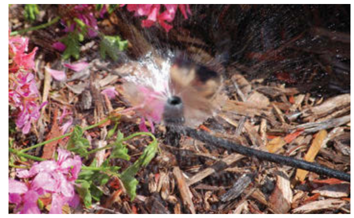
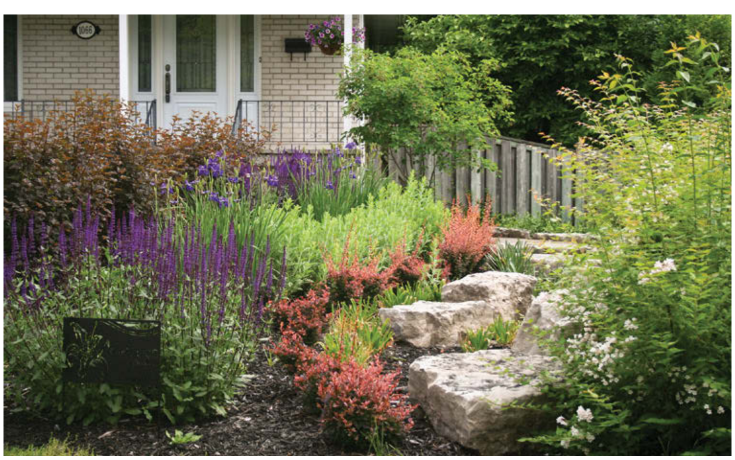
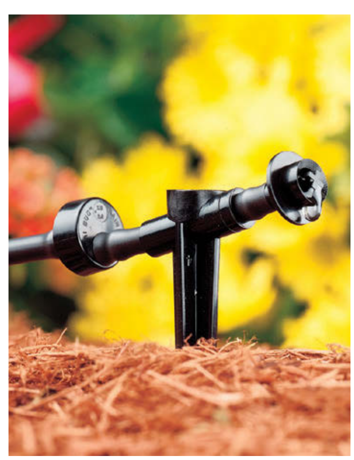
EPA WaterSense



Adding Microirrigation to Your Services: A Mini-Guide for Irrigation Professionals





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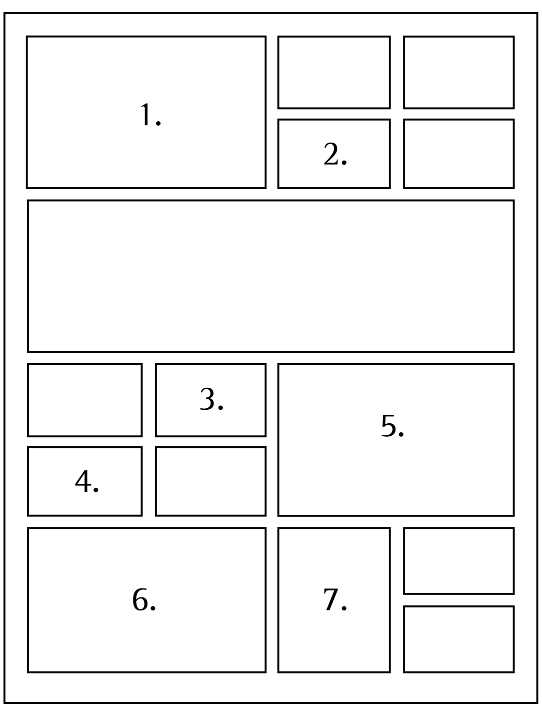

Cover Photos

1. *WaterSense Landscape Photo Gallery*
2. *Photo courtesy of Hunter Industries Incorporated*
3. *Photo courtesy of Hunter Industries Incorporated*
4. *Photo courtesy of The Toro Company*
5. *WaterSense Landscape Photo Gallery*
6. *Southern Nevada Landscape Award Winner*
7. *Photo courtesy of Rain Bird Incorporated*

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Microirrigation can reduce residential or commercial landscape irrigation water use by applying water directly to the root zone of plants where it is needed most, thereby reducing the potential for excessive runoff and evaporation. The U.S. Environmental Protection Agency's (EPA's) WaterSense® program encourages microirrigation, where appropriate, to reduce outdoor water waste. For landscape irrigation professionals, it can be a good method to improve commercial or residential watering efficiency.

Overview

Microirrigation is a low-pressure, low-flow-rate form of irrigation that can reduce the likelihood of overwatering a landscape. Microirrigation can also be referred to as low-flow, trickle, or drip irrigation, but to be considered microirrigation under the current American Society of Agricultural and Biological Engineers/ International Code Council (ASABE/ ICC) 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*, water must discharge at flow rates less than 30 gallons per hour operated at 30 pounds per square inch (psi).

Microirrigation delivers water directly to the root zone of plants, where water is needed most, as well as more slowly and over a longer period of time, preventing water from running off on the surface and reducing evaporation associated with sprinkler irrigation. By applying water at a low rate over an extended period of time, microirrigation allows the water to better infiltrate into the soil. Water applied by higher-flow-rate methods, such as spray sprinklers, can form puddles, evaporate, or land in soil beyond plant roots, leading to less efficient watering.

A microirrigation system can be installed on a newly developed landscape with no existing irrigation system, retrofitted on a traditional sprinkler system, or added on to an existing system. Microirrigation can be adapted to a variety of residential or commercial landscapes, regardless of topography or plant type. However, it is most effective when used to water trees, shrubs, and other ornamental plants that are spaced widely apart, as opposed to large areas of turfgrass or other plants that cover the entire soil area, where spray sprinkler systems provide the more uniform coverage needed.

Microirrigation systems help homes, businesses, and institutions water their landscapes more efficiently. Research indicates that microirrigation systems use between 20 to 50 percent less water than conventional spray sprinkler systems.[1] Installing a microirrigation system instead of a traditional system can save a typical home more than 25,000 gallons of water per year.[2]

This guide provides an overview of the benefits, design considerations, installation considerations, scheduling, and maintenance of a microirrigation system. It also includes helpful tips for troubleshooting microirrigation systems that may not be watering efficiently and suggestions for improvement. For more detailed information, consult the resources developed by product manufacturers and information from utilities and extension services listed at the end of this document.

[1] Pacific Institute. 2003. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*.

[2] Ibid; DeOreo, Mayer, Deziegielewski, and Kiefer. Water Research Foundation. 2016. *Residential End-Uses of Water*, Version 2.

Why Microirrigate?

On average, single-family homes in the United States use 30 percent of their household water outdoors, but that percentage can be much higher in drier regions of the country. Similarly, outdoor water use ranges from 5 to 30 percent of the total water use for commercial facilities. When commercial or residential landscapes are watered with automatic irrigation systems, as much as 50 percent of the water applied can be wasted due to runoff, wind, or evaporation, if the system is not installed, maintained, or used properly. Because microirrigation provides water directly at the root zone of plants at a lower flow rate, it allows the water to soak into the soil, rather than run off, and applies water only where it is needed.

The main benefit of microirrigation is efficient water delivery at the root zone, although there are a variety of secondary benefits that make this type of system a preferred choice in many landscape settings. For example, with microirrigation, the bare areas of soil or mulch between plants do not receive water, which reduces the chances of weed growth. This results in an aesthetically pleasing and healthy landscape, decreasing the need for added herbicides. Furthermore, pools of standing water, which can attract insects, are reduced, resulting in a decreased need for pesticides. Finally, these systems help protect local water bodies such as streams, lakes, and rivers, because they reduce runoff due to high application rates that can sometimes be associated with sprinkler irrigation.

Because microirrigation provides water directly at the root zone of plants at a lower flow rate, it allows the water to soak into the soil, rather than run off, and applies water only where it is needed.

While microirrigation holds great potential to reduce outdoor water use, proper design, installation, scheduling, and maintenance are essential. As with sprinklers and other forms of irrigation, overwatering with microirrigation can occur if efficient practices are not followed. This guide explores these important factors (which are critical to any landscape irrigation system) as they relate to a successful microirrigation system. Additional details and guidance on these topics can be found in the resources listed at the end of this guide.

Photo courtesy of Hunter Industries Incorporated

Microirrigation System Design

Key design questions to ask with a microirrigation system include: 1) how much water is needed by different plant types based on where they are located; 2) what types of emission devices should be used to dispense the water; and 3) how and where the emission devices should be placed. Ideally, the design starts with a new landscape that is organized by plants' different water needs, but the system can still be effective on existing landscapes.

Hydrozoning

Different areas of the landscape have varying irrigation requirements based on plant type, soil type, and sun exposure. To achieve the most efficient application of water, the landscape and associated irrigation system should be divided into hydrozones, or different irrigation zones based on the plant water requirements. To reach this goal, irrigation zones should have plants with similar irrigation needs grouped together in the landscape. For example, turfgrass and shrubs have different irrigation needs and should be in different irrigation zones. This will allow the turfgrass to be independently watered with sprinkler irrigation and the shrubs watered separately with microirrigation. Tailoring the amount of water applied to each zone can prevent overwatering areas with different water requirements.

Emission Devices

A microirrigation system can include several different types of emission devices (see Figure 1), depending on soil type, the landscape's topography, and plant types and their associated water requirements:

- **Drip line emitters** are tubes with integrated evenly spaced emitters that discharge at a uniform rate.
- **Multiple outlet emitters** have a centralized assembly with multiple emission points that can be connected based on irrigation requirements.
- **Point-source emitters** discharge water at a single emission point and can extend from the lateral pipe.
- **Microsprays** spread water over a larger area, but still at a low pressure and low flow.

When designing a system where the water supply pressure is greater than that recommended by the manufacturer (typically more than 30 psi), emission devices should include pressure compensation to ensure a consistent flow rate despite varying supply pressure, resulting in a more efficient application of water. Emission devices with built-in pressure compensation will maintain a consistent flow rate. Connecting a pressure regulator at the water source will compensate if the incoming water pressure is too high. In-line pressure-regulating valves can be used throughout larger systems with slopes that have intermittent high-pressure areas.

Figure 1. *Examples of Different Types of Microirrigation Emitters*

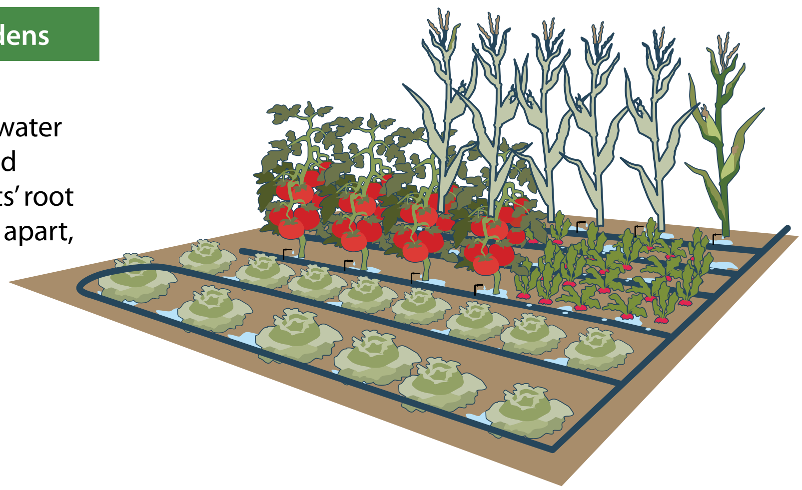
Photos courtesy of Hunter Industries Incorporated

As shown in Figures 2 and 3, selecting the appropriate emission devices and determining the most efficient spacing are important considerations when designing a microirrigation system to deliver the right amount of water to plants. Pipes need to be sized appropriately to allow for sufficient pressure at the end of the system. If there is a significant pressure drop, the flow rate furthest from the water source will not be sufficient to provide the intended amount of water. More in-depth design considerations are covered in several of the resources suggested at the end of this document.

Figure 2. *Sample Microirrigation Applications for Three Different Plant Types*

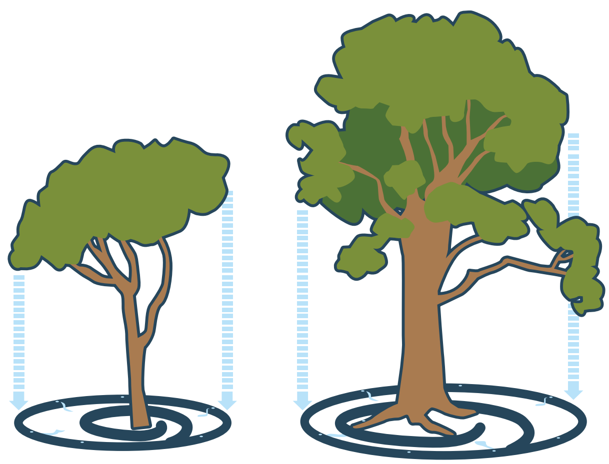
Vegetables and Flower Gardens

Drip line emitters can efficiently water vegetable and flower gardens and should be routed along the plants' root zone. If plants are spaced further apart, point-source emitters can be used to avoid watering bare soil.



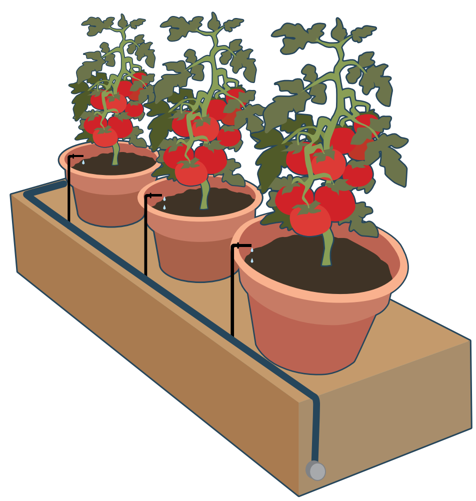
Trees

Newly installed trees can start with several drip line emitters, point-source emitters, or microsprayers at the base of each tree. Additional emission devices can be installed as the tree grows and requires more water. The emitters should be moved outward to align with the edges of the tree canopy as it grows.



Containers/Hanging Plants

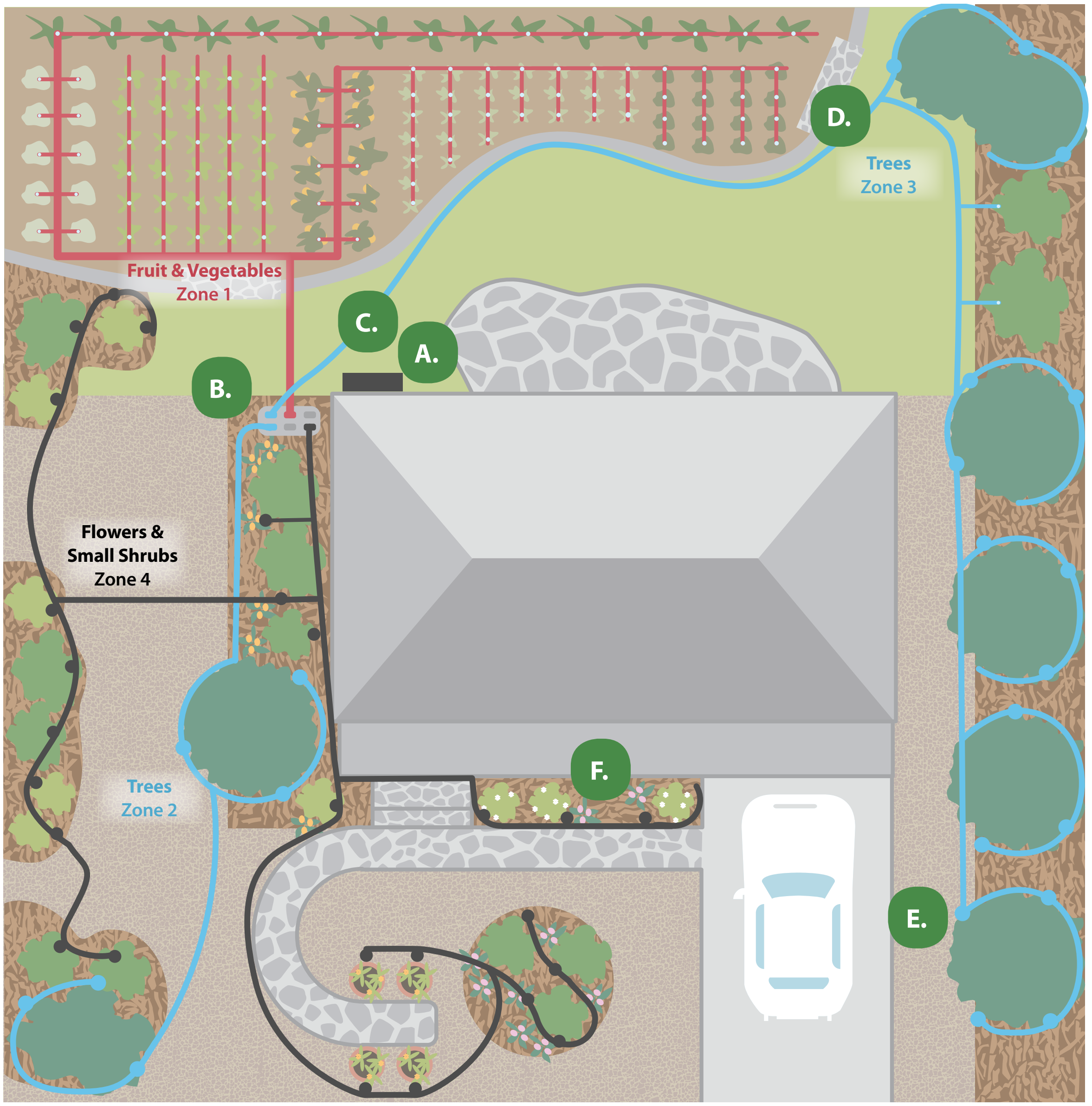
Container plants require frequent watering due to their size and porous nature of potting soils. Typically, risers and point-source drip emitters are most appropriate for these plantings.



In some cases, flowerbeds and vegetable gardens may only need one emitter per plant. Shrubs may require one or two emitters per plant. Trees typically require drip line emitters or microsprays placed in concentric circles below the edge of the tree canopy. Figure 3 shows an example landscape that was designed based on the water requirements of different plant types that would commonly occur in typical irrigation zones, as well as the appropriate emitter choice and spacing.

The types and number of emitters used per zone will result in different flow rates for each zone. In this example, drip line emitters are selected to water shrubs and flower gardens, and point-source emitters are used to access pots or water trees.

Figure 3. *Sample Landscape With Zones Divided Based on Plant Type and Location*



Areas of the landscape have different water requirements based on plant type, soil type, and sun exposure. Plants with similar water requirements should be grouped together to create irrigation zones.

A. Controller

Photo courtesy of Rachio

B. Valve Box Pressure Regulator and Filter

Photo courtesy of Rain Bird

C. Lateral Supply Tubing

Photo courtesy of Rain Bird

D. T Joint

Photo courtesy of Rain Bird

E. L Joint

Photo courtesy of Rain Bird

F. Microspray Emitter

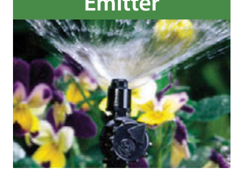


Photo courtesy of Rain Bird

Installation Considerations

The following section provides general information regarding microirrigation installation. Detailed instructions for installing microirrigation systems should be provided with the products. Most manufacturers also provide detailed guides online, as well as training courses for professionals to learn more about installing these products. The basic materials needed to install a system are listed in the Terms to Know section. Many irrigation distributors and home improvement stores sell the suite of materials, either individually or in a kit for ease of selection.

Water Source Connection and Components

The first step in installing a microirrigation system is to identify and connect to the water source, also known as the point of connection. For smaller residential landscapes, the water source may be the outdoor hose bib. For larger systems or systems using well water, the water source may be an existing valve. For retrofit systems, the point of connection may be an existing sprinkler head replaced by a drip zone kit. A filter, pressure regulator, and backflow preventer will likely have to be connected to the water source. An irrigation controller is connected to the valves.

Depending on the source water quality, additional filtration may need to be installed. Water provided by the city should not require any additional treatment beyond a basic filter. However, if the water source is untreated well water or surface water (e.g., harvested rainwater/stormwater), there may be a need for filtration, such as screen filters, as these sources may contain soil particles or organic matter. Even if the water is relatively clean, using a filter will prevent the buildup of particles over time and extend the life of the irrigation system. Additionally, a backflow preventer may be required by local codes to protect the potable water supplying the house from contamination by the irrigation water.

Many irrigation systems require pressure regulators to maintain a constant pressure, even under varying incoming pressure conditions. The maximum allowable pressure will vary depending on the system design, but should typically be kept at less than 30 psi. Drip line emitters, point-source emitters, and microsprays are designed to operate efficiently between 15 and 30 psi. Manufacturer guides will have specific information on flow rate performance and different incoming pressures for each emission device. Water pressure higher than 30 psi may result in unexpected increases in flow, reducing efficiency and possible system failure. In these cases, a pressure regulator should be considered.

Photo courtesy of Hunter Industries Incorporated

Routing the Lateral Lines and Installing Emission Devices

After the water source has been connected and proper filtration and pressure regulation have been installed, the next step is to route the lateral water lines to the appropriate area of the landscape. Where the landscape is divided based on plant type and water requirements (i.e., hydrozoning), the lateral lines should be positioned to deliver water to each zone. Drip lines and the appropriate emitters (as determined in the design phase) should then be installed to supply water to the root zone of the plants. If the area is not properly hydrozoned, it is important to tailor the number and type of emitters to each plant to deliver the appropriate amount of water.

There are adapters that can be used to replace a single sprinkler head with a microirrigation line. These can be used in situations where only a few plants need watering and won't require replacing an entire system.

After installing the lateral lines, drip lines, and emission devices, check the system to confirm that everything is connected properly. This can be done by turning the system on and inspecting it for leaks, looking for pooling water in undesired places. Examine each emission device to confirm that the flow is consistent throughout the zone. If water is not flowing from an emission device, it may be clogged or blocked, or that area of the system may not be receiving water.

Irrigation Scheduling

Several factors should be considered when developing an irrigation schedule, including the water requirements of the plants in each zone, local climate and weather, soil composition, sun exposure, slope, and depth of the root zone.

Plant Water Requirement

The plant type and size impact how much water a plant will require to remain healthy in the landscape. Information regarding plant water requirements for common landscape plants is often provided by local utilities or extension offices, as well as online. The age of the landscape also impacts the schedule. Immediately following plant installation, landscapes at their early stages require frequent irrigation intervals to establish the plants. Once the landscape is established, however, the schedule should be adjusted to reduce the irrigation frequency appropriate for those plants.

Safety First

It's important to ensure that areas of the landscape that have high foot traffic or cross over hardscapes have portions of the irrigation lines buried where pedestrians could trip on them.

Weather Conditions

Local climate and variations in evapotranspiration (or the amount of moisture that is both transpired by the plant and evaporated from the soil and plant surfaces) play a significant role in determining how irrigation schedules should shift over the season. In addition, specific weather events, such as rainfall, should be considered. If scheduling manually, take these parameters into consideration and create monthly schedules.

A variety of irrigation controllers and sensors on the market can use local conditions to determine watering times and amounts. WaterSense labeled weather-based irrigation controllers have been independently certified for efficiency and performance; they use local weather and landscape conditions to tailor watering schedules to actual conditions on the site. Similarly, soil moisture-based control technologies use moisture sensed in the soil to adapt scheduling to plant water needs. Additional sensors, such as rain, wind, and freeze sensors, can also help delay or prevent irrigation if conditions are not ideal or necessary for watering.

Soil Types

Soil type should also be considered when developing any irrigation schedule. The infiltration rate of the water depends on the composition of the soil. Coarse soil requires frequent irrigation intervals; medium loamy soil requires longer, less frequent watering; and fine clay soils have a high water-holding capacity that requires the least frequent irrigation. If soil type is not taken into account when developing a schedule, water could be wasted due to runoff or deep percolation. For example, if a coarse soil is not irrigated properly, the water will infiltrate to the deep soil quickly and without enough time for the plants to access it. Irrigation water on a clay soil does not infiltrate quickly, and if the system is run too long, the landscape will begin to flood and runoff could occur. Figure 4 demonstrates how water infiltrates into the various soil types over the same irrigation period.

One way to make irrigation in different soil types more efficient is by including cycle and soak in the irrigation schedule. Rather than irrigating each zone fully in a single cycle, the cycle and soak method irrigates each zone in short intervals and allows water to infiltrate between intervals. This is popular for sprinkler irrigation, but can still be useful in microirrigation, depending on the flow rate of the system. If the flow rate is slow enough, there will be no pooling on the surface during the entire cycle and no need to adjust the schedule.

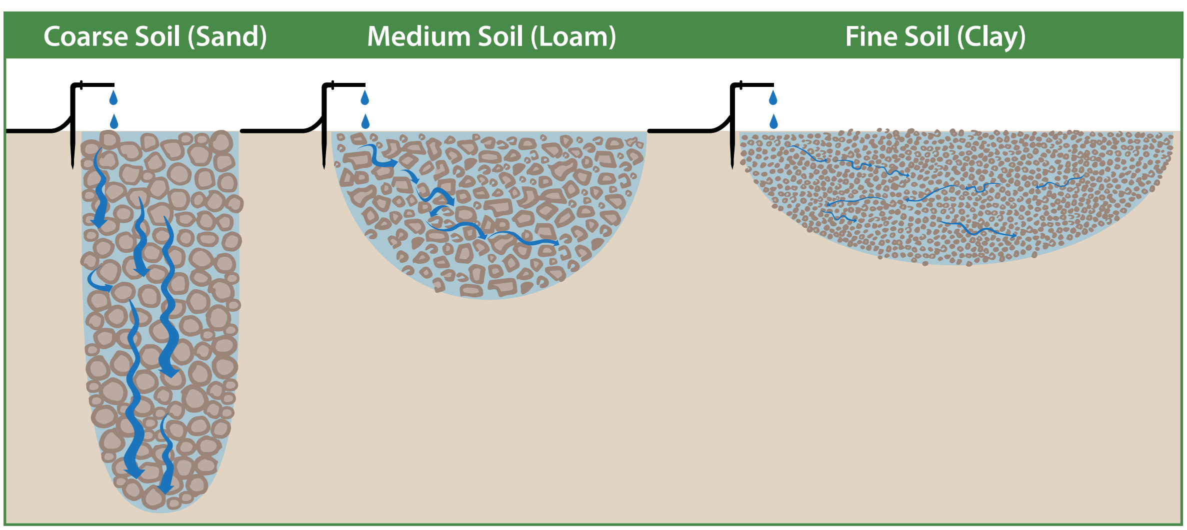
Slope and Sunlight

The slope of the landscape and its orientation to the sun should also be considered when developing an irrigation schedule. Care should be taken so as to not schedule long irrigation events on slopes, as this could result in water running off the landscape. Similarly, ponding is more likely to occur at the lower end of the landscape due to runoff from the elevated areas, so lower-flow-rate emitters should be installed, and/or more frequent, shorter events should be scheduled. Regarding sun exposure, plants exposed to intense sunlight, or on slopes with southern or western exposure, might require more irrigation due to the increased evapotranspiration of those plants.

Depth

Lastly, the depth of the root zone should be considered when scheduling irrigation. If irrigation does not reach the full depth of the root system, plants are not receiving enough water to maximize growth. Both plant type and age should be considered when determining root depth and associated schedule parameters.

Figure 4. *Example of Infiltration Pattern Through the Soil Profile*



Maintenance

Proper maintenance is essential to the success of a well-designed and well-installed system. Because microirrigation is typically installed at ground level, it is commonly exposed to scenarios that result in system damage, such as weed growth damage, clogged emitters, freezing pipes, and damage from landscape work or animals.

Weeding

While water applied directly to the desired plant's root zone leaves little opportunity for weeds to grow between plants, weed growth is still possible. Weeds can grow into the emitters, causing clogs. If this occurs, weeds should be removed at their roots frequently to avoid damage to the microirrigation system.

Preventing Clogs

An emitter can also be clogged by soil or mulch blocking the outlet, or due to unfiltered water from the mainline. Particles such as soil can enter the irrigation system from untreated water sources or can be sucked into the emitter at the end of an irrigation cycle. These particles can collect at the emitter and prevent flow or even grow large enough to block the entire pipe. To prevent clogging, filters are used to block particles from entering the system and should be flushed regularly, especially on systems using nonpotable water.

Winter Maintenance

In many areas of the country, the growing season and associated irrigation season are limited to the times of year conducive to plant growth. At the end of the irrigation season, the system should be flushed to prevent the lines from freezing during the winter months. Water frozen in pipes can expand and cause cracks in the pipes, which will ultimately waste water and not reach plants.

Leaks From Landscape Work or Animals

Because much of the microirrigation system is located on the surface, pipes, tubing, and emitters are exposed to landscape work; as such, they could become damaged by shovels and other landscaping equipment. Similarly, because these systems are located on the surface, animals may bite into tubing to reach the water inside. Since these systems are usually covered by plant material or mulch, leaks can go undetected until plants wither from underwatering. Flow meters can help identify if the flow through the microirrigation system is not running correctly, possibly indicating a leak or damage to the system.

Talking to Clients

When talking to clients about landscape irrigation, consider communicating the following:

- Explain how microirrigation provides direct water for trees, shrubs, and flowers, whereas sprinkler irrigation provides a broader application for dense plants like turfgrass.
- During site inspection, locate different plant types for each zone and test for soil types.
- Explain the value of selecting the correct emitter type for each plant.
- When providing an estimate, determine the quantity of materials needed, expected installation time, and cost of materials.

After installation, walk through the system with your customer. Explain to them how to operate the system to turn it on and off. Check that all connections have been secured safely and that tubing will not cause a trip hazard.

Lastly, give the customer a timeline for maintenance, repairs, and upgrades. Leave the customers with your contact information if they have any questions. You can also provide guides or documents for the customer to better understand the maintenance of their system.

The troubleshooting table on the next page can help you solve common problems that make irrigation systems inefficient.

Tips for Troubleshooting

Many possible issues and important concepts are discussed throughout this guide. The following table can be used by professionals during the microirrigation design, installation, and maintenance process, or when auditing an existing microirrigation system.

ISSUE	EFFECT	EFFICIENT SOLUTION
Design		
Poor spacing or number of emission devices	Too much or too little water could go to an individual plant	Research and install the correct number of emission devices per plant
Incorrect emission device flow rate	Plants could receive too much or not enough water	Consult manufacturer guide for emission device flow rates
Pipes are too small	Pressure will drop at the end of the system, reducing flow rate	Size pipes to handle the necessary system flow rate
Scheduling		
Failure to adjust the irrigation schedule based on the season	The system will irrigate too much in cooler weather and/or not enough in warmer weather	Adjust the system to account for the changing season or consider a WaterSense labeled weather-based irrigation controller
Letting the system run during rain or snow	If the precipitation has already filled the soil to capacity, water is wasted	Turn off the system during rain or snow and consider a WaterSense labeled weather-based controller, as well as a rain sensor
Letting the system run in the heat of the day during full sun	A significant amount of water can be lost to evaporation	Avoid watering during the hottest time of the day
Irrigating beyond the soil's water-holding capacity	The soil will become flooded, causing runoff and water waste	Use the cycle-and-soak irrigation method to prevent flooding the soil
Irrigation does not reach the full depth of the root system	Plants might not receive enough water	Irrigate enough to fully saturate the plant root system
Maintenance		
Water is not consistently filtered or the landscape is not kept free of debris	Emitters could clog	Use a filter to remove particles from the water and keep the area around emitters free from debris
System not properly winterized	Water in the pipes could freeze and cause it to break	Insulate pipes where practical to protect the pipes from freezing, blow out all of the water from the system at the end of the season, and stop any irrigation schedules
Exposed pipes on the surface	Trips and falls from pedestrians or animals may damage pipes	Bury pipes under mulch that are in high traffic areas of the landscape

Terms to Know

The terminology used to describe microirrigation is not consistent throughout the irrigation industry. Drip irrigation, low-flow irrigation, microirrigation, and other terms are often used interchangeably. Many of the terms and definitions provided below and throughout this guide are based on the ASABE/ICC 802-2014 *Landscape Irrigation Sprinkler and Emitter Standard*, and they are included to provide a basic understanding of the terms, with a focus on the components and their role in installing an efficient microirrigation system.

Backflow prevention device: A device that prevents water in the irrigation system from flowing into the water supply lines that could potentially contaminate drinking water.

Distribution pipes: Tubes that deliver water from the supply line to the plant area. Types of pipes include lateral lines and supply tubing.

Filter

Photo courtesy of Hunter Industries Incorporated

Filter: Device used in irrigation systems to remove particles from water to prevent the microirrigation lines and emitters from clogging. While filters are generally recommended for irrigation systems, they are especially important if the water has the potential to contain particulates.

Irrigation controller: A smart device that uses local weather conditions or other scheduling device to automatically turn irrigation water on and off.

Microirrigation emission device: A device intended to discharge water in drops or continuous flow at rates less than 30 gallons per hour (113.5 liters per hour) at the largest area of coverage available for the nozzle series when operated at 30 psi, except during flushing.

- **Drip emitter:** A microirrigation emission device, with a flow rate less than or equal to 6.3 gallons per hour (24 liters per hour) when operated at 30 psi (206.8 kPa), designed to dissipate pressure and discharge a small uniform flow or trickle of water at a constant discharge rate.
  - **Drip line emitter:** A tube that discharges water from integrated evenly spaced emitters, perforations, or a porous wall. They are also known as "line-source emitters" or "in-line emitters."
  - **Multiple outlet emitter:** A microirrigation emission device with more than one emission point from a centralized assembly.
  - **Point-source emitter:** A drip emitter that discharges water at a single emission point.
- **Microspray:** A microirrigation emission device with one or more orifices to convert irrigation water pressure to water discharge with a flow rate not to exceed 30 gallons per hour (113.5 liters per hour) at the largest area of coverage available for the nozzle series when operated at 30 psi. Microsprays are inclusive of "microbubblers," "microspinners," and "microspray jets."

Valve, Filter, Pressure Regulator Combination

Photo courtesy of Hunter Industries Incorporated

Pressure regulator: A device that maintains constant downstream operating pressure immediately downstream from the device, which is lower than the upstream pressure. Microirrigation operates at a lower pressure than sprinkler irrigation. A pressure regulator should be used if the incoming water pressure is higher than the manufacturer's recommended pressure for the given emitter.

Valves: Mechanical devices that control the flow of water, providing water to each zone in the landscape. Valves can be automatic or manual.

Resources

The following are resources that were used in the development of this guide:

ASABE/ICC 802-2014. 2014. *Landscape Irrigation Sprinkler and Emitter Standard*. www.asabe.org/standards/asabe-icc-802.aspx

City of Albuquerque, Public Works Department. *Low-Volume Irrigation Design and Installation Guide*. http://en.calameo.com/books/0016401573f683a688fd3

DeOreo, Mayer, Deziegielewski, and Kiefer. Water Research Foundation. 2016. *Residential End-Uses of Water*, Version 2. http://www.waterrf.org/Pages/Projects.aspx?PID=4309

Pacific Institute. 2003. *Waste Not Want Not: The Potential for Urban Water Conservation in California*. 2003. https://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf

Tampa Bay Water. 2006. *A Guide to Microirrigation for West-Central Florida Landscapes*. https://www.tampabaywater.org/documents/conservation/microIrrigationMODIFIED.PDF

Additional resources include:

Alliance for Water Efficiency. Drip and Micro-Spray Irrigation Introduction. http://www.allianceforwaterefficiency.org/Drip_and_Micro-Spray_Irrigation_Introduction.aspx

Arizona Landscape Irrigation Guidelines Committee. Guidelines for Landscape Drip Irrigation Systems. http://www.amwua.org/pdfs/drip_irrigation_guide.pdf

California Water Efficiency Partnership. Drip and micro irrigation systems. http://calwep.org/Research-Portal/Drip-and-micro-irrigation-systems

City of Bellevue Utilities: Natural Gardening Guides. https://utilities.bellevuewa.gov/UserFiles/Servers/Server_4779004/File/pdf/Utilities/Drip_and_Soak.pdf

Irrigation Association. https://www.irrigation.org/

Colorado State University Extension. Drip Irrigation for Home Gardens. http://extension.colostate.edu/topic-areas/yard-garden/drip-irrigation-home-gardens-4-702/

Oregon State University Malheur Experiment Station. An Introduction to Drip Irrigation. http://cropinfo.net/water/dripIrrigation.php

University of Georgia Extension. Irrigation for Lawns and Gardens. http://extension.uga.edu/publications/detail.html?number=B894#Drip

University of Arizona Cooperative Extension. Drip Irrigation: The Basics. https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1392-2016_0.pdf

Each manufacturer of microirrigation equipment also has its own detailed guides that can be referenced for product-specific information, as well as design, installation, and maintenance guidance.

Programs that certify irrigation professionals in design, auditing, and installation and maintenance can earn the WaterSense label if they focus on water-efficient technologies and methods. If you are interested in becoming a certified irrigation professional through a WaterSense labeled program, visit www.epa.gov/watersense/professional-certification-0 to find a list of labeled programs. Individuals certified through these programs are listed in the WaterSense Directory of Certified Professionals, at www.epa.gov/watersense/find-pro.

United States Environmental Protection Agency
(4204M)

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May 2018
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