MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #260-268

Irrigation Management

Cross Section of Irrigated Root Vegetable Raised Bed

This Irrigation Management curriculum was developed by David Whiting, CSU Extension, retired; Carl Wilson, CSU Extension, retired; and Catherine Moravec, former CSU Extension employee. Cover art by Melissa Schreiner. Used with permission.

Updated 2023

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CMG GardenNotes #260

Irrigation Management

References and Review Material

Reading/Reference Materials

CSU GardenNotes

- https://cmg.extension.colostate.edu/volunteer-information/cmg-gardennotes-class-handouts/.
- #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, *Irrigation Management Worksheet: Lawn In-Ground Sprinkler System Checkup*.

CSU Extension Fact Sheets

- https://extension.colostate.edu/topic-areas/yard-garden/.
- #4.702, *Drip Irrigation for Home Gardens*.
- #4.714, *Home Sprinkler Systems: Backflow Prevention Devices*.
- #4.722, *Irrigation: Inspecting and Correcting Turf Irrigation System Problems*.
- #6.702, *Graywater Reuse and Rainwater Harvesting*.
- #7.199, *Watering Established Lawns*.
- #7.239, *Home Sprinkler Systems: Operating and Maintaining*.
- #9.952, *Water Conservation In and Around the Home*.

Plant*talk* Colorado™

- https://planttalk.colostate.edu/.
- #1621, *Watering Colorado Soils*.
- #1903, *Xeriscape-Efficient Irrigation*.
- #2201, *Automatic Sprinkler System Overview*.

Other

- Denver Water: www.denverwater.org.
- Northern Colorado Water Conservancy District: www.ncwcd.org.

Learning Objectives

At the end of this unit, the student will be able to:
- Describe issues around the current water situation in Colorado and the western United States.
- 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.

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?
10. What factors influence ET rates?

Understanding Irrigation Management

11. Describe how these factors influence irrigation management:
    - Location of soil moisture.
    - Type of soil.
    - Water holding capacity.
    - ET.
    - Rooting depth.
12. How does improving a sandy soil with organic matter influence irrigation management? How does improving a clayey soil with organic matter influence irrigation management?
13. Define *water holding capacity*, *saturation*, *field capacity*, *permanent wilting point*, and available *water*.
14. Compare the historical ET for a lawn in spring, summer, and fall.
15. 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.
16. Describe the textbook amount of water to apply if a lawn requires water every two, three, four, or five days in the typical summer.
17. Describe how these factors influence irrigation management:
    - Exposure.
    - Previous irrigation pattern.
    - Stage of growth.
18. Give examples of mechanisms that plants use to tolerate/escape drought.

Irrigation Equipment

19. 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.
    - Winter drainage.
20. Describe the advantages and limitations of pop- up spray heads and rotor heads.
21. Describe the strengths and weaknesses of an in- ground sprinkler system.
22. 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.
23. Describe a drip system made with soaker hose or soaker tubing.
24. Describe the strengths and weaknesses of drip irrigation.
25. Describe the strengths and weaknesses of hose-end, hand watering.

Methods to Schedule Irrigation

26. Describe irrigation scheduling by the Type of Sprinkler Method.
27. Describe irrigation by the Precipitation Rate Method. Explain how to do a Precipitation Rate (Catch Can) Test.
28. What is the purpose of cycle and soak? Explain how to add cycle and soak to an irrigation scheduling method.
29. What is an ET controller? What is a soil moisture sensor?
30. Explain how to fine-tune an irrigation schedule.

Watering Efficiently

31. Of the seven principles of water wise gardening, why does watering efficiently have the greatest potential for water conservation in the typical home landscape?
32. With attention to irrigation design, maintenance, and management, what are the potential water savings for a typical home landscape?
33. List factors to consider with irrigation zones.
34. Describe design criteria for uniform water distribution.
35. Describe maintenance techniques for water wise irrigation management.
36. Describe management techniques for water wise irrigation management.

Irrigation Checkup

37. What is the purpose of an irrigation checkup?

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 their 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, then 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 overly 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 Platte, 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.

> ***Non-potable 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. ***Graywater*** 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 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 non-potable water or raw water. In some western communities, homes have a waterline for drinking water and a second, non-potable 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.

Rainwater and Graywater

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 two rain barrels cannot exceed 110 gallons. Rain barrels can only be used to capture rainwater from rooftop downspouts. The captured rainwater must be used on the same property from which the rainwater was captured, only for outdoor purposes, including watering 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 use 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 Sheets #6.702, *Graywater Reuse and Rainwater Harvesting*, and #6.707, *Rainwater Collection in Colorado*, available on the CSU web site at https://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	86.7%
Municipal	6.7%
Recreation and Fisheries	5.5%
Large Industrial	1.1%

Citizen's Guide to Colorado Water Conservation, second edition, copyright 2016.

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 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 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 ten to fifteen days per year when water use greatly exceeds average use. Because peak demand 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). Schedules are designed to spread the water demand more evenly over the week. 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

- #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, *Irrigation Management Worksheet: Lawn In-Ground Check-Up.*

Other Resources to Examine

Water Education Colorado has publications available at https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/.

- Citizen's Guide to Colorado's Interstate Water Compacts, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorados-interstate-compacts/.
- Citizen's Guide to Colorado Water Law, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorado-water-law/.
- Citizen's Guide to Colorado Groundwater, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorado-groundwater/.
- Citizen's Guide to Colorado Water Quality Protection, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorado-water-quality-protection/.
- Citizen's Guide to Where Your Water Comes From, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-where-your-water-comes-from/.
- Citizen's Guide to Colorado's Transbasin Diversions, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorados-transbasin-diversions/.
- Citizen's Guide to Colorado's Water Heritage, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorado-water-heritage/.
- Citizen's Guide to Colorado Water Conservation, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorado-water-conservation/.
- Citizen's Guide to Colorado's Environmental Era, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-colorados-environmental-era/.
- Citizen's Guide to Denver Basin Groundwater, https://www.watereducationcolorado.org/publications-and-radio/citizen-guides/citizens-guide-to-denver-basin-groundwater/.

Authors: David Whiting, CSU Extension, retired. Revised September 2017 and reviewed August 2022 by Kurt M. Jones, CSU Extension.

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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 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 four inches per hour, but a clayey soil may take in only half an inch of water per hour –

that is eight 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 in water film 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, so it 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 insect and disease problems and abiotic stress factors.

Some soils store more water than others. The amount of water held in the soil and available to plants 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 **transpires** out of the leaf's 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 <u>rate of water loss</u>, such as ¼ inch per day. In this example, an ET of ¼ inch per day means that a ¼ 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 bright sunshine, high wind, high temperature, and/or low humidity.

Summary

Water entries and exits are summarized in **Figure 1**. To maximize plant health in the 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.

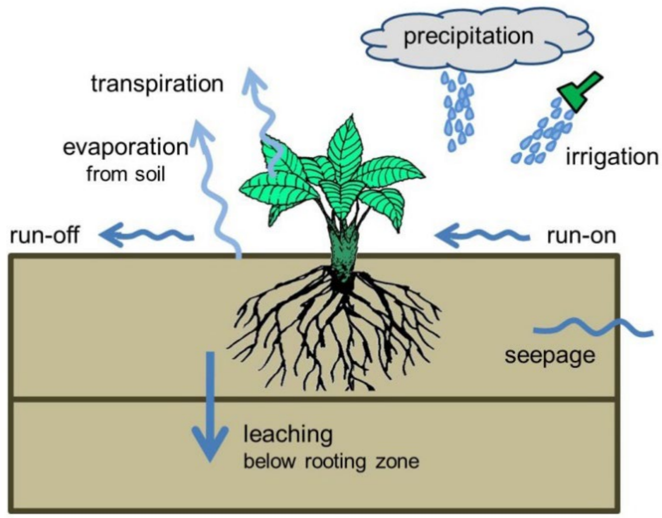

Figure 1.
Typical water entries and exits in the soil-plant-water system.

Authors: Catherine Moravec, former CSU Extension employee and David Whiting, CSU Extension, retired. Artwork by David Whiting. Used with permission. Revised September 2017 by Kurt M. Jones, CSU Extension. Reviewed October 2022 by Marvin Reynolds, CSU Extension.

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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 rot, and water pollution. On a community-wide basis, landscape irrigation typically uses twice the amount of water that the plants require, **adding unnecessary demand to a limited and valuable natural resource, water.**

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 used 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.

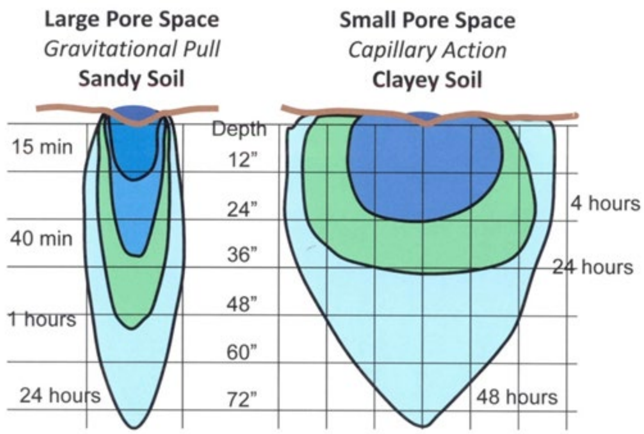
Irrigation management is applying the correct amount of water at the correct frequency to supply the water needs of the plants. Additional water would be wasted as it would leach below the rooting zone.

Type of Soil

Soil texture, structure, and organic matter content determine the soil's water-holding capacity and water movement in 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 pore space, water moves slowly in all directions by **capillary action**. **Figure 1** illustrates water movement in a sandy soil with large pore space and clayey soil with small pore space.

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



Sandy Soil

Large pore space dominates 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 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 shallower rooting.

With higher water-holding capacity but limited drainage, clayey soils need heavier, but less frequent irrigations than sandy soils. Watering <u>too often</u> 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: Texture, Structure, and Pore Space*.

Water Holding Capacity

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

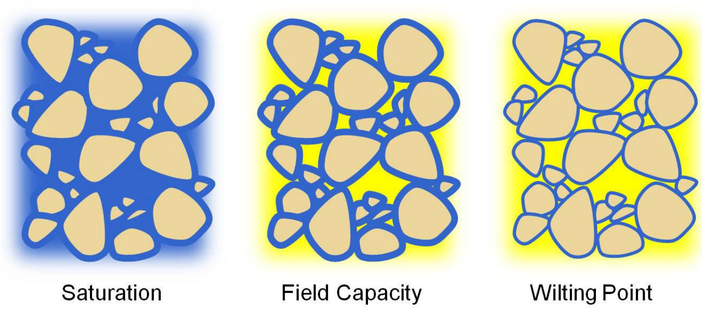


Figure 2.
At ***saturation*** water fills the pore spaces. At ***field capacity*** air occupies the large pore spaces while water fills the small pore spaces. At the ***wilting point***, plants cannot extract additional water from the soil.

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).

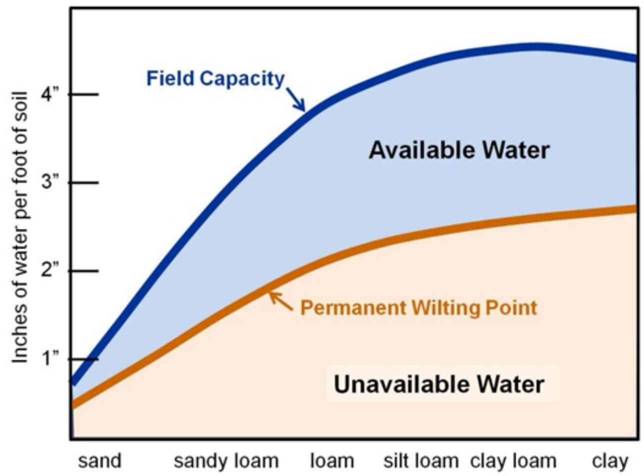
Prolonged periods without root oxygen will cause most plants to wilt (due to a lack of water uptake), to show general symptoms of stress, to decline (due to a lack of root function) and to die (due to root dieback). During summer flooding of the Mississippi River in Iowa and Illinois it was observed that healthy trees were 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 **Figure 3**, 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.
Relationship between soil texture and available water.



Evapotranspiration, ET

Evapotranspiration, ET, is the rate at which a plant 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.
Weekly Water Requirements 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

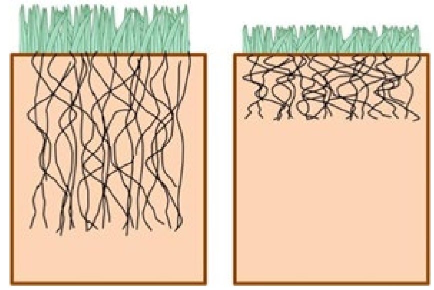
Irrigation management should consider the rooting depth, adding water to the actual root area. Root systems may be contained or spreading. Annual plants tend to have contained root systems, whereas woody trees and shrubs have more wide-reaching roots.

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 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 time 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 **Inches of water to apply per irrigation** (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 **Inches of water to apply per irrigation** (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 **Inches of water to apply per irrigation** (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

These textbook figures are a good starting point to understand irrigation management. When coupled with careful observations, a gardener can quickly fine-tune their 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:

- **If the lawn will go five days on one-inch of water**, and additional water will not extend the interval between required irrigations, the water-holding capacity (for this soil and rooting depth) is one inch. One inch would be the maximum amount of water to apply per irrigation, as additional amounts would leach below the rooting zone. The ideal irrigation would be one inch of water every five days.
- **If the lawn will go four days on 0.80 inch of water**, and additional water will not extend the interval between required irrigations, the water-holding capacity (for this soil and rooting depth) is 0.80 inch. This would be the maximum amount of water to apply per irrigation, as additional amounts would leach below the rooting zone. The ideal irrigation would be 0.8 inches of water every four days.
- **If the lawn will go two days on 0.40 inch of water**, and additional water will not extend the interval between required irrigations, the water-holding capacity (for this soil and rooting depth) is 0.40 inch. This would be the maximum amount of water to apply per irrigation, as additional amounts would leach below the rooting zone. Irrigation options include the following: The ideal irrigation would be 0.4 inches of water every two days.

These textbook figures do not consider exposure, wind, or irrigation system efficiency. They make a good starting 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 example, in one 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.

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% increments to fine-tune the irrigation.**

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

Other Factors Influencing Irrigation Management

Other factors also have a direct influence on the actual water-holding capacity and irrigation demand:

- **Exposure** – The plant's exposure 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 for 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 during the season and peaks during flowering and fruit development.
  - Compared to the rooting system of a mature plant, newly planted or seeded crops do not 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 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 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 consider life-cycle stages.
- **Water demand of a plant** – Plants vary 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:
  - 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 cannot go dormant.

Tools to Evaluate Soil Moisture

Gardeners have several 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 sixty 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 Materials.*
- #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, *Irrigation Management Worksheet: Lawn In-Ground Sprinkler System Checkup.*

Authors: David Whiting, CSU Extension, retired; with Carl Wilson, CSU Extension, retired. Artwork by David Whiting. Used with permission. Revised September 2017 by Kurt M. Jones, CSU Extension. Reviewed Augst 2023 by Chris Hilgert, CSU Extension.

Reviewed Augst 2023

MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

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

Variations of plantings in the personal garden landscape require diverse types of irrigation equipment. 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. All 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, usually in the basement of the typical house. The size of the pipe and water pressure determines water flow and thus influences the design of the system (how many heads can run at one time). [**Figure 1**]

Pressure Regulator – 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 and shut-off valve for outdoor line and drain valve that drains the outdoor line to the backflow prevention device (located just outside the house).

Backflow Prevention Device – 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 built into the valve. The type to use depends on local building codes. [**Figure 2**]

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

Main Supply Line – The main supply line is the line holding water under pressure throughout the summer. It splits in the valve box, providing 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 fittings are connected with special glue. Copper pipefittings are soldered. [**Figure 3**]

Figure 3.
Valve box with two zone valves.

Secondary Lines – 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.

Controller – 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.
Many brands of controllers offer a variety of features.

End of Season

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.

Pop-Up Spray Heads

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, up to fifteen feet.

Delivery Pattern – Pop-ups spray heads are best suited for small to moderate sized home lawn areas (larger than seven to ten feet wide up to thirty to forty-five feet wide) and irregular or curvilinear areas.

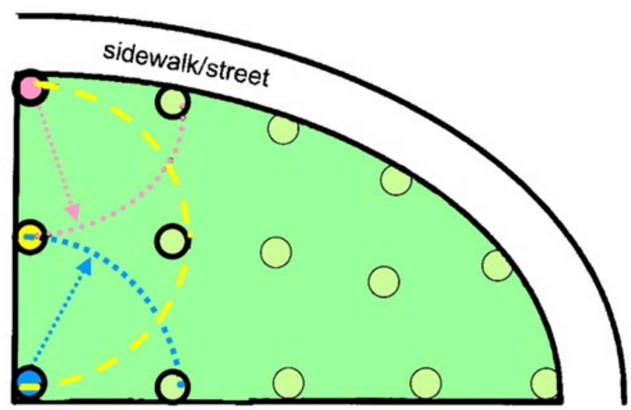
Pop-up spray nozzles are most common with fifteen-, twelve-, ten-, and eight-foot ranges. The radius can usually be adjusted down about 30%, using the nozzle's adjustment screw. Therefore, a commonly available ten-foot nozzle can be adjusted down to seven feet. Any greater adjustment would significantly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

The spray pattern of a pop-up spray head depends on the nozzle's ability 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 manage 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 four inch pop-up style most popular. High pop-up heads, with a twelve 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 increases 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 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 ½ inch of water in just twenty 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 eighteen-to-twenty-four-foot radius and greater. Some rotor-type heads in the commercial line have a radius of thirty to ninety 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, <u>do not mix quarter, half, and full circle patterns in the same zone</u>. 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 sixty 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 personal 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 thirty 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.
- Saving Time.
- Ability to irrigate small areas.
- Efficient if well-designed, maintained, and managed according to plant water needs.

Weaknesses of in-ground sprinklers include the following:

- Inefficient if poorly designed, maintained, or managed.
- Being too convenient, gardeners give them little attention, which can cause significant water waste.

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%.

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

Drip emitters, micro-sprayers, and drip lines require clean water, which is 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), usually with 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**]

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.

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

Figure 10. Drip emitter on ½" poly tubing.

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.

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 Gardens.*

Drip Emitters deliver water at a slow, consistent rate, such as one-half gallon, one gallon, or two gallons per hour. 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**]

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, twelve, or twenty-four-inch intervals. The twelve-inch spacing is readily available in the home garden trade. These are great for snaking through a bed area. For sandy soils, the spacing of the tubing should be at twelve inches. For clayey soils, spacing may be at eighteen to twenty-four inches for perennial beds.

Micro-Sprayers often held up on a spike, covering a radius of two to thirteen 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.

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 twelve inches. For flower and shrubs beds on clayey soil, space runs at eighteen to twenty-four 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 ten to twenty minutes.

Quarter-inch Soaker Tubing – Quarter-inch soaker tubing is available 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 9**] 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 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 see **Figure 11**. To adequately water the garden with this type of regulator, the drip line runs ten to twenty minutes. Without a pressure regulator of some type, the soaker hose tends to rupture, sending out streams of water at spots rather than dripping along the line.

Figure 11.
Tap, pressure regulator, hose connection, and half-inch drip hose in a raised bed garden.

This half-inch hose style is more tolerant of tiny 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 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 savings.
- 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:
- Requires good-quality water and filtration.
- Difficulty seeing if systems are operating.
- Water delivery to individual plants needs to be checked.
- For large areas, the cost will be significantly higher than a sprinkler system.
- Unsuitable for watering large trees.

Subsurface Drip

Subsurface drip is a recent 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 and Weaknesses of Subsurface Drip

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.
- Unable to see if it is operating correctly.
- Needs to be dug up if not operating properly to correct issue(s).
- Unable to insert stakes in the ground.
- Requires professional installation.
- Relatively high cost.
- Evolving technology has not stood the test of time yet.

Hose-End and Hand Watering

Hose-end watering devices include several 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 inefficient in uniformity of water delivery, resulting in high water use. However, significant water savings *may* occur if gardeners do not water until the lawn/garden show signs of being dry.

A frequent 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**]

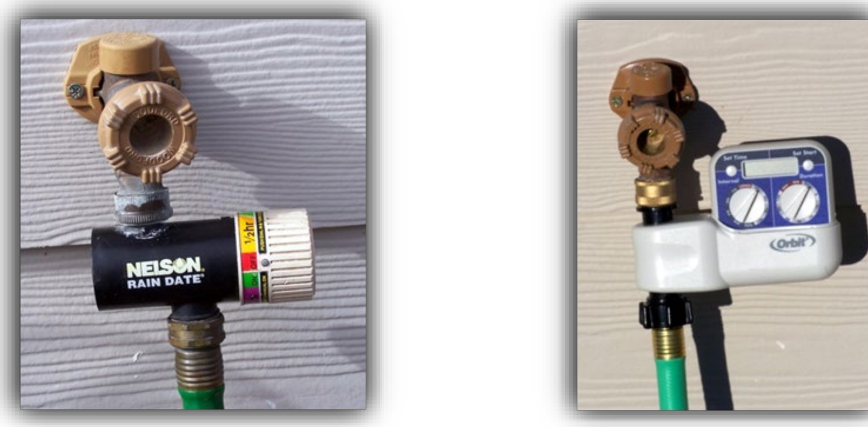


Figure 12. Single-zone controllers connect to the hose line.
Left: This style is manually turned on and automatically turns off after a set number of minutes.
Right: This battery powered controller turns water on and off at the day and time intervals set by the gardener.

Strengths and Weaknesses of Hose-End and Hand Watering

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

- Relative low cost of equipment.
- Ability to water plants differently and is useful 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.
- Water can be wasted by allowing it to run too long.

Summary

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

CMG GardenNotes on Irrigation Management

- #260, *Irrigation Management: References and Study 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, *Irrigation Management Worksheet: Lawn In-Ground Sprinkler System Check-Up*

Authors: David Whiting, CSU Extension, retired and Carl Wilson, CSU Extension, retired. Artwork by David Whiting. Used with permission. Revised September 2017 by Kurt M. Jones, CSU Extension. Reviewed October 2022 by Brian Kailey, CSU Extension.

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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, considering 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 vastly 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.

This 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 actual water application rates for each zone.

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 (known as ***precipitation rate***). The actual precipitation rate is determined by the sprinkler type and brand, water pressure, and head spacing. It may be 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.

Precipitation Rate (Catch Can) Test

Step 1. Place six identical, straight-sided, flat-bottomed cans randomly around the area between sprinkler heads in the same 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 precipitation rate in inches per hour.** Write it down for future reference.
Step 5. Repeat steps 1 and 2 for each irrigation zone.
Step 6. Use **Tables 2** and **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.

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

Tables on next page.

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

	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”**
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 most 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 your catch can test information, 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 twenty-six 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 twenty-six 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, keep in mind that the 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. Emerging technology 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.

Emerging Technology Controller

The **emerging technology controller** is a relatively new piece of equipment that automatically adjusts the irrigation to the daily **ET** (**evapotranspiration**). Emerging technology 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 needs.

For additional information on emerging technology controllers and the use of ET in irrigation management, refer to the Northern Colorado Water Conservancy District website at https://www.northernwater.org (Efficient Water Use).

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.

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

When adjusting a single zone, adjust the run times for that zone up or 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 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.

Authors: David Whiting, CSU Extension, retired. Revised September 2017 by Kurt M. Jones, CSU Extension. Reviewed April 2023 by Marvin Reynolds, CSU Extension.

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CMG GardenNotes #266

Converting Inches to Minutes

Gardeners often wonder, how long should my sprinklers run in order to apply the right amount of water? The difficulty is that water is usually measured in inches while the irrigation controller (timer) works in minutes. The challenge is to convert minutes to inches so that sprinkler run times provide the correct amount of water that is applied to the lawn or garden. It's easy to make the conversion using the following process. First, calculate the precipitation rate for each irrigation zone, then convert inches to minutes using the formulas given in **Tables 1**, **2**, and **3**.

Calculate the Precipitation Rate

The following steps need to be done for each irrigation zone (or each location you placed the sprinkler(s) if you are manually attaching and dragging a hose). To do the calculations you will need six identical straight-sided flat bottom containers, such as soup cans, fruit or vegetable cans, or coffee mugs. (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 sod growers and local water providers give out small rain gauges with a ruler on the side for this measurement. You will need six of the same type.

Steps

1. Place six identical rain gauges, or straight-sided, flat-bottomed cans/mugs between sprinkler heads in the zone.
2. Turn on the sprinklers for exactly ten minutes.
3. Pour all the water into one rain gauge or container.
4. With a ruler, measure the depth of the water in the rain gauge or container. 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:

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

Example: You have done the above steps and calculated that this sprinkler zone has a precipitation rate of 1 ½ inches per hour. You desire to apply ½ inch of water.

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

You need to calculate this for each zone. A common mistake is assuming that all zones have the same water needs or that all zones run the same. In the typical yard, they do not!

Table 2. Sprinkler Run Timetable (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 ½ inches per hour and you want to apply ½ inch, it takes 20 minutes.

Table 3. Sprinkler Run Timetable (in Minutes) by 1/10th 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**
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 ½ inches per hour and you want to apply ½ inch, it takes 20 minutes.

Authors: David Whiting, CSU Extension, retired. Revised September 2017 by Kurt M. Jones, CSU Extension. Reviewed August 2023 by Chris Hilgert, CSU Extension.

Reviewed August 2023

MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #267

Watering Efficiently

Between 40% and 50% of annual domestic water use in Colorado (about 318 billion gallons a year) is used to water landscaping. According to Colorado Water Center, outdoor residential use in the state is nearly double outdoor park and commercial use—individual gardeners in the state, working together, can make a substantial difference in water supplies! According to the US EPA, as much as half of residential outdoor water is wasted through evaporation or runoff due to poor irrigation design, installation, operation, and maintenance.

Irrigation Zones Reflect Water Need

Irrigation zones are not always aligned with plant water needs. Irrigation zones may be installed poorly planned, or a landscape might change over time so that it no longer aligns with the originally intended watering patterns. A foundational step of irrigation efficiency is to be sure that the plants watered by any particular zone have similar water needs. For example, a lawn zone should water only lawn, not lawn plus flower beds, trees, or vegetable gardens, etc.

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

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

Drip irrigation: 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*, Understanding Irrigation Management Factors*.

Sprinkler Design Criteria for Uniform Water Distribution

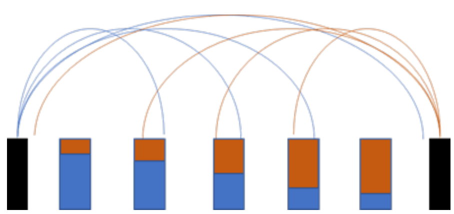
Unfortunately, in the design of many home and commercial sprinkler systems, little attention is given to design criteria for water conservation.

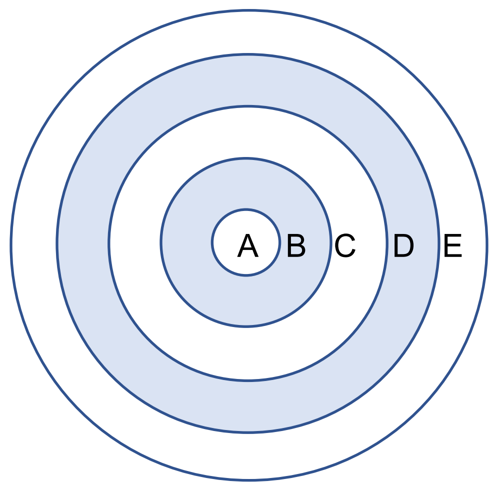
Sprinklers do not deliver a uniform quantity of water over their distribution area; areas close to the irrigation head receive more precipitation than those farther away. If irrigation systems are not designed to account for this unevenness, land managers are likely to overwater much of the lawn in order to keep the drier spots green. 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 achievable with attention to design and management.

Sprinkler design criteria for uniform water distribution includes the following:

Head-to-head coverage. In most residential and small commercial irrigation systems, irrigation heads should never be placed more than the distance of their throw *radius*, or half of the throw *diameter,* apart. Under no circumstance should heads be placed more than 60% of the throw diameter apart. For example, if the radius of a pop-up spray head is fifteen feet, the ideal spacing would be fifteen feet. Even if sprinkler heads apply water evenly, the areas farther from the head receive less water because they are larger. [**Figure 1**] If the sprinkler head is in the center of circle “A”, circle “E” would receive about half as much water than “C”, and nine times less than spots closest to the head (Irrigation Association).

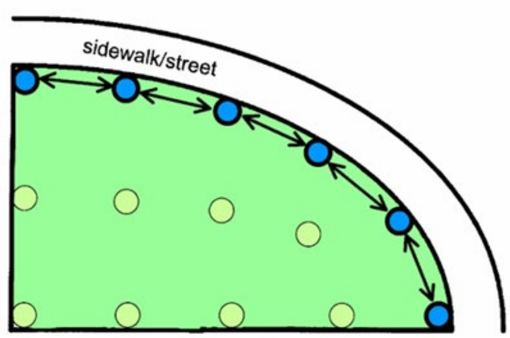
Figure 1.
Because areas far from an irrigation head receive less water than those closer, head-to-head coverage ensures even water application. The two heads below, working together, apply water evenly in the area between them (water from the sprinkler on the left appears blue, from the right, orange).





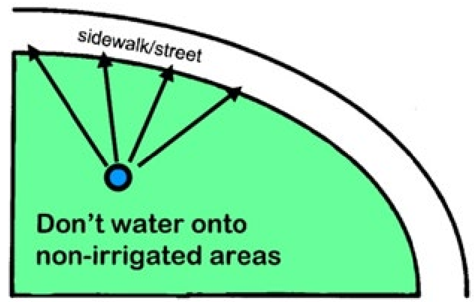
Watering from the edge. Sprinklers should be lining out the edges of the zones (i.e., run a line of sprinkler heads down the edge of the lawn or irrigated area), spraying onto the lawn but not onto the sidewalk, street, or non-irrigated area. [**Figure 2**]

Figure 2.
An efficient layout for irrigation is heads lined-out on the edge of the zone or irrigated area, evenly spaced at a distance of half their throw diameter.



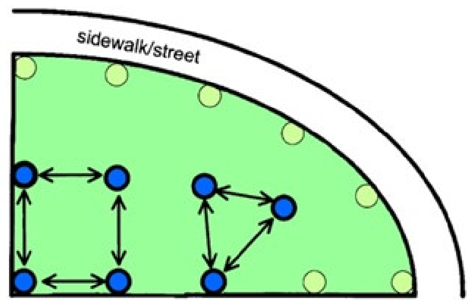
In sprinkler design, avoid layouts where sprinkler heads spray from the center of the lawn area out onto the sidewalk. It either wastes water as it sprays onto the sidewalk or creates a dry lawn area along the edge. [**Figure 3**]

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



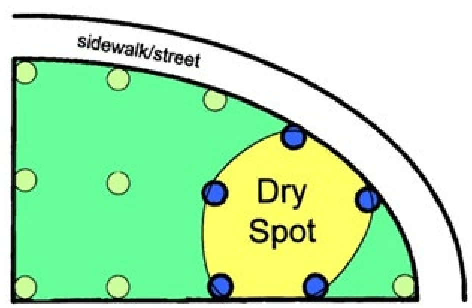
Arrange heads in square or triangular patterns. In the next step of the irrigation design process, fill in larger areas with sprinkler heads in regular square or triangular patterns. Spacing at no more than half of the throw diameter should take precedence over regular patterning. [**Figure 4**]

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. Add another head, maintaining head-to-head coverage.



Avoid irrigating small, irregularly shaped areas. It is impractical to irrigate small lawns (less than eight feet wide) and irregularly shaped patches of turf 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, a ground cover requiring low water, or a non-irrigated mulch area are water-efficient options.

Use recommended water pressure. 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 Checklist for Uniform Water Distribution

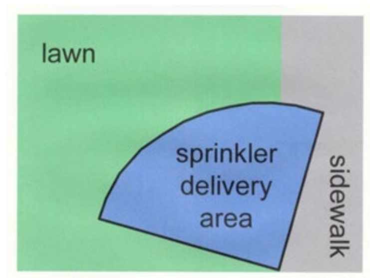
We have all noticed that blown sprinkler head down the street that goes unfixed for weeks. A problem with automatic sprinkler systems is that the gardener may not be aware of a system malfunction. Check the irrigation system's operations frequently.

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.

Regular sprinkler maintenance issues for uniform water distribution includes 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**]

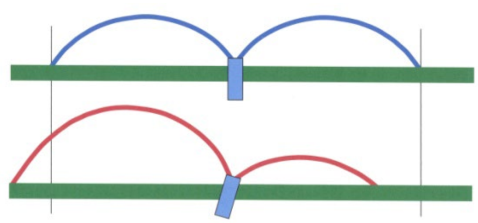
Figure 6.
Heads frequently shift their delivery arc. Frequent adjustment is required.



Adjust radius of throw. As discussed in design, water from one sprinkler head needs to reach adjacent heads for uniform delivery. 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 vertically. 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**]

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 firmly pack soil around the base of the head before replacing the sod.

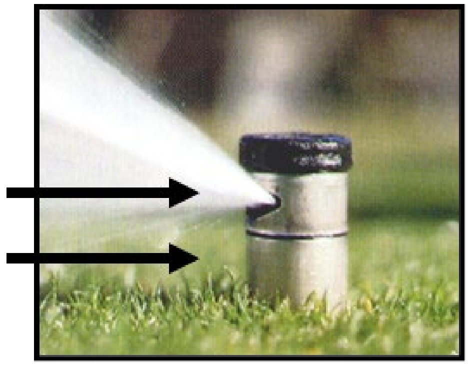
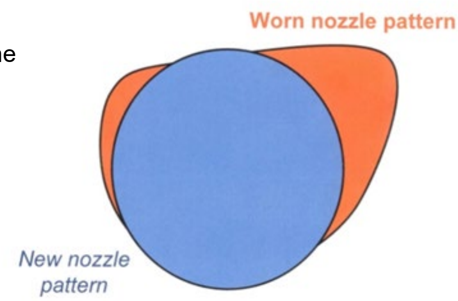


Figure 8.
Raise height of head to a point where water is released well above the grass height.

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 the 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 turns water on and off ages over time. Valves that do not shut off completely need the diaphragm or entire valve replaced. Valves 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: how much to water and how often to water? 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 needs of each zone. The first step in irrigation management is to calculate the precipitation rate for each zone. Once the precipitation rate is known, the controller can be set to deliver the desired amount of water. Because distribution patterns and precipitation rates vary from zone to zone, run times should be set for each 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 overwatered.

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. Without seasonal adjustment, lawns and gardens are overwatered in the spring and fall. Iron chlorosis is a common symptom of springtime overwatering. 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% evapotranspiration. When water is available, Kentucky bluegrass uses significantly more water than what it 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 may show signs of stress like thinning, and will tolerate less foot traffic.

Summer-dormant Kentucky bluegrass. Where appropriate for the use of the site, allowing Kentucky bluegrass to go dormant in summer is very water efficient. Summer-dormant bluegrass requires only about fourteen 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 local ordinances require rain shut-off sensors.

Use cycle-and-soak timing. 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 one 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 their cycles again.

Determine the reason for 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 overwaters the rest of the lawn, wasting water.

To evaluate a dry spot, first place some identical, straight-sided, flat-bottomed cans (like soup, vegetable cans, or coffee mugs) 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 or plant related (like compaction, thatch, and root damage).

> **Note:** As the gardener fine-tunes the management of their irrigation system, dry spots will show up in hot weather. This indicates that they are successfully walking the edge on ideal irrigation management, applying nearly exactly what the turf needs, not more.

Aeration. This is a primary tool to increase water infiltration. Aeration may be useful in the spring and fall on lawns with a lot of traffic (children and dogs), compacted, clayey soils, and slopes. For details refer to CMG GardenNotes #551 *Basic Turf Management*.

Water deeply and infrequently. This develops 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 p.m. and 9:00 a.m. In many areas, wind drift is less in the early morning hours.

CMG GardenNotes on Irrigation Management

- #260, *Irrigation Management: References and Study 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, *Irrigation Management Worksheet: Lawn In-Ground Sprinkler System Check-Up.*

Authors: David Whiting, CSU Extension, retired. Artwork by David Whiting. Used with permission. Revised September 2017 by Kurt M. Jones, CSU Extension. Reviewed August 2023 by John Murgel, CSU Extension.

Reviewed August 2023

CMG GardenNotes #268

Irrigation Management Worksheet:
Lawn In-Ground Sprinkler System Checkup

To complete this irrigation checkup, you will need the following items:

- Six identical straight-sided, flat bottom cans or cups.
- Watch/Timer.
- Ruler.
- Colored flags or other markers to mark sprinkler heads by zone (optional but helpful).
- Calculator.
- 10" Screwdriver and/or soil probe.

Why Do an Irrigation Checkup?

Of all the principles of water wise landscaping, attention to irrigation efficiency has the greatest potential for water conservation.

A lawn irrigation checkup is a systematic evaluation of the irrigation system design, maintenance, and management. It will identify areas where adjustments will make either a minor or major impact on water conservation and lawn quality. After performing the checkup you will be able to:

1. Recommend appropriate run times for each sprinkler zone, calculated based on the precipitation rate of each zone.
2. Recommend maintenance, such as replacing or adjusting nozzles, moving, or adding heads, or adjusting water pressure.
3. Recommend lawn care practices such as fertility management and core aeration to improve turf quality.

This checkup is only a tool to help identify where the system is working adequately and where adjustments need to be made. Knowing that action is required does not save water. Actual water conservation comes when findings are put into action!

Important Note: Perform a normal watering the day before doing the checkup.

Step 1. Evaluate the Lawn

A. **How does the lawn look?** Visual indicators of lawn quality show where to look for potential problems.

- ☐ 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

B. Check the soil conditions. Since the lawn was watered the day before the checkup, probing the soil can show where compaction or drought from uneven watering are issues.

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

2. If possible, use a soil probe to get a sense of soil texture, compaction, soil layers, rooting depth, and thatch layer. Note: On compacted or rocky soil, it may be 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.
  - ☐ Moderate compaction (recommend core-aeration of three-inch centers).
  - ☐ Severe compaction (recommend core-aeration of three-inch centers or other remediation).

- **Soil texture (use the soil texture by feel method found in GardenNotes #214, *Estimating Soil Texture*). Based on the soil texture expected speed of soil water infiltration is:**
  - ☐ High.
  - ☐ Moderate.
  - ☐ Low.

- **Soil profile:**
  - ☐ Changes in soil texture evident.
  - ☐ Hardpan layer present at ______ depth.
  - ☐ Evidence of drainage problems (such as surface pooling).

- **Thatch layer:**
  - ☐ Less than ½ inch.
  - ☐ Greater than ½ inch (may require core-aeration on three-inch centers).

- **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.

C. 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 at 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).**

D. **Notes & Recommendations:**

Step 2. Current Controller Settings

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

Controller is set for ___________________ (month).

Step 2. 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 different colors of landscape flags or other marking devices (like screwdrivers or sticks 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:**

Step 3. Irrigation Zones	**OK.** Concept incorporated.	**Minor**. Benefits with minor adjustments or implementation.	**Major**. Benefits 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 (e.g., high input, moderate input, and low input areas on separate irrigation zones).				
3. Zone by exposure (e.g., 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 irrigation on small, irregular shaped areas (generally areas less than 10 feet wide).				

If the current system design fails to meet one or more of the above criteria, consider upgrading the irrigation system.

C. **Notes:**

Step 4. Evaluate Sprinkler Performance

Turn on sprinklers and evaluate sprinkler performance as outlined below, repeating steps for each zone. Refer to GardenNotes #267, *Watering Efficiently* for more details.

A. **Design criteria for even water distribution.**

1. **Head-to-Head Coverage** – Does the water from each head reach neighboring heads?

Step 4A 1. 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 upgraded for water conservation.

2. **Head Position** – Are sprinkler heads "lined-out" along the edge of non-irrigated areas (watering from the outside in)?

Step 4A 2. 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 even pattern, equal distance without gaps?

Step 4A 3. 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 heads/nozzles in a zone the same brand and type?

Step 4A 4. Zone Uniformity						
Zone	1	2	3	4	5	6
Yes = OK						
No = adjustments needed*						

* In some situations, replacing heads or nozzles may correct the problem. In other situations, the system design may need to be upgraded for water conservation.

5. **Pressure** – Is there a mist cloud around sprinkler heads? Refer to GardenNotes #267, *Watering Efficiently*.

Step 4A 5. 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:**

B. Maintenance criteria for even water distribution.

1. **Delivery Arc** – For each head, does the delivery angle need adjustment (to avoid spraying the sidewalk, driveway, or other areas outside the zone)?

Step 4B 1. 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 (are the heads and risers straight up and down)?

Step 4B 2. 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 vertically to conserve water.

3. **Height** – Is nozzle releasing water above grass height and un-blocked by obstacles (trees, mailboxes, boulders, etc.)?

Step 4B 3. Height						
Zone	1	2	3	4	5	6
No = OK						
Yes = 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? Rotating nozzles can become stuck in place.

Step 4B 4. Worn Nozzles						
Zone	1	2	3	4	5	6
No = OK						
Yes = 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 turns water on and off, degrades over time. Valves that do not shut-off completely need the diaphragm or entire valve replaced. Valves may also fail to open fully, reducing available water pressure for the system.

Step 4B 5. Leaky Valves						
Zone	1	2	3	4	5	6
No = OK						
Yes = adjustments needed*						
Identify heads needing adjustments						

6. **Evaluate Dry Spots** – If the lawn has obvious dry spots, place five to ten identical containers on the lawn, in the dry spot and on the green areas. After running the sprinkler for their normal time, compare the amount of water collected in each can (measure to at least 1/10-inch accuracy if measuring by depth).

Step 4B 6. Evaluate Dry Spots						
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 are 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.

Adjustments identified in Step 4 need to be performed before continuing to step 5.

Step 5. Perform Precipitation Rate (Catch Can) Test

Perform a precipitation rate test (catch can test) for each zone, recording the precipitation rates in Table **6A, *Run Times***.

Precipitation Rate (Catch Can Test)

To do the calculations you will need six identical, straight-sided, flat bottom containers, such as soup cans, fruit or vegetable cans, or even coffee mugs. (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:

- Place six identical, straight-sided, flat bottom containers randomly around the area between sprinkler heads in the zone.
- Turn on the sprinklers for exactly ten minutes.
- Pour all that water into one container.
- With a ruler, measure the depth of the water in the can. This is your precipitation rate in inches per hour.
- Write down the rate for each zone in ***Step 8***.
- Repeat the first five steps 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.

Step 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.

Step 6A. Run Times						
Zone	1	2	3	4	5	6
1. Historical Summer ET. Amount of water to apply.	1.5 inches weekly					
2. Precipitation Rate – inches/hour.						
3. Run time per week (July/August) Based on Precipitation Rate for the zone.						
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.						

Note: ET, or evapotranspiration, is a term used to describe the amount of water consumed by plants over a period of time. In landscapes that provide complete ground cover, like lawns, ET is almost entirely made up of water that is transpired through plants as they pull water through the soil and release it into the air through stomates on leaves. For up-to-date and local ET data throughout Colorado, visit coagmet.colostate.edu.

B. Adding cycle and soak.

Most clayey and/or compacted soils cannot absorb water as quickly as pop-up spray sprinkler nozzles 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 were to have ¾ inch, set the controller to apply ¼ inch per cycle with three cycles.

Cycle and soak are particularly helpful on slopes to avoid wasteful surface runoff.

Step 6B. Cycle and Soak						
Zone	1	2	3	4	5	6
1. Need for Cycle and Soak? Yes or No						
2. Run Time Per Irrigation from Step 6A, line 5.						
3. Number of Cycles.						
4. Run Time Per Cycle Divide Run Time (line 2) per Irrigation 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 a.m. to 6 a.m. as many sprinklers come on. If you have low-pressure issues, take advantage of the whole watering window and use a less popular time.

Enter your first start time into the table for **Step 7A & B. Start Time(s)**, row #1.

B. Add additional start times for Cycle and Soak (if needed).

1. Add all the Run Times 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 **Step 7A & B. Start Time(s)**, Rows 2 and 3. Or add one 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 **Step 7A & B. Start Time(s)**, 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 the table **Step 7A & B. Start Time(s)**, Start Time 3.

Step 7A & B. Start Time(s)	
1. Start time 1	
Total cycle time	
2. Start time 2 (if needed, add line 1 to line 2.)	
Total cycle time	
3. Start time 3 (if needed, add line 3 to line 4.)	
Total cycle time	

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

A. Set the run times for each zone as listed in table **Step 6B. Cycle and Soak**, if Cycle and Soak is not used, or **Step 6B. Cycle and Soak**, line 4 if Cycle and Soak is used.

B. Set the start time(s) as given in table **Step 7A & B. 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 **Steps 6 to 8** for the spring/fall season.

Step 10. Fine-Tune to Match Site Specific Needs

These textbook figures are a good starting 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**, using the *Percent Key* on most controllers is an easy method to fine-tune for the water delivery by adjusting the percentage up/down in 10% increments. Adjustments can also be made by changing the run time of each zone up/down in 10% increments.
- **When adjusting a single zone**, adjust the run time 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. With experience, it becomes easy to fine-tune each irrigation zone. During multiple days of unseasonably hot weather, dry spots should begin to pop up provided the controller has been precisely fine-tuned. Otherwise, if dry spots do not pop up during unseasonably hot weather, the lawn is overwatered. Cut back the time in 10% increments, until each zone has been fine-tuned.

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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