 | 34 | 36 |

Select the precipitation rate of your sprinkler zone along the left column and move right until you are in the column of the amount of water to be applied. This is the number of minutes to run your sprinkler.
Example: Your sprinkler applies water at 1.5 inches per hour and you want to apply 0.5 inch, it takes 20 minutes.

Author: David Whiting, Colorado State University Extension (retired).
Revision: Kurt M. Jones, Chaffee County Extension Director (9/2017).



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*CMG GardenNotes #267*

# Watering Efficiently



Of the seven principles of water-wise gardening, attention to irrigation efficiency has the greatest potential for water conservation for most residents. In the typical home yard, extra attention to irrigation system design, maintenance and management could reduce water use by 20 to 70%, or 40% on average.

## Irrigation Zones Reflect Water Need

Unfortunately, in the design of many home irrigation systems, little attention is given to zoning by water need.

- **Zone by irrigation demand** – The following examples have different water requirements and should be independent irrigation zones.
    - Lawns—Routine irrigation
    - Lawns—Reduced irrigation
    - Lawns—Limited irrigation or non-irrigated
    - Mixed flower and shrub beds—Routine irrigation
    - Mixed flower and shrub beds—Reduced irrigation
    - Mixed flower and shrub beds—Limited irrigation
    - Vegetables – routine irrigation
    - Tree fruits – reduced irrigation
    - Small fruits – routine to reduced irrigation depending on the fruit

- **Zone by exposure** – Because exposure to sun, heat, and wind also plays a significant role in water requirements, irrigation zones should reflect exposure levels. For example, lawn on an open, windy, southwest-facing slope will have considerably higher water requirements than the average lawn. Design this southwest slope as an independent irrigation zone.

  Areas in full or partial shade may have lower irrigation needs than areas in full sun. As a rule of thumb, if a shady area is outside of the rooting zone of large trees, water use may be 30 to 50% lower. If the shady area is in the rooting zone of large trees, water use will be similar to full sun (the tree pulling water from the soil is not in the shade.) Irrigation zones should reflect site needs.

- **<u>Drip irrigation</u>** in flower and shrub beds, small fruit gardens, and vegetable gardens can reduce water usage by 50% when coupled with organic mulch. For details on drip irrigation, refer to *CMG GardenNotes #263*, Irrigation Equipment.

## Sprinkler Design Criteria for Uniform Water Distribution

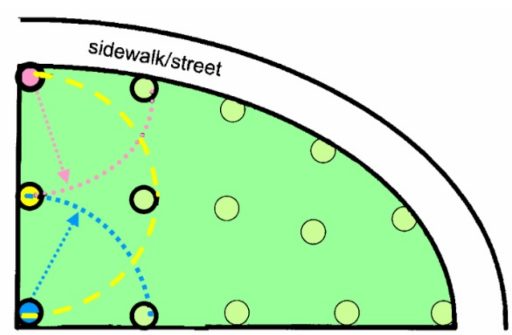
Unfortunately, in the design of many home (and commercial) sprinkler systems, little attention is given to design criteria for water conservation.

Sprinklers do not deliver a uniform quantity of water over their distribution area. Thus to keep the dryer spots (i.e., spots that receive less water) green the rest of the area receives more water than needed. Designing sprinkler layouts to provide a more uniform water delivery can reduce water use by 25 to 50%. Most home lawn sprinkler systems have a 30 to 40% efficiency rating, whereas a 70 to 80% rating is very achievable with attention to design and management.

Sprinkler design criteria for uniform water distribution include the following:

1. **<u>Head-to-head coverage</u>** – Designs with head-to-head coverage (i.e., the water from a sprinkler head reaches the neighboring sprinkler heads) generally give the most uniform delivery. A 10 to 20% overlap may actually give the best uniformity. In other words, space heads at 90% of their radius of throw. For example if the radius of a pop-up spray head is 15 feet, the ideal spacing would be 13.5 feet (15’ x 90%); and maximum spacing would be 15 feet. Wider spacing could increase water use by 25 to 50%. [Figure 1]

Figure 1. A standard in sprinkler design is head-to-head coverage. Ten to 15% overlap may give even better uniformity.



2. ***Line out* the edge** – In the design process, start by *lining out* the edges (i.e., run a line of sprinkler heads down the edge of the lawn or irrigated area), spraying onto the lawn but not onto the sidewalk, street or non-irrigated area. [Figure 2]

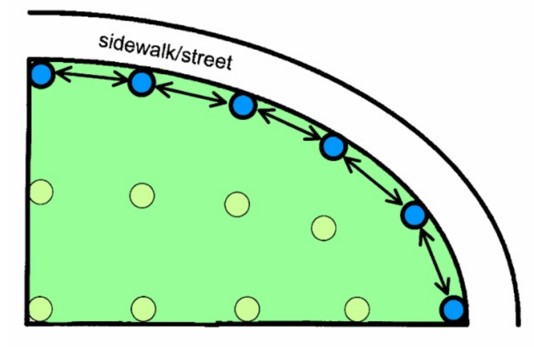



Figure 2. Start the layout by lining out the edge, running a row of sprinkler heads along the edge of the irrigated/non-irrigated areas.

In sprinkler design, avoid layouts where sprinkler heads spray from the center of the lawn area out onto the sidewalk. It either wastes 20% of the water as it over-sprays onto the sidewalk or creates a dry lawn area along the edge. [Figure 3]

If our society is going to deal with limited water supplies, it has to become <u>unacceptable</u> for the homeowner, private and commercial property manager or government entity to apply irrigation water onto roads, sidewalks and parking lots.

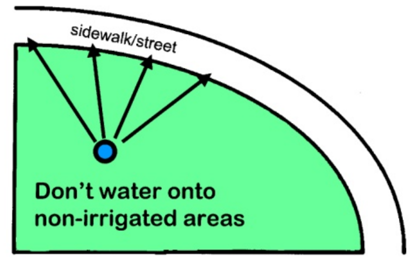



Figure 3. Spraying from the center out onto a sidewalk or non-irrigated area is unacceptable in water-wise landscaping.

3. **<u>Arrange heads in square or triangular patterns</u>** – In the next step of the irrigation design process, fill in larger areas with sprinkler heads in square or triangular patterns. Square and triangular head patterns give the most uniform water delivery. [Figure 4]

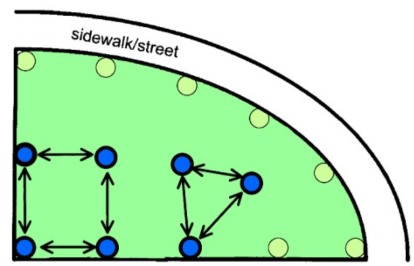



Figure 4. For uniform water delivery, fill in heads in square and triangular patterns.

In irregularly shaped areas, heads easily fall into pentagon (five-sided) patterns. Avoid these as it creates an area that receives less water than other parts of the lawn. [Figure 5]

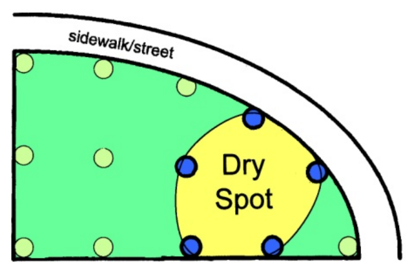



Figure 5. Avoid pentagon-shaped head layout. The area receives less water, creating a dry spot.

4. **<u>Avoid irrigating small, irregularly shaped areas</u>** – It is impractical to sprinkle irrigate small areas (less than eight feet wide) and irregularly shaped patches without applying water where it is not needed. In small or irregularly shaped areas, consider replacing lawns with plantings that can be watered with drip irrigation, or consider non-irrigated options. For example, in the narrow side yards around urban homes, consider a low-water-requiring ground cover or a non-irrigated mulch area.

5. **<u>Use recommended water pressure</u>** – Water distribution patterns change with pressure. Use the pressure recommended for the specific sprinkler head in use. Most sprinklers in the home garden trade are designed to operate at 30 to 40 psi. Commercial heads typically operate at 40 to 100 psi, and some heads have built-in pressure regulators.

New homes typically have a pressure regulator where the water line enters the home. In older homes, adding a pressure regulator may significantly reduce landscape water use.

## Sprinkler Maintenance Criteria for Uniform Water Distribution

We have all noticed that blown sprinkler head down the street that goes unfixed for weeks. A problem with automatic sprinkler systems is that the gardener may not be aware of a system malfunction. Check the irrigation system's operations frequently.

As water-wise gardening concepts spread in our community, we need to adapt the practice of alerting neighbors to popped sprinkler heads and other system malfunctions. With an automated sprinkler system, many residents or landscape managers may be unaware of the mechanical failure.

Maintenance issues for uniform water distribution include the following:

- **Arc adjustment** – Sprinkler heads (particularly rotor-type heads) frequently require adjustment of delivery angle to keep water on the irrigated areas and off non-irrigated areas. [Figure 6]

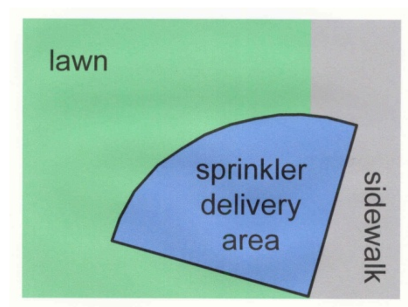
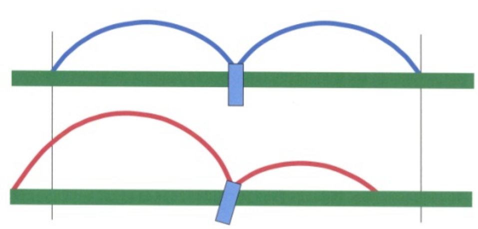



Figure 6. Heads frequently shift their delivery arc. Frequent adjustment is required.

- **Adjust radius of throw** – As discussed in design, water from one sprinkler head needs to reach adjacent heads for uniform delivery. A 10 to 20% overlap is preferred where it does not spray a non-irrigated area. Occasional adjustment on the radius of throw may be needed. This is done with a screw adjustment on the nozzle or changing out the nozzle to one with a different radius.

- **Adjust sprinkler heads to vertical** – Distribution patterns change when the head tilts off vertical alignment. To correct it, remove a donut shape of sod around the head with a shovel. Carefully loosen the soil around the head. Realign the head to vertical, and then firmly pack soil around the base of the head before replacing the sod. [Figure 7]

Figure 7. Heads require frequent adjustment back to vertical. Tilted heads change the distribution pattern.



- **Adjust head height** – When water flow does not clear the grass height, the distribution pattern can be distorted. Raise heads to release water above grass height. On the other hand, sprinkler heads set excessively high can be a trip hazard and can interfere with mowing. [Figure 8]

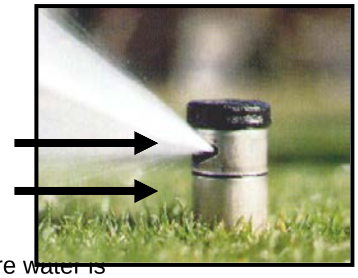


Figure 8. Raise height of head to a point where water is released well above the grass height.

  To correct this, remove a donut shape of sod around the head with a shovel. Carefully loosen the soil around the head. Adjust head to the correct height, and then <u>firmly pack</u> soil around the base of the head before replacing the sod.

- **Replace worn nozzles** – As sprinkler nozzles wear, distribution patterns change, giving a less uniform water delivery. Periodically replace old, worn nozzles. [Figure 9]

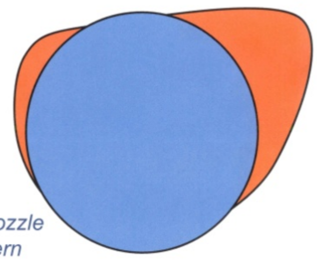



Figure 9. Worn nozzles distort the delivery pattern.

- **Adjust pressure** – A mist cloud around a sprinkler head indicates that the water pressure is too high for the head. Reduce pressure to avoid wasting water. A pressure regulator can be added to the main supply line. When adjusting pressure, slowly drop the pressure until you see water flow just start to drop, then up the pressure just a touch.

- **Replace leaky valves** – In an irrigation valve, the rubber diaphragm that actually turns water on and off ages over time. Valves that do not shut off completely need the diaphragm or entire valve replaced. Values often fail to shut off if the pressure is above 80 psi.

## Sprinkler Management Criteria for Water-Wise Irrigation

Sprinkler management addresses two primary questions, <u>how much</u> and <u>how often</u>. Irrigation scheduling is discussed in more detail in *CMG GardenNotes #265*, Methods to Schedule Home Lawn Irrigation.

- **Know the *precipitation rate* for each irrigation zone, and adjust run time to match water need of each zone.** – The first step in irrigation management is to calculate the precipitation rate for each zone. Once the precipitation rate is know, the controller can be set to deliver the desired amount of water. Because distribution patterns and precipitation rates generally vary from zone to zone, run times should be set for <u>each</u> irrigation zone based on precipitation rates.

Most irrigation controllers are set with all zones receiving the same run time. This results in zones that need less water being over-watered.

- **Adjust irrigation controller for the season** – As summer temperatures increase, water use goes up; as cooler fall weather moves in, water use goes down. Unfortunately, most gardeners have their controllers set for the summer, and never adjust the controllers for the season. Most lawns and gardens are over-watered by 40% in the spring and fall. Iron chlorosis is a common symptom of springtime over-watering. Several methods can be used for irrigation scheduling. For details, refer to CMG GardenNotes #265, *Methods to Schedule Home Lawn Irrigation.*

- **Water bluegrass at 80% ET** – When water is available, Kentucky bluegrass uses significantly more water than what it actually needs to remain green. Bluegrass also slows its water use and growth rate as soil moisture decreases. Watered at 80% ET, a home bluegrass lawn will remain thick and green. Watered at 60% ET, a home bluegrass lawn will remain green, but not as thick.

- **Summer-dormant Kentucky bluegrass** – Where appropriate for the use of the site, summer-dormant Kentucky bluegrass has a very low seasonal water use. It requires only 14 inches of rain and irrigation per year (applied in the spring and fall). For additional details, refer to *CMG GardenNotes #412*, Water-Wise Landscape Design: Selecting Turf Options.

- **Turn off sprinklers in rainy weather** – Manually shutting off the sprinkler system during rainy weather is another effective management tool. An inexpensive investment (around $25) to help manage the irrigation system is a rain shut-off sensor. In many parts of the country, but not Colorado at this time, local ordinances require rain shut-off sensors.

- **Soak and cycle** – On slopes and on compacted or clayey soils water can be applied much faster than it can infiltrate into the soil, leading to surface run-off. To deal with this, use multiple short-run cycles that allow the water to soak in between cycles. Most controllers readily accommodate this with multiple start times.

  On clayey soil with pop-up spray heads, apply about quarter-inch per cycle (about eight to ten minutes) with two or three cycles to apply one-half-inch to three-quarters-inch of water per irrigation. Runs are typically spaced an hour apart or, more commonly, after all the zones have run it cycles again.

- **Dry spots** – The common approach for managing dry spots is to increase the amount of water applied. Although it may green up the dry spots, it also over-waters the rest of the lawn, wasting water.

  To evaluate a dry spot, first place some identical, straight-sided, flat bottomed cans (like soup or vegetable cans) out to measure the water applied. Compare the amount of water received in the dry spot to the amount of water received in green areas. If the dry spot receives significantly less water, it is a water delivery problem (like a malfunctioning head or design problem). If similar amounts of water are being received, the problem is soil/plant related (like compaction, thatch and root damage).

Note: as the gardener fine-tunes the management of his/her irrigation system, dry spots will show up in hot weather. This indicates that he/she is successfully walking the edge on ideal irrigation management.

- **Aeration** is a primary tool to increase water infiltration. Aeration may be useful spring and fall on lawns with a lot of traffic (children and dogs), compacted, clayey soils and slopes. Refer to lawn care information for details.

- **Water deeply and infrequently** to develop a deep root system that gives the plants more resilience in hot, dry weather.

- **Water at night or early morning hours –** To reduce water loss from evaporation, water between 9:00 in the evening and 9:00 in the morning. In many areas, wind drift is less in the early morning hours. (Note: Some cities experience peak water use from 4 to 6 in the morning as automatic sprinkler systems come on. To help the community avoid spikes in water demand, remember the suggested watering window is 9 in the evening to 9 in the morning, not just 4 to 6.)

## Additional Information – *CMG GardenNotes* on Irrigation Management

#260 Irrigation Management: References and Review Questions
#261 Colorado's Water Situation
#262 Water Movement Through the Landscape
#263 Understanding Irrigation Management Factors
#264 Irrigation Equipment
#265 Methods to Schedule Home Lawn Irrigation
#266 Converting Inches to Minutes
#267 Watering Efficiently
#268 Home Lawn Irrigation Check-Up

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Author: David Whiting, Colorado State University Extension (retired).
Artwork by David Whiting; used by permission.
Revision: Kurt M. Jones, Chaffee County Extension Director (9/2017).



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*CMG GardenNotes #268*

# Irrigation Management Worksheet:
# Lawn In-Ground Sprinkler System Check-UP

Name: ___________________

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This activity is a check-up on an in-ground lawn sprinkler system. If you don't have access to an in-ground sprinkler system for the activity, please contact the instructor for an alternative activity.

To complete the irrigation check-up, you will need the following items:

- 6, identical straight-sided, flat bottom cans or cups (do not use tuna or other short cans)
- Watch
- Ruler
- Colored flags or other marking tools (screwdrivers or sticks) to mark sprinkler heads by zone (helpful)
- Calculator
- Screwdriver and/or soil probe

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## Why do an irrigation check-up

**For most residents, attention to irrigation efficiency has the greatest potential for water conservation of all the principles of water wise landscaping.** In the typical home yard, extra attention to irrigation system design, maintenance, and management will reduce water use by 20% to 70%; 40% being average.

The purpose of a lawn irrigation check-up is a systematic evaluation of the irrigation system design, maintenance, and management. It will identify areas where adjustments will make a minor or major impact on water conservation and lawn quality. Run times for each sprinkler zone will be calculated based on the precipitation rate of each zone.

The check-up is only a tool to help the gardener identify where the system is working adequately and where adjustments need to be made. Actual water conservation comes as findings are incorporated.

**Note: Carry out a normal watering the day before doing the check-up.**

## Step 1 – Visually evaluate the lawn

### 1. How does the lawn look?

- ☐ Green (high input lawn)
- ☐ Green (moderate input lawn)
- ☐ Green (low input lawn)
- ☐ Dry spots: _____% of lawn
- ☐ Dry/Dormant

- ☐ Thick
- ☐ Thin

- ☐ Weed free
- ☐ Few weeds
- ☐ Weedy

### 2. Soil conditions

1. Stick a screwdriver in the ground to get a sense about soil compaction. The ease or difficulty at which the screwdriver can be pushed into a <u>moist</u> soil gives a grasp of soil compaction.

2. If possible, use a soil probe to get a sense on soil texture, compaction, soil layers, rooting depth, and thatch layer. Note: On compacted or rocky soil, it may impossible to push a soil probe into the soil. On extremely compacted soils, it may even be impossible to push a screwdriver into the soil.

- Soil compaction
  - ☐ Little to no compaction (screwdriver/probe readily goes in)
  - ☐ Moderate compaction (screwdriver/probe hard to push in)
  - ☐ Severe compaction (screwdriver/probe extremely difficult to impossible to push in)
  - ☐ Aeration needed to increase infiltration

- Soil texture
  - ☐ Coarse texture (sandy)
  - ☐ Moderate texture (loamy)
  - ☐ Fine texture (clayey)

- Soil profile
  - ☐ Changes in soil texture evident
  - ☐ Hardpan layer
  - ☐ Evidence of drainage problems (such as surface pooling)

- Thatch layer
  - ☐ Less than 1/2 inch
  - ☐ Greater than 1/2 inch
    - ☐ Aeration needed to manage thatch

- Runoff potential
  - ☐ Low potential
  - ☐ High potential (use cycle and soak application)
    - ☐ Due to slope
    - ☐ Due to soil conditions (compaction and clayey soils)
    - ☐ Due to heavy thatch

3. **Current irrigation pattern**

- During the summer (July/August) the lawn is typically watered ____________________ (days) for ____minutes

- During the typical July/August weather, the lawn can go ____ days between irrigation before getting dry.

    - Multiply the number of days (maximum) between summer irrigations by 0.20 to estimate the water holding capacity for the soil and rooting depth at this site. This is the maximum amount of water to apply per irrigation.

    - **___ days x 0.20 inches = _____ inches per irrigation (maximum)**

4. **Notes**

## Step 2 – Current Controller Settings

Record current settings from the controller including watering days, start time(s) and run times. Note Precipitation rates and inches applied may be calculated later. This will be used to document water saving potential from the check-up.

Controller is set for ___________________ (month).

| **Table: Step 4 – Current Setting and Inches Applied** | | | | | | |
|---|---|---|---|---|---|---|
| **Zone** | **Zone Identity** | **Watering day(s)** | **Start time(s)** | **Run time** | **Precipitation Rate** | **Inches Applied** |
| **1** | | | | | | |
| **2** | | | | | | |
| **3** | | | | | | |
| **4** | | | | | | |
| **5** | | | | | | |
| **6** | | | | | | |

# Step 3 – Identify and Evaluate Irrigation Zones

A. Identify the location of each sprinkler head in each zone (a group of sprinkler heads that come on at the same time). Using difference colors of landscape flags or other marking devices (like screwdriver or stick pushed in the ground near each head) is helpful. Sprinklers may need to be turned on to find and identify sprinkler heads by zone.

B. Evaluate the following hydrozone layouts

| **Step 3. Irrigation Zones** | OK – Concept incorporated | Minor – Benefits received with minor adjustments or implementation | Major – Benefits received with major adjustments or implementation | Not applicable to site |
|---|---|---|---|---|
| **Irrigation Zones** | | | | |
| 1. Lawn zones separate from flower and shrub bed zones | | | | |
| 2. Lawn areas zoned by irrigation demand (i.e., high input, moderate input, and low input areas on separate irrigation zones) | | | | |
| 3. Zone by exposure (i.e., extreme exposures, full sun, partial shade, full shade, and slopes on separate irrigation zones) | | | | |
| 4. Drip or bubblers used in flowerbeds, shrub beds, small fruits, and vegetable gardens | | | | |
| 5. Design avoids sprinkler irritation on small, irregular shaped areas (generally areas less than 10 feet wide) | | | | |

C. If design does not meet this criteria, consider upgrading the irrigation system.

D. Notes:

## Step 4 – Evaluate sprinkler performance

Turn on sprinklers and evaluate sprinkler performance as outlined below, repeating steps for each zone.

### A. Design criteria for even water distribution

1. **Head to head coverage** – Does the water from each head reach neighboring heads? [*The Science of Gardening*, page 620]

| Table 4a1 – Head to Head Coverage | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| NO = adjustments needed* | | | | | | |

* In some situations adjusting heads or changing nozzles may correct the problem. In other situations, the system design may need to be up-graded for water conservation.

2. **Lined-out –** Are sprinkler heads "lined-out" along the edge of non-irrigated areas (watering form the outside in)? [*The Science of Gardening*, page 620]

| Table 4a2 – Lined-out | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| NO = upgrade needed* | | | | | | |

* If no, consider upgrading the sprinkler system for improved water conservation.

3. **Head layout –** Are sprinkler heads arranged in triangle and square patterns, avoiding pentagon patterns? [*The Science of Gardening*, page 621]

| Table 4a3 – Head Layout | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| NO = upgrade needed* | | | | | | |

* If no, consider upgrading the sprinkler system for improved water conservation.

4. **Zone uniformity** – Are all head in a zone the same brand and type?

| **Table 4a4 – Zone Uniformity** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| NO = adjustments needed* | | | | | | |

* In some situations, replacing heads may correct the problem. In other situations, the system design may need to be up-graded for water conservation.

5. **Pressure –** Is there a mist cloud around sprinkler heads? [The Science of Gardening, page 621]

| **Table 4a5 – Pressure / Mist Cloud** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| NO = adjustments needed* | | | | | | |

* A mist cloud indicates excessive pressure. Lower pressure to conserve water. In some situations, this may involve installation of an in-line pressure regulator.

6. **Notes/Comments**

## B. Maintenance criteria for even water distribution

1. **Delivery arc –** For each head does the delivery angle need adjustments (to avoid spraying the sidewalk, driveway, or other areas outside the zone)? [*The Science of Gardening*, page 621]

| **Table 4b1 – Delivery Arc** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| No = OK | | | | | | |
| Yes = adjustments needed | | | | | | |
| Identify heads needing adjustments | | | | | | |

2. **Vertical adjustment** – Do heads need adjustment to vertical (straight up and down)? [*The Science of Gardening*, page 622]

| **Table 4b2 – Vertical adjustment** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| No = OK | | | | | | |
| Yes = adjustments needed* | | | | | | |
| Identify heads needing adjustments | | | | | | |

* Heads off vertical will distort the delivery pattern. Adjust to vertical to conserve water.

3. **Height** – Is nozzle releasing water above grass height? [*The Science of Gardening*, page 622]

| **Table 4b3 – Height** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| No = adjustments needed* | | | | | | |
| Identify heads needing adjustments | | | | | | |

* When water doesn't clear grass height, distribution pattern may be distorted. Raise head.

4. **Worn Nozzles**– Look at the fan created by the water spray for each head. Is it uniform around the arc? This is rather difficult to evaluate by line of sight. [*The Science of Gardening*, page 622]

| **Table 4b4 – Worn Nozzles** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Yes = OK | | | | | | |
| No = adjustments needed* | | | | | | |
| Identify heads needing adjustments | | | | | | |

* Replace worn nozzles to improve distribution pattern.

5. **Replace leaky valves –** In the irrigation valve, the rubber diaphragm that actually turns water on and off ages over time. Valves that do not shut-off completely need the diaphragm or entire valve replaced. [*The Science of Gardening*, page 622]

| **Table 4b5 – Leaky Valves** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| Valve not leaking = OK | | | | | | |
| Valve leaking = needing replacement | | | | | | |

6. **Evaluate dry spots** – If the zone has a dry spot, place some cans on the dry spot and on the green areas. After running the sprinkler for their normal time, compare the amount of water received in each can. [*The Science of Gardening*, page 622]

| **Table 4b6 – Evaluate Dry Spot** | | | | | | |
|---|---|---|---|---|---|---|
| Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| No dry spots | | | | | | |
| Dry spot(s) receiving less water than the green areas[1] | | | | | | |
| Dry spot(s) receiving similar amounts of water as green areas[2] | | | | | | |

[1] When the amount of water received in dry area cans is significantly less than the green area cans, poor water distribution is a primary contributor. Evaluate irrigation design and maintenance issue.
[2] When the amount of water received in both the green area cans and dry area cans is similar, the problem is not directly related to sprinkler performance. Evaluate other growth factors, including soil compaction, thatch, run-off, insect or disease problems, etc.

**<u>Adjusts identified in step 4 need to be performed before continuing to step 5.</u>**

## Step 5 – Perform precipitation rate (catch can) test

Perform a precipitation rate test (catch can test) for <u>each</u> zone, recording the precipitation rates in **Run Time Table.** [*The Science of Gardening*, page 631]

### <u>Precipitation Rate (Catch Can Test)</u>

To do the calculations you will need 6 identical, straight-sided, flat bottom, cans or coffee mugs such as soup cans, fruit or vegetable cans, or coffee cans. (Do not use short cans like tuna cans as they are too shallow and water may splash out.) You will need a ruler, a watch, and paper/pen to record your findings.

**Steps**

a. Place 6 identical, straight-sided, flat bottom cans or coffee mugs randomly around the area between sprinkler heads in the zone.
b. Turn on the sprinklers for exactly 10 minutes.
c. Pour all the water into one can.
d. With a ruler, measure the depth of the water in the can. This is your precipitation rate in inches per hour.
e. Write down the rate for each zone in **Table: Step 8**
f. Repeat steps 1-5 for each irrigation zone.

Note: if the amount of water in some containers is significantly more or less than others, it indicates that the system is poorly designed or head(s) are malfunctioning.

| **Table 5 – Precipitation Rate** | | | | | | |
|---|---|---|---|---|---|---|
| 1. Zone | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. Precipitation Rate (inches/hour) | | | | | | |

# Step 6 – Calculate system run times for each zone

## A. Working down through the table, calculate the run time per irrigation.

| **Table 6a – Run Times** | | | | | | |
|---|---|---|---|---|---|---|
| **Zone** | **1** | **2** | **3** | **4** | **5** | **6** |
| **1. Historical Summer ET** amount of water to apply | 1.5"/week | | | | | |
| **2. Precipitation Rate – inches/hour** from catch can test, Table 5, Row 2 | | | | | | |
| **3. Run time per week (July/August)** Based on Precipitation Rate for the zone (line 3), look this up from Table 50-2 (page 612) or Table 52-1 (page 632). | | | | | | |
| **4. Number of irrigations/week** Refer to Step 1-3 above | | | | | | |
| **5. Run time per irrigation** Convert the ***Run Time per Week*** (line 4) to ***Run Time per Irrigation*** using table 50-3 (page 612) or Table 52-2 (page 633) | | | | | | |

## B. Adding Cycle and Soak

Most clayey and/or compacted soils cannot absorb water as quickly as sprinklers apply it. Many clayey soils, typical of the Front Range, absorb about ¼ inch of water per hour. Therefore, the most effective watering schedule on these soils would be to set each zone to deliver no more than ¼ inch per cycle with multiple cycles. For example, if the lawn is to have ½ inch of water, set controller to apply ¼ inch and cycle back an hour later to apply the second ¼ inch. If the lawn was to have ¾ inch, set the controller to apply ¼ inch per cycle with 3 cycles.

Soak and cycle is particularly helpful on slopes to avoid wasteful surface runoff.

Use Table 50-4 (page 613) or Table 52-3 (page 633) to determine if Cycle and Soak is desired.

| **Table 6b – Cycle and Soak** | | | | | | |
|---|---|---|---|---|---|---|
| **Zone** | **1** | **2** | **3** | **4** | **5** | **6** |
| **1. Need for *Cycle and Soak*?** Yes/No | | | | | | |
| **2. Run Time Per Irrigation** from Table 6a, Line 65 | | | | | | |
| **3. Number of cycles** from Table 50-4 (page 613) or Table 52-3 (page 633) | | | | | | |
| **4. Run Time Per Cycle** Divide ***Run Time per Irrigation*** (line 2) by ***Number of Cycles*** (line 3) | | | | | | |

# Step 7 – Start time(s)

### a. Determine the first start time

Most communities suggest nighttime irrigation, between 9 p.m. and 9 a.m. Winds are typically less in the early morning, and evaporation loss will be lower. However, many communities experience peak water use from 4 to 6 a.m. as many sprinklers come on, so remember that the irrigation window is 9 to 9, not just 4 in the morning.

Enter your first start time into Table **7–Start Time(s), row 1**

### b. Adding additional start times for Cycle and Soak (if needed)

1. Add all the Run Time per CYCLE together.
2. **Cycle Time** – Round this up to the next ¼ or ½ hour (depending on what start time intervals are used in your controller start options). This is the time to run through all the zones. Add this to **Table 7-Start Time(s), Rows 2 and 4** below. Or add 1 hour if the total run time is less than 60 minutes.
3. Add this to the first start time for the second start time. Record your second start time in **Table 7-Start Times) Row 3, Start Time 2**.
4. Likewise, if a third cycle is needed, add this to the second start time to get the third start time. Record this in **Table 7-Start Times) Row 5, Start Time 2**.

| **Table 7 – Start Time(s)** | |
|---|---|
| **1. Start time 1** | |
| 2. Total cycle time | |
| **3. Start time 2** (if needed) [add line 1 to line 2] | |
| 4. Total cycle time | |
| **5. Start time 3** (if needed) [add line 3 to line 4] | |

## Step 8. Set the Controller for July/August Run Time

1. Set the run times for each zone as listed in **Table 6a, line 6** if Cycle and Soak is not used, or **Table 6b, line 4** if Cycle and Soak is used.

2. Set the start time(s) as given in Table 7-Start Time(s)

## Step 9. Seasonal Adjustment

A simple way to adjust for the season is to use the *Percent Key* found on most controllers.

- For Late April and early October, set the percentage to 50%
- For May/June and September, set the percentage to 67%

An alternative method is to repeat Step 6 to 8 for the spring/fall season.

## Step 10. Fine-Tune to Match Site Specific Needs

These textbook figures are a good start point in irrigation management. However, any scheduling method will need fine-tuning to match the actual water need of the site based on the exposure, wind, heat, and shade. This is done by careful observation of the lawn.

- **When adjusting all zones**, the *Percent Key* on most controllers makes an easy method to fine-tune for the actual site by adjusting the percentage up/down in 10% increments, as needed. It can also be done by adjusting the run time of each zone up/down in 10% increments, as needed.

- **When adjusting a single zone**, adjust the run time for that zone up/down in 10% increments, as needed.

In the typical summer weather, if the lawn starts to become dry between irrigations, increase the run time in 10% increments, as needed. By experience, it is easy to fine-tune each irrigation zone. In multiple days of unseasonably hot weather, dry spots should begin to pop up if the controller if precisely fine-tuned. In unseasonably hot weather, if dry spots do not pop up, the lawn is being overwatered. Cut back the time in 10% increments, as needed to fine-tune each zone.

The following guidelines may help you understand some needs for adjustments:

- In full shade (not under a large tree), water use (ET) could be 30% less.
- In hot and/or windy sites, water use (ET) could be 20% to over 50% higher.
- In the rooting area of large shade trees, water use (ET) could be 30% to 50% higher.

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