The next step in the process of designing and installing a native landscape is to deal explicitly with how your plantings will be watered. Your completed planting plan shows the species that are to be planted into each area, as well as the spatial configuration of the planting. Each planting area has been designated as belonging to one of the five watering zones: minimal, low, medium, high, or very high. Now you will decide the most efficient and best way to provide water to each watering zone. Plants in all zones will need to be watered during establishment, so there must be some way to get supplemental water into each area, at least initially. But only areas representing watering zones that will receive supplemental water on a regular basis will need more permanent irrigation systems. These are the zones that represent plant communities from places that receive more annual precipitation than your site and that cannot be situated in sufficiently favorable microsites to preclude the need for added water.

There are four principal ways to water plants: water harvesting, hand watering, sprinkler irrigation, and drip irrigation. Which method you choose for a particular water zone will depend on how often the area will likely need to be watered, how much water will need to be added, and how the plants are spaced. The first method, water harvesting, uses water received onsite, while the other methods involve the use of water from offsite, usually water from the same supply line that provides culinary water to your house. Another possible source of offsite water that is sometimes available is ditch irrigation water—a remnant of farming days in small towns of our region. Or in some scenarios, “gray” waste water (wash water) from the house may be an option—see the resource section for more information.
Water Harvesting

Water harvesting is a much-neglected method of irrigating landscape plantings. It uses water from the rain and snow that fall onto non-planted areas of your site to supplement the water available in planted areas. It involves collecting rainwater or snowmelt from an impervious catchment area and redistributing it to an area where it can be used by plants. Sometimes a storage system, such as rain barrels or a cistern (underground water storage tank), is included to make it possible to water plants during periods when the catchment areas are dry. Water-harvesting systems can be simple or complex. Large landscape rocks can act as catchment areas that redistribute water to the areas around their bases. This, combined with the shade created by the rock and its ability to lower evaporation from the soil surface, makes places adjacent to landscape rocks distinctly wetter than surrounding areas. Another simple form of water harvesting is laying a new slab of cement for a driveway with a slight slope toward the adjacent planting area, so that rainwater will run off into the planting. Even very shallow slopes are sufficient to create flow over a smooth surface.

The catchment area represented by the roof of the house is usually the most significant source of extra water for the landscape. And even though water harvesting is not 100 percent efficient, the amount of extra water that can be made available to plants is considerable. Most houses have gutters and downspouts to collect water from the roof and carry it away from the house foundation. It is not difficult to intercept the water at the base of the downspout and direct it to the designated planting area, as long as the pipe or drain that carries the water slopes downward. Again, only a shallow slope is required, about one foot of drop for every hundred feet traversed. An elegant way to transport the water is to use a French drain, which is essentially a gravel-filled ditch, often lined with polyethylene plastic sheeting. These structures are commonly used to divert water away from areas where it is not wanted. But they are just as good at carrying the water to areas where it is desired, namely the planting areas in your design that will depend on harvested water for part of their water needs. The planting area receiving the water can be shaped so that it holds the water, either in a depression or swale, or on a flat surface with berms to make a “moat.” Often the areas receiving the water are arranged in a series, each slightly lower than the next, so that once the water has filled the first receiving area, it can spill gently over into the next one. It is also possible to store water harvested from a roof and distribute it later using drip irrigation. We include some excellent references in our resource section to help those of you interested in water harvesting to engineer a harvesting and distribution system that will make you proud.
Water Harvesting

You can take advantage of water harvesting on a small scale by planting species with higher water requirements around landscape rocks, especially on the shady north side. The rock sheds water down its sides and also protects the water underneath from evaporation.

A French drain is a clever device for carrying water some distance away from a gutter downspout. A slightly sloping trench is filled with gravel, and the water flows through this gravel to its destination. The trench is often lined and covered with plastic, so that it conducts water more efficiently and can be buried in soil without clogging the gravel.

Roof water can be guided directly from the gutter downspout to adjacent shallow planting basins. These can be tiered, so that the lower basin receives harvested water only when the upper basin fills to overflowing.

It is important to note that in certain areas of the Intermountain West, state or local ordinances restrict some forms of water harvesting and some uses of gray water. Be sure you know what is permitted in your area before you begin planning your own system.
Adding Supplemental Water

Hand watering, sprinkler irrigation, and drip irrigation are all methods of adding supplemental water from offsite. Hand watering is usually most appropriate during the establishment phase. It can also be used during exceptionally dry years to apply supplemental water in zones that usually do not require extra water. Watering the wells around trees by filling them from a hand-held hose is hand watering, as is carrying around a watering can or milk jugs to water new transplants in an established planting that does not generally require supplemental water. If you water small plants with a hose, use a spray wand to keep from washing out the roots. Occasional hand watering is not a big job unless the area is large, though it can be somewhat labor intensive.

Sprinkler irrigation is the traditional method for watering lawns, and is best suited for watering large areas that are densely planted. It can also be used as a temporary method of providing supplemental water during exceptionally dry years in zones that do not have permanent irrigation systems. Using a portable sprinkler on the end of a hose to water a large area is essentially an extension of hand watering. In contrast, turf sprinkler irrigation systems, with buried supply lines, multiple sprinkler heads on a grid, and automated run times, are at the other extreme, requiring little labor or even thought once they are installed and placed in operation.

---

**Watering by the Numbers**

1. **Estimating Water Yield from a House Roof**

   Every inch of rain that falls onto your roof drops 0.625 gallons onto each square foot of roof surface.

   To calculate the potential water yield per inch of rainfall:

   \[ \text{house length} \times \text{house width} \times 0.625 = \text{gallons per inch of rain}. \]

   For example, if your house is 80 feet long and 40 feet wide, a 1” rainstorm can generate \[80 \times 40 \times 0.625 = 2,000\] gallons of water.

   To estimate the total potential water yield from your roof:

   \[ \text{gallons per inch} \times \text{average annual precipitation} = \text{total gallons}. \]

   In a 12” precipitation zone, your potential water yield could total \[2,000 \times 12 = 24,000\] gallons of water over the course of the year, potentially a rather substantial contribution to landscape irrigation.
Sprinkler irrigation has several disadvantages in the context of native plant landscaping. First, it wastes water, because a significant fraction of the water is often lost to evaporation before it even hits the ground. Second, it applies water equally to plant root zones and interspaces, so that, unless the plants are very closely spaced, it tends to encourage weeds. Third, many native species are prone to leaf diseases when their foliage is wetted on a regular basis. And fourth, it is difficult to water uniformly if there are plants present that are tall enough to obstruct the spray. Design and installation of overhead sprinkler systems is therefore not covered in this book. Fortunately, if you already have a sprinkler irrigation system in place, it is not too difficult to switch this system over to a drip irrigation system, the method of choice for watering native plant landscapes.

Drip irrigation is characterized by the use of low pressure to apply a small volume of water over an extended period of time directly to a localized area around the plant. Applying water slowly over a targeted area works very well in native landscapes, because it waters only the root zone, not the interspaces. Very little water is lost to evaporation, and the problems of spray interception and diseases associated with wet leaves are avoided.

A Primer on Drip Irrigation

Drip irrigation is an easy concept to grasp, and installation of a drip irrigation system can be a relatively simple process. The exact design of the system is not critical, so do not worry too much about calculating everything perfectly. But you will probably approach your installation project with more confidence if you have an underlying understanding of some drip irrigation principles. This book can only provide the basics of drip irrigation, but you can find sources of additional information listed in the resource section.

Drip Layout

In drip irrigation, water is provided from a supply pipe that is usually at high pressure (50–80 psi, or pounds per square inch), such as a hose bibb or converted sprinkler system. You first need to reduce this pressure to 10–30 psi, the low pressure needed to operate a drip system, by installing a pressure regulator in the line. Next, this water at reduced pressure is passed through a filter. This is necessary because the orifices of the drip emitters, the devices that actually apply the water, are very small and easily clogged. Even culinary water can contain particles that can clog the emitters. The filtered water passes through a fitting that connects the filter to the drip line itself. This drip line, or tubing, is usually made of flexible polyethylene (PE) and is usually half-inch tubing (actually 16 mm or 0.62” in diameter). The emitters are installed at intervals along this tubing, which is capped at the end to prevent a loss of pressure to the emitters.
This is the simplest case scenario for a drip system, with a single drip line attached directly to a hose bibb. In fact, many variants are possible. One alternative is to install the drip system from scratch in a manner analogous to the installation of a sprinkler irrigation system, with buried lines, usually made out of rigid polyvinyl chloride (PVC) pipe, and multiple risers where drip lines are then attached. Installation of this kind of system involves a lot of serious trenching and leveling, and is probably best left to the same professionals who routinely install sprinkler irrigation systems, though a zealous do-it-yourselfer could do the job. If you hire professionals to do the installation, you need to make sure that they understand exactly how the drip system is designed and how it is intended to function.
Another common drip irrigation variant, one that is superior in design to a single long drip line attached to a water supply, is a design that has a main line that branches one or more times. This makes it possible to cover more area with the drip system, and to provide different watering regimes to different parts of the system. A branched system is also more efficient, as will be explained below.

A third drip irrigation possibility is to retrofit an existing sprinkler system as a drip irrigation system. Because sprinkler systems operate at high pressure and the sprinkler water passes through large orifices, these systems do not need filters or pressure regulation. To convert a sprinkler system to drip, it is necessary to insert both a pressure regulator and a filter into the line. Some drip conversion fittings have built-in pressure regulation and filters, but for other, simpler types of fittings, these components must be inserted into the supply line. The sprinkler heads can then be replaced with drip lines. Any sprinkler head locations that are not needed can just be capped off.

The number of emitters that can be installed in a drip system depends on several factors. The water demand created by the emitters depends on the number and flow rate of the emitters, while the ability of the system to meet that demand is determined by the size of the supply pipe. If the demand exceeds the ability of the supply pipe to provide water, the emitters toward the ends of the lines will either not drip at all or will drip at a lower rate. Because all the water in the supply pipe (e.g., the pipe that supplies your hose bibb) is reduced to the same low pressure, the supply of water to the emitters will depend directly on the diameter of the supply pipe. It would theoretically be possible to force a small supply pipe to provide the same amount of water as a large supply pipe, but only by increasing the pressure and therefore the flow rate beyond the tolerances of the drip irrigation components. Selection of appropriate emitter sizes is covered below. If you need to have more total emitter output per hour than your supply pipe can provide, you can split your system into two or more subsystems. By running these subsystems at different times, you will be able to supply water to as many emitters as needed. There are other advantages to multiple subsystems as well, such as providing the correct timing and amount of water to plantings in different water zones.
Another factor that affects how well the emitters at the end of the drip line will function is the length of the drip line. This is because the interior wall of the line creates friction as the water passes through, and this decreases the pressure, so that by the end of a long run of line, the pressure could be too low for the emitters to operate correctly. Two hundred feet is considered the maximum acceptable length for a single run of drip line, but if you can reduce the length of the run, the drip system will probably operate more precisely, especially on irregular terrain. The way to do this is to branch the lines. With a branching system, the maximum run length can be kept shorter while still maximizing the total length of line. The limiting factor in a well-designed system is the number of emitters at a given flow rate that the water supply can support, rather than the length of the run.Sloping ground can also cause uneven pressure along the length of a drip line run. If the ground is sloping, run the main line up or down the slope and the lateral lines along the contours. If possible, loop your main lines so that they return to a spot near the starting point. This helps equalize the pressure to emitters throughout the line and is generally a good idea, even on apparently level ground.
Watering by the Numbers

3. Reducing Friction Loss in the Supply Lines

Friction loss in a branched line is determined by the length of the run, which is the distance from the beginning of a line to the end of its longest branch. If the line is attached to the water supply in the middle of a 400-foot run, for example, then in effect you have two lines, each 200 feet long, the maximum recommended run length.

Or suppose you run your line out 130 feet, then create 8 laterals at the end at 10-foot intervals, each 50 feet long. Your longest run is 180 feet, namely the sum of the length of main line to the point where the last lateral is attached (130 feet) plus the length of the last lateral (50 feet). But you have supplied 400 feet of drip line to your plants.

Emitter Basics

There are a number of different designs for emitters, and each is suited to a different application. The three common designs are point-source emitters, inline emitters, and microsprinklers.

Point source emitters are the original form of drip irrigation, where a small piece of well-designed plastic restricts the flow of water from a large line down to a drip, so that only a small surface area is wetted. Note that the numbers stamped into the emitter plastic are almost always in liters, not gallons. For example, the numeral 4 means four liters per hour, or approximately one gallon per hour (gph). A point-source drip emitter has a barbed inlet that allows it to grip and hold when it is attached to the line. Pressure compensating emitters, which maintain a constant pressure inside the emitter regardless of pressure variations in the line, perform much better than regular emitters, especially
where the ground is sloping. All point-source emitters can drip directly onto the ground. Some emitter types can be made to drip into a narrow piece of “spaghetti tubing” pushed over the top of the emitter. This tubing permits pinpoint application of the water at some distance from the line. Spaghetti tubing is often not necessary, as the lines generally pass close by the plants, and the emitters can drip directly onto the root zone without any extra tubing.

Inline emitters are emitters that are pre-installed inside the line. The best inline emitters are drip emitters inserted into the polyethylene tubing during the manufacturing process. These are spaced evenly along the length of tubing at 6-, 12-, 18-, or 24-inch intervals, and have either 1/2, 1, or 2 gph flow rates. There are two other types of inline emitters, trickle tape and porous tubing, but we do not recommend them. Trickle tape is difficult to handle and not very durable, while porous tubing (soaker hose) is hard to control and clogs quickly, especially where the water is hard. These types of inline irrigation might be economical alternatives for a temporary watering system, but for the most part they should be avoided.

The third type of emitter is the microsprinkler, which is really somewhat of a hybrid between a drip emitter and a sprinkler. Microsprinkler irrigation is relatively low volume irrigation that pushes water through a tube and into a plastic head that breaks up the stream of water into a spray pattern, similar to a spray head in a regular overhead irrigation system. Microsprinklers come in different specifications that deliver water at rates from 2 to 15 gph and cover a circular or semicircular area of ground from one to eight feet in diameter. The spray head is detachable from the tube, and the tube is usually attached to a stake that is pushed into the ground. This tube is
made from heavy-walled PE that is more rigid than spaghetti tubing. A barbed fitting similar to the one used with drip emitters connects the tube to the supply line. Microsprinklers are good for larger plants because they irrigate a larger area of the root zone, with more water coming out of a bigger opening than that for drip emitters. Because they are upright and more visible, microsprinklers are easier to troubleshoot, but they are also much more likely to be damaged. They offer little advantage over drip emitters, except for large shrubs and trees.

Another handy little piece of plastic that looks a bit like an emitter is the goof plug. This is used to correct any mistakes when you are placing emitters, that is, to plug up a hole where an emitter has been removed.

**Putting the Pieces Together**

Assembling a drip irrigation system is a lot like playing with tinker toys. The fittings that attach pieces of drip line to each other are called couplers or connectors, and they come in several configurations. Straight couplers attach two pieces of tubing in a line, while tee couplers attach three pieces of tubing, and elbow couplers attach two pieces of tubing at right angles, permitting the line to go around a corner. The couplers that attach directly to PE tubing are generally of two types, compression fittings or barbed fittings. Each has its proponents. To attach tubing to compression fittings, the tubing is pushed into a tight opening at the end of the fitting. Compression fittings that are not properly drained can trap water that can later freeze and cause damage to the fitting. To attach tubing to a barbed fitting, the tubing is pushed over a series of ridges on the outside of the opening into the fitting. Barbed fittings tend to stretch and weaken the end of the PE pipe,
eventually causing it to split. In a third type, a spin-locl fitting, the tube slips over a nipple with an O-ring, which is then tightened down with a twisting nut. It is important to make sure that all connectors are the correct size for the PE tubing. Tubing sizes are actually in metric units, and there are two tubing sizes (16 mm and 18 mm) that are commonly referred to as “half-inch.” The fittings for these are not interchangeable.

Some connectors take PE tubing directly at all connection points. Others, called adapter connectors, have at least one male or female threaded connection point for attaching to other connectors, for example, when interfacing with a line of a different size. For threaded connectors, it is important to note whether they have pipe threading or hose threading. Pipe threading is finer than hose threading, and the two are not interchangeable. Many connectors also have built-in filters to further reduce the chances of clogging the emitters.

Another very important fitting for drip irrigation systems is the valve. A valve is a device for regulating the flow of water. In a system attached to a hose bibb, the valve (faucet) that turns on the water can also regulate the amount of water that passes through; in effect, this is a manual form of pressure regulation. In most cases, though, the valve will either turn the flow on or turn it off. If you have a system with multiple lines and a total number of emitters that exceeds the capacity of your supply line, it will be necessary to install valves on each subsystem, so that water can be delivered to the different subsystems at different times. The valves could be manually operated ball valves, similar to those used on hose Y-connectors, or they could be sophisticated electronic valves. Areas that represent different water zones in your landscape will need to be on separate subsystems.

Another use for valves is in connection with automatic timers. The timer signals the valve to open or close at pre-set times, thus controlling the timing and duration of the irrigation. This is the method commonly used with sprinkler irrigation systems. A problem with automatic timers for drip irrigation is that they rarely have options for irrigation intervals and durations that are appropriate for a drip system. Make sure when you buy a timer for your system that it has sufficient programming flexibility to meet your needs—most are designed for watering lawns. The timer program needs to be able to specify watering periods of one to eight hours at intervals at least up to thirty days. Eight hours may seem like a very long time, but remember, the water is being applied slowly. Many a plant on drip irrigation has died from overwatering because the timer insisted on fifteen-minute irrigations every other day. This may conceivably add up to the correct amount of water, but it is not the correct way to apply it, for reasons that are discussed below. It may sometimes be easier to dispense with the automatic timer altogether and operate your drip system manually.
This has the added advantage of providing an opportunity to exercise judgment on when the water is applied. How many of us have shaken our heads in exasperation upon seeing the neighbor’s automatic lawn sprinklers come on in the middle of a downpour?

**How Much to Water**

One thing you will have noticed in this discussion is that drip application rates are expressed in terms of gallons, while the watering recommendations described earlier in this book are expressed in terms of inches. Our task now is to get these two descriptions of water application to “speak” to each other. We first need to know the area of ground that a single drip emitter can water. This is difficult to learn by inspection, because most of the water that drips onto the ground disappears. At appropriate application rates, only a small spot on the soil surface is wetted. Fortunately, other people have made a study of this subject. A frequently recommended spacing between emitters is twenty-four inches, or two feet. The water spreads laterally underground, out of sight, to a distance of roughly twelve inches, or one foot, in a circle that radiates out from the emitter. You could therefore say that, on average, a single emitter can wet an area equal to the area of a circle with a radius of one foot, or a little more than three square feet. To apply an inch of water to the three square feet that it can wet, the emitter needs to apply about two gallons of water.
The distance out from the drip emitter that the water actually spreads underground depends on soil type. Because of smaller pore size, fine-textured clay soils conduct water laterally through wicking action better than coarse-textured sandy soils, and loamy soils have an intermediate lateral spread. As long as the water is applied at a suitable rate, different soils can absorb water equally well, but in sandy soil the water will penetrate more deeply, while in finertextured soil it will not penetrate as deeply but will spread more to the sides. Thus the effective area watered by a drip emitter on a sandy soil will be somewhat less than the area watered on a loam or clay soil. The flow rate of the emitter also influences the lateral spread of water in a soil. The lateral spread can be increased by increasing the flow rate, which is appropriate in a sandy soil, where you might want to increase the spread. In heavier soils, slower flow rates are needed to keep the water from puddling on the surface, and this will decrease the lateral spread.

In practice, differences in lateral spread due to soil type or flow rate are not too important, provided that the emitters are arrayed so that they target individual plants. As long as you do not grossly overwater, native plants are likely to send their roots to whatever depth the water has penetrated. They will use the water whether it spreads laterally or penetrates deeply, pretty much minimizing the effect of soil type on water availability. This might not be true for tomatoes or petunias, which have shallow root systems, no matter how deep the water penetrates. For these plants, a sandy soil must be watered more often, because there is less water held in this shallow root zone. But part of the remarkable ability of many native plants to survive with little water involves their capacity to extend roots to whatever depth the water penetrates and to whatever extent it spreads.

This capacity for root development in response to water availability also means that it is not necessary to apply irrigation water over the entire crown area of a plant. This is true even for trees from wetter places. Tree canopies intercept rainfall, so that the ground directly under the tree receives less rainfall than open ground next to the tree. Much of this intercepted water is redistributed in the canopy and ends up dripping from the branch tips in a ring around the outer perimeter of the tree. Surface roots are often concentrated beneath this drip line, so that irrigation water applied in this area is more effective than water applied near the trunk, where surface roots tend to be sparse. This is the reason that drip emitters for trees are usually arrayed in a ring just inside the drip line. As long as a sufficient volume of water is applied within the crown area of a plant, the exact placement of the water is usually not too critical.
Natives Versus Tomatoes: Root System Differences

These root systems were excavated and mapped on a hillside in central Idaho over eighty years ago. Native plants have deep and extensive root systems but usually lack a major concentration of roots near the surface. Even these small plants, including a serviceberry shrub hardly past the seedling stage, have roots 5–10 feet deep. In contrast, roots of cultivated plants like tomatoes have dense root systems concentrated near the surface.
To design your drip irrigation system, you first need a clear idea of how much water you will need to apply to each plant in a single irrigation. Our recommendation is to apply two inches of water each time you irrigate, regardless of the water zone being irrigated. Water zones requiring less irrigation will be watered less frequently than those requiring more irrigation, but when water is applied, it is best to apply enough water to ensure deep penetration. This places most of the water where it is protected from evaporation and can remain available for a longer period, and also encourages deep rooting.

Our watering recommendations are based on the principle that all the plants within a watering zone have similar water requirements. Applying the correct number of supplemental inches of water to the entire planting, even if it is made up of shrubs, trees, grasses, and wildflowers, should provide sufficient but not excessive water to all. The main distinction among different kinds of plants within a watering zone can largely be reduced to differences in plant size, that is, larger plants within a given watering zone need more water than smaller plants. These differing needs are met by supplying different sizes of plants with different numbers and types of emitters.

When designing your drip system, keep in mind that the system will need to be able to supply sufficient water to the plants after they reach mature size.
Obviously, a small sapling will not need as much water as a fully grown tree, but the initial system should allow for growth. The best way to do this is to increase the capacity of adjustable microsprinklers or to add point-source emitters as the tree develops. For point-source emitters on plants that will change greatly in size through time, it is a good idea to run a “rat-tail” line (a side line that attaches to the main drip line using a tee-connector) that is long enough to accommodate all the emitters that the mature plant will need. This way, you can add more emitters and widen the spacing of the loop as the plant grows, without needing to move lines or add more line. Make sure that you do not push the number of emitters beyond the capacity of the supply line. When you are calculating water demand on the supply line, you need to use the capacity of emitters that will water the mature tree, not the number that you plan to install for the sapling.

It is usually easier and more practical to place large plants such as trees on their own supply line, separate from the supply line for smaller plants, even within a water zone. This is because the absolute amounts of water to be applied are so different that smaller plants would be overwatered, even with a minimum number of emitters at the lowest flow rates, at the longer durations needed for larger plants. In order to water more of the crown area of a tree, it is often better to use microsprinklers than to multiply the number of drip emitters excessively. Combining microsprinklers and drip emitters on the same supply line can be problematic because of pressure issues. Microsprinklers also have higher flow ratings, and when the trees are mature, they could take up most of the capacity of a single supply line. Having the trees on their own supply line also introduces the possibility of multiple water zone plantings, with the trees in an irrigated water zone but the understory and interspace plantings in a zone that does not require supplemental irrigation.

Random Versus Regular Emitter Spacing

The drip system we have been discussing so far is designed to target each plant individually. Such a system is called a random spacing system because the placement of the lines and emitters follows the placement of the plants rather than being arrayed in a regular grid. The underlying reason for choosing a random spacing layout is that when plants are widely and irregularly spaced, targeting water to the root zone of each plant is the most efficient way to apply it. Most of the planting areas in a native plant landscape will be
suited to watering with a random spacing system, because the plans generally call for relatively wide spacing, mainly to avoid root zone overlap and the resulting competition for water. Wide spacing is also quite characteristic of many natural plant communities in the region. To capture the aesthetic of such communities, this spacing needs to be maintained.

The other type of irrigation layout is called grid or fixed spacing. There is definitely a place for fixed spacing drip systems in native plant landscaping. Fixed spacing drip is a practical way to irrigate a densely planted native landscape, such as a ground cover of trailing daisy or a blue grama lawn. In other words, fixed spacing drip systems can be a water-saving alternative in situations that would traditionally call for overhead sprinkler irrigation.

The simplest fixed spacing system uses inline emitters and is easy to envision, engineer, and install compared to the random spacing layout. All you have to do is lay out the inline emitter tubing in parallel rows to create a grid of emitters. The assumption with this design is that water will move laterally through capillary action to create a solid wetting front that provides uniform water. How you lay out inline drip tubing in a fixed-spacing grid will depend on your soil. As mentioned above, the pore spaces in sandy soil are large, water flows downward quickly, and there is little lateral movement, so you need to use tubing with a relatively narrow spacing between emitters, and have only a short distance between the lines. With a loamy or clay soil, lateral water movement is greater, so you can use a wider spacing between emitters and between rows. We recommend twelve-inch spacing in sandy soils and eighteen-inch spacing in loamy or clay soils for fixed spacing drip irrigation grids. This spacing creates considerable overlap in emitter coverage, and ensures an ample and uniform near-surface water supply that simulates rainfall across the entire area, especially necessary for plants like blue grama, which have relatively shallow roots.

Sometimes it will be advantageous to combine random and regular spacing in the drip system for a single planting. In this case, it may be easier to use regular drip line and installed emitters for the grid portion of the area, rather than inline emitters. For example, suppose you have an area planted to trees and shrubs that are fairly widely spaced and require targeted watering, but that these areas interfinger with others that have a ground cover of bunchgrasses and perennial flowers at closer spacing, with interspaces narrower than the average crown diameter of the plants. Targeting every one of these small plants with
its own emitter would create a maze of snaking lines and would probably result in overwatering. In these areas, it would be better just to lay out lateral supply lines parallel to each other with an eighteen- to twenty-four-inch spacing and to install emitters at eighteen- to twenty-four-inch intervals, creating a subsection of the system with regular spacing. It is not important that these lines be perfectly straight—they can go around plants if necessary. The point is to optimize the number of emitters to a level that provides adequate water to all the plants without creating greatly overlapping coverage and wasting water because emitters are too close together. The emitters do not need to be as close together as in the ground cover or lawn scenario, because the bunchgrasses and perennial flowers are generally not shallow-rooted. You could use inline drip line for this purpose, but mixing systems from different manufacturers can be tricky. You need to make sure that you have the correct connectors for interfacing the two types of drip line and that they work optimally over the same pressure range.

Designing a Drip Irrigation System

Now that you have some idea of how a drip system is put together, it is time to take out a copy of your planting plan and apply this knowledge, along with information about your site and the plants you are going to grow, to the design of your irrigation system. You will begin by sketching in a provisional watering system. For planting areas that will not need regular water, the most important consideration is the availability of water for establishment and for occasional hand or portable sprinkler irrigation during exceptionally dry periods. If you have the option of installing hose bibbs, install one or more within easy reach of all planting areas that will not have a permanent system. At least try to plan a route from an existing hose bibb, either along a path or across an unplanted area, to provide hose access to each area.

For planting areas that will have permanent drip irrigation systems, the planning can take one of several courses at this point. If you have an existing sprinkler system that you propose to convert to drip, the current location of sprinkler heads will form the basis of your design. If you plan to operate your system aboveground from one or more hose bibbs, the location of these bibbs will provide the starting point. If you plan to install an independent drip system from buried PVC pipe, the design of your system will need to include the point at which your buried system ties into the main water supply, the layout of the buried lines, and the location of risers where drip lines will be attached, as well as a plan for how the drip lines themselves will be laid out. Guidelines for designing and installing a drip system that includes buried PVC pipe are beyond the scope of this book, though the principles we describe here apply to the parts of the system that involve PE tubing and emitters.
To give you a clearer idea of the watering system planning process, we provide a hands-on example for the landscape illustrated in our design sequence. The site description tells us that this landscape is situated in the semi-desert water zone, with a mean annual precipitation of fifteen inches. Areas on the landscape plan that are designated as minimal (desert) and low (semi-desert) water zones should not require a formal irrigation system, especially as this site is at the high end of the semi-desert zone. The principal areas that will need drip irrigation are the three medium-water-zone canopy plantings and the high-water-zone plantings close to the north and east walls of the house. The understory plant species in the medium-water-zone canopy plantings are comprised entirely of bunchgrasses and perennials from the low water zone. It would be OK to provide these with supplemental water along with the trees and shrubs—but this really is not necessary for low-water-use plants. Because drip irrigation can target the individual trees and shrubs, we can in effect have two water zones in the same general area. This greatly simplifies the job of irrigating these areas. To avoid overwatering the low-water-use shrubs in this area, namely the cliffrose, they too can simply be excluded from the drip system.

Three hose bibbs already available on the outside of the house will provide the water for the irrigation system. These have three-quarter-inch supply pipes, so the maximum number of gallons per hour on each line should not exceed two hundred. Divide the yard into areas that will tentatively be supplied with individual lines, and determine which hose bibb will supply each area. For example, the medium-water mid-height and canopy areas in the back yard make a logical grouping to water on a single line from the back hose bibb. Use an irrigation design worksheet like the one shown here to determine whether your supply pipe can provide the plants you plan to water on each single line with sufficient water to meet their needs when mature, and determine how long you will need to water each time you irrigate to apply the requisite two inches of irrigation for each line. Once you have determined that the line as designed will supply the mature plants and will not have a run that exceeds two hundred feet, you can calculate the water demand and the length of an irrigation event for the new planting. Then you can determine what your emitter needs will be for each plant.

Specifying emitters for the near-term scenario is most important now, but it is also a good idea to consider how you will eventually water the mature plants. There are many correct ways to specify emitters for a given number of gallons per hour, and each has its pros and cons. In general, emitters with higher flow rates tend to water more deeply, while increased emitter numbers spread the water more widely within the crown area. Once the trees begin to approach full size, you will probably want to switch to microsprinklers, which can cover more crown area with a given volume of water. If you use the “rat-tail” method
Designing the Watering System

The goal for watering is to design an efficient and functional drip system that includes separate lines for plants in different water zones and for plants within a water zone that differ greatly in size. For each line, make sure not to exceed the maximum number of gallons per hour for the supply pipe, and ensure that the maximum run of line is less than 200 feet. This landscape design is efficiently watered with four lines, three for the medium-water-zone plantings and one for the high-water-zone planting. The low- and minimal-water-zone plantings do not need a permanent watering system.

1. The first line starts at the back hose bibb and waters the trees and shrubs in the back yard medium water zone. Note that the understory plantings are low-water-zone plants that do not require extra water.
2. The second line also starts at the back hose bibb. It waters the high-water-zone plantings near the north wall and on the east side of the house.
3. The third line starts at the hose bibb on the east side of the house. It waters the medium-water canopy planting to the east of the front driveway.
4. The fourth line starts at the front hose bibb. It waters the canopy plantings on the west side of the front driveway.
5. The hose bibbs can also be used to provide occasional extra water to the low-water plantings during exceptionally dry times.
6. The minimal-water plantings should not need extra water after establishment, even during dry times.
7. Remember, all plants need extra water during establishment.
### Watering by the Numbers

#### 6. Making a Drip Irrigation Design Worksheet

Irrigation at Maturity—8 hours per irrigation event  
*drp = drip emitter; ms = microsprinkler*

<table>
<thead>
<tr>
<th>Plant no.</th>
<th>Crown diam. (feet)</th>
<th>Gallons per plant for 2&quot;</th>
<th>Total gallons planned</th>
<th>GPH per plant</th>
<th>Emitters per plant in the example</th>
<th>Total GPH</th>
<th>Total gallons delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky Mtn. Juniper</td>
<td>4</td>
<td>12</td>
<td>144</td>
<td>576</td>
<td>18</td>
<td>2 (8 gph) ms</td>
<td>64</td>
</tr>
<tr>
<td>Pinyon Pine</td>
<td>1</td>
<td>15</td>
<td>225</td>
<td>225</td>
<td>28</td>
<td>2 (15 gph) ms</td>
<td>30</td>
</tr>
<tr>
<td>Bigtooth Maple</td>
<td>1</td>
<td>25</td>
<td>625</td>
<td>625</td>
<td>78</td>
<td>5 (15 gph) ms</td>
<td>75</td>
</tr>
<tr>
<td>Utah Serviceberry</td>
<td>3</td>
<td>6</td>
<td>36</td>
<td>108</td>
<td>4.5</td>
<td>1 (5 gph) ms</td>
<td>15</td>
</tr>
<tr>
<td>Alderleaf Mtn. Mahogany</td>
<td>3</td>
<td>5</td>
<td>25</td>
<td>75</td>
<td>3</td>
<td>1 (3 gph) ms</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total Planned</strong></td>
<td></td>
<td></td>
<td>1609</td>
<td></td>
<td>193</td>
<td></td>
<td>1544</td>
</tr>
</tbody>
</table>

Irrigation First Year—2 hours per irrigation event

<table>
<thead>
<tr>
<th>Plant no.</th>
<th>Crown diam. (feet)</th>
<th>Gallons per plant for 2&quot;</th>
<th>Total gallons planned</th>
<th>GPH per plant</th>
<th>Emitters per plant in the example</th>
<th>Total GPH</th>
<th>Total gallons delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky Mtn. Juniper</td>
<td>4</td>
<td>3</td>
<td>9</td>
<td>36</td>
<td>4.5</td>
<td>2 (2 gph) drp</td>
<td>16</td>
</tr>
<tr>
<td>Pinyon Pine</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1 (2 gph) drp</td>
<td>2</td>
</tr>
<tr>
<td>Bigtooth Maple</td>
<td>1</td>
<td>4</td>
<td>16</td>
<td>16</td>
<td>8</td>
<td>4 (2 gph) drp</td>
<td>8</td>
</tr>
<tr>
<td>Utah Serviceberry</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>1 (2 gph) drp</td>
<td>6</td>
</tr>
<tr>
<td>Alderleaf Mtn. Mahogany</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0.5</td>
<td>1 (1/2 gph) drp</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total Planned</strong></td>
<td></td>
<td></td>
<td>71</td>
<td></td>
<td>33.5</td>
<td></td>
<td>67</td>
</tr>
</tbody>
</table>
To calculate water demand and emitter needs for a proposed drip supply line:

1. Make a list of the plants on the proposed line, listing species and the numbers of each.
2. Note the crown diameter at maturity for each species (from the Plant Palette table).
3. Calculate the gallons per plant for a 2" irrigation (crown diameter squared).
4. Calculate the total gallons planned by multiplying plant number times gallons per plant for each species and summing these numbers for all species.
5. Divide the total gallons planned by the gallons per hour (gph) that your supply line can deliver to get an estimate of the number of hours you will need to irrigate when the plants have reached maturity in order to apply 2" of water: \( \frac{1609 \text{ gallons}}{200 \text{ gallons per hour}} = \text{approximately 8 hours} \). 
6. Calculate gph for each plant by dividing the gallons needed for a 2" irrigation by the hours of irrigation: For pinyon pine: \( \frac{225 \text{ gallons}}{8 \text{ hours}} = 28 \text{ gph} \).
7. Determine a combination of emitter capacity and number that yields approximately the appropriate number of gallons: two 15–gph microsprinklers = 30 gph.

Repeat the calculations using the crown diameter at planting for each plant to determine the water demand for the new planting. This will usually be much less than for the mature planting, especially for woody plants that increase greatly in size.
we described earlier, with spur lines to each plant, you can add capacity to your system every year or two to accommodate the growth of the shrubs and trees without undue trouble. It usually is not necessary to change out or add emitters for perennials, which rarely have a crown area larger than a single emitter can supply. You may sometimes find that you cannot easily come up with an emitter combination that gives you the exact number of gallons per hour specified. But as long as you are ballpark close—say, within 10 percent or so—the system should work well, and your plants should get enough water.

You can approach design of any drip system using a strategy similar to the one just described. It is helpful to place Y-connectors at each hose bibb, so that you can easily attach a garden hose for hand watering or any other water use that arises without disconnecting the drip system. This is especially important for the back hose bibb in this design, in light of the fact that you may want to provide occasional supplemental water in the summer to the blue grama lawn area adjacent to the patio, especially if you live in an area with little natural summer precipitation. This grass can survive perfectly well without much summer rain. But if you want a lawn that can be mown for a children’s play area, as indicated in the human needs analysis, it will perform better if it receives an inch or two of supplemental water every few weeks. A portable sprinkler could easily accomplish this task. It won’t be necessary to water the blue grama on the west side of the house, as your expectations for this area would probably not be as high.
Emitter Needs for Watering Plants of Different Sizes with Drip Irrigation

The goal is to apply the approximate number of gallons needed to add the equivalent of 2” of water over the entire crown area of the plant.

The total number of gallons needed is obtained by multiplying the crown area of the plant in square feet by 1.25, a conversion factor which represents the number of gallons needed to apply 2” of water to one square foot.

<table>
<thead>
<tr>
<th>Plant Crown Diameter (feet)</th>
<th>Crown Area (square feet)</th>
<th>Gallons for a 2” irrigation</th>
<th>Example Drip Emitter Combinations for Applying ca. 2” of Water during Irrigation Periods of Different Durations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 hours</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1-1/2gph</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2-1gph</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>9</td>
<td>4-1gph</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>16</td>
<td>4-2gph</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>25</td>
<td>6-2gph</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>36</td>
<td>9-2gph</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>49</td>
<td>6-4gph</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>64</td>
<td>8-4gph</td>
</tr>
<tr>
<td>9</td>
<td>65</td>
<td>81</td>
<td>10-4gph</td>
</tr>
<tr>
<td>10</td>
<td>80</td>
<td>100</td>
<td>13-4gph</td>
</tr>
<tr>
<td>11</td>
<td>95</td>
<td>121</td>
<td>15-4gph</td>
</tr>
<tr>
<td>12</td>
<td>110</td>
<td>144</td>
<td>18-4gph</td>
</tr>
<tr>
<td>13</td>
<td>135</td>
<td>169</td>
<td>--*</td>
</tr>
<tr>
<td>14</td>
<td>155</td>
<td>192</td>
<td>--*</td>
</tr>
<tr>
<td>15</td>
<td>180</td>
<td>225</td>
<td>--*</td>
</tr>
<tr>
<td>16</td>
<td>200</td>
<td>256</td>
<td>--*</td>
</tr>
<tr>
<td>20</td>
<td>310</td>
<td>400</td>
<td>--*</td>
</tr>
<tr>
<td>25</td>
<td>500</td>
<td>625</td>
<td>--*</td>
</tr>
</tbody>
</table>

Rule of thumb: Gallons needed for a 2” irrigation = crown diameter² ( = crown diameter x itself).

* Better watered with microsprinklers.
** Irrigation period too long for small plants - smallest emitter overwaters.