Spacing sprinklers and calculating precipitation rates

Before talking about sprinkler spacing patterns, let's take a look at sprinkler distribution in general, and the need for overlapping sprinkler coverage in particular.

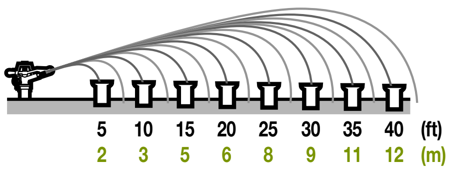


Figure 32: Measuring sprinkler distribution with containers

When a sprinkler is tested to determine its distribution rate curve (often abbreviated as DRC), the sprinkler is placed at a given point and containers are positioned at equal intervals along a leg of the expected radius of coverage. The sprinkler is operated for a predetermined amount of time and then the water in each container is measured to determine how well the sprinkler distributed the water.

DRCs can be obtained from Rain Bird or they can be obtained from an independent testing agency such as the Center for Irrigation Technology (CIT) in Fresno, California. Understanding the DRC also allows the comparison of sprinkler, pressure and nozzle combinations to determine which combination has the potential to apply water with the greatest efficiency. One metric used to compare DRCs is the **scheduling coefficient** or **SC**.

SC is calculated for overlapping sprinklers. The calculation can be done on a theoretical basis or using catch can measurements made on site by operating a built irrigation system. SC is the average depth of water in the catch cans divided by the depth of water in the catch can having the least amount of water. A perfect, and non-existent, SC is one. Actual SCs are greater than 1.0 and the potentially most efficient overlap patterns are those with the lowest SC. Practically speaking, an SC of 1.15 is considered excellent.

Rain Bird can provide graphics that help ascertain the best DRC, and consequently the best SC, or CIT has a computer program available that can be used to compare DRCs.

The resulting data, when plotted on a graph, should ideally look like a 30° slope coming down from the sprinkler location — a wedge. In the case of a full circle sprinkler, the graph would look like a cone with the sprinkler location at the center and the sloping sides indicating less and less water being measured as the distance increases from the sprinkler. Finally, where the sprinkler radius came to an end, there would be a container far enough from the sprinkler to have no measurable water.

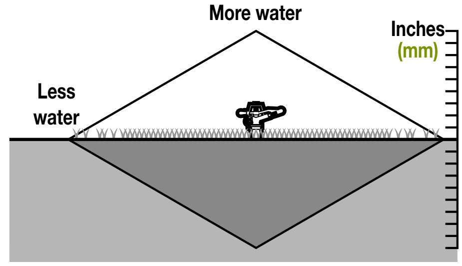


Figure 33: Sprinkler water distribution graph

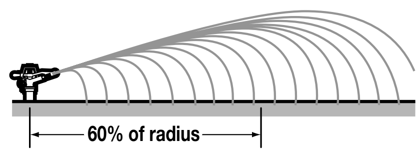


Figure 34: 60% sprinkler radius

The area under the first 60% of the sprinkler's radius is generally sufficiently irrigated to grow vegetation without the need for an overlapping sprinkler. Beyond this 60% line, the amounts of water, diminishing with distance, become less and less effective and eventually will not support plants.

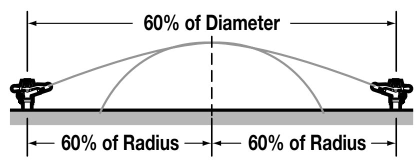


Figure 35: 60% diameter sprinkler spacing

The maximum spacing recommended, therefore, is where the sprinkler is located, so its 60% of radius line meets the 60% line of its neighbor. This is the 60% of diameter that was noted earlier. The less effective, last 40% of each sprinkler's throw is overlapped into the more effective close-in coverage of the adjacent sprinkler. In cases where very coarse soil, high winds, low humidity or high heat inhibit effective irrigation, closer spacing is recommended.

Head-to-head, or 50% sprinkler spacing, is the most common spacing used in landscape irrigation. Where winds are a threat to good coverage, spacing as close as 40% may be required. When sprinkler spacing is stretched, turfgrass will exhibit dry spots within the area of the spacing pattern. These weak spots may show up as lighter green turf, yellowing or brown foliage or dead plant material. When the system is installed and this problem of "stretched" spacing shows up, the project owner often over-waters the rest of the areas trying to make up for the lack of water in the weak spots.

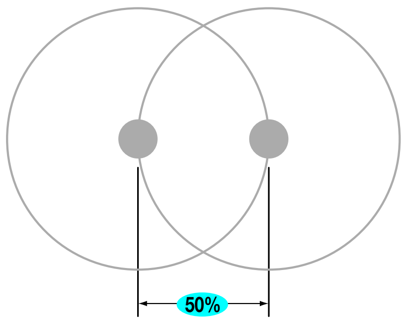


Figure 36: 50% sprinkler head spacing

One of the main reasons for carefully selecting the sprinklers is so they can be accurately plotted on the plan. Once the designer chooses the equipment he or she plans to use, proper spacing is the next critical step. The site information will usually dictate what spacing pattern makes those arcs of coverage fit into the planting areas.

There are three main types of sprinkler spacing patterns and a number of variations to adapt these patterns to special situations.

The **square pattern**, with its equal sides running between four sprinkler locations, is used for irrigating areas that are square themselves, or have borders at 90° angles to each other, and that confine the design to that pattern. Although the square pattern is the weakest for proper coverage if not used carefully, enclosed areas often rule out the use of other patterns.

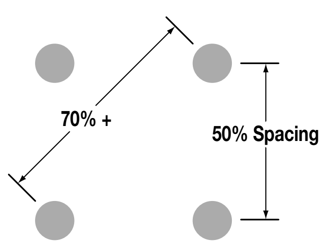


Figure 37: Square sprinkler spacing pattern

The weakness in square spacing coverage is caused by the diagonal distance between sprinklers across the pattern from each other. When the sprinklers are spaced head-to-head along the sides of the square pattern, the distance between sprinklers in opposite corners of the pattern is over 70% spacing. This 70% diagonal stretch across the square pattern can leave a weak spot at the center. The wind may move the weak spot slightly away from the center and summer heat may make the weak spot quite large if it is a common climatic condition for the site.

To minimize the effects of wind trouble when using the square pattern, closer spacings (which require more sprinklers) are recommended, depending on the severity of the wind conditions. The recommendation on the chart for low or no wind is for 55% spacing. And on projects with higher winds, the spacing should be reduced as indicated below.

For sites with wind velocities of:	Use maximum spacings of:
0 to 3 mph (0 to 5 km/h)	55% of diameter
4 to 7 mph (6 to 11 km/h)	50% of diameter
8 to 12 mph (13 to 19 km/h)	45% of diameter

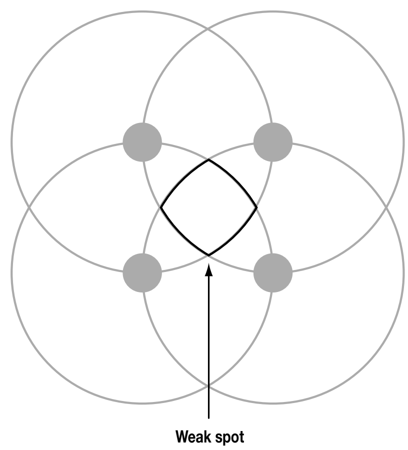


Figure 38: Square sprinkler spacing pattern weak spot

The **triangular pattern** is generally used where the area to be irrigated has irregular boundaries or borders that are open to over spray, or do not require part-circle sprinklers. The equilateral triangle pattern, where the sprinklers are spaced at equal distances from each other, has some advantages over square spacing.

Because the rows of sprinklers are offset from adjacent rows to establish the triangular pattern, the weak spot that could be a problem in square spacing is absent. In most cases, the sprinklers can be spaced further using triangular spacing than with square spacing. This additional distance between sprinklers often means fewer sprinklers will be required on the project. Fewer sprinklers on the site means less equipment cost for the project, less installation time and lower maintenance costs over the life of the system.

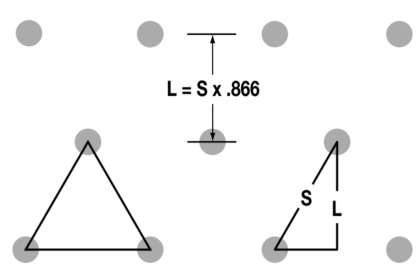


Figure 39: Triangular sprinkler spacing pattern

The dimensions of a spacing pattern are often labeled "S" and "L." "S" stands for the **spacing** between sprinklers and "L" stands for the spacing between the rows of sprinklers or **laterals**. In an equilateral triangular spacing pattern, the distance "L" (the height of the triangle) is the sprinkler spacing "S" x .866. If large rotors on a golf course were spaced at 80 ft (25 m) in an equilateral triangular pattern, the distance between rows of sprinklers would be 80 ft (25 m) x .866 = 69.28 ft (21,65 m).

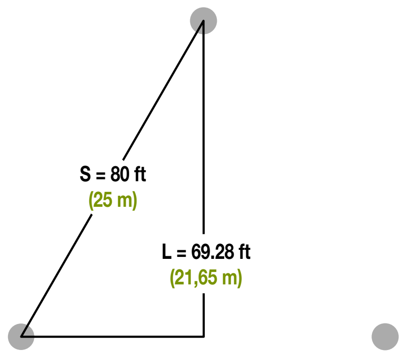


Figure 40: S and L triangular sprinkler spacing pattern

As you can see, there is no unequally stretched spacing like the diagonal line in square spacing. Because of this factor, the spacing recommendations of an equilateral triangular pattern are somewhat less restrictive for windy conditions. The chart allows greater distances between sprinklers beginning with 60% spacing and reducing down to head-to-head spacing for windier areas.

For sites with wind velocities of:	Use maximum spacings of:
0 to 3 mph (0 to 5 km/h)	60% of diameter
4 to 7 mph (6 to 11 km/h)	55% of diameter
8 to 12 mph (12 to 19 km/h)	50% of diameter

The **rectangular pattern** has the advantages of fighting windy site conditions and being able to fit in areas with defined straight boundaries and corners. By closing in the spacing across the wind and opening up the length of the pattern with the wind, the designer can maintain good sprinkler coverage.

In each case listed on the chart, the length of the pattern remains at 60% spacing, while the distance across the wind is decreased to combat increasing velocities.

For sites with wind velocities of:	Use maximum spacings of:
0 to 3 mph (0 to 5 km/h)	L = 60% of diameter S = 50% of diameter
4 to 7 mph (6 to 11 km/h)	L = 60% of diameter S = 45% of diameter
8 to 12 mph (13 to 19 km/h)	L = 60% of diameter S = 40% of diameter

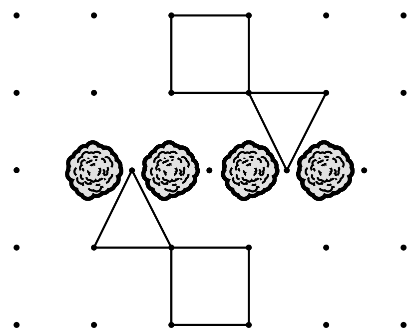


Figure 41: Staggered sprinkler spacing pattern

Combinations of the various patterns mentioned so far may be used on the same area of a project to adapt to special conditions. If the designer is laying out sprinklers for a lawn area, for instance, and comes to a tree or row of shrubs, a staggered spacing pattern to adjust for the obstacles can be used. By staggering the pattern from square or rectangular to a slightly tilted parallelogram or to triangular shape, the degree of coverage can be maintained even though the pattern doesn't match the rest of the area. After positioning the sprinklers to surround or pass through the area of the obstructions, the designer can return from the staggered pattern to the original spacing pattern.

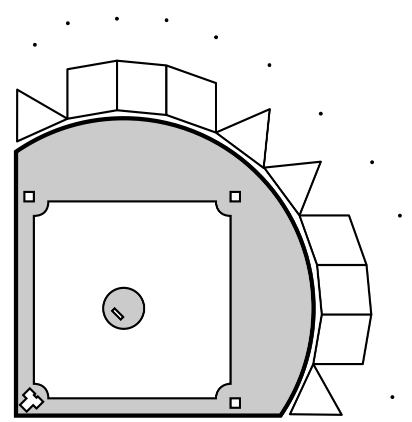


Figure 42: Sliding pattern

To adapt to a curving boundary, the **sliding pattern** allows for a gradual change from perhaps square or rectangular spacing to a parallelogram, and then to triangular spacing and back again if necessary. By sliding the pattern to maintain spacing requirements along a curving border, the designer avoids bunching up sprinklers on the inside curves and stretching the spacing on outside curves.

A good example for the use of the sliding pattern method is the sprinkler spacing often designed for the outfield of a baseball field. The designer may start with rectangular spacing behind third base and, while following the outside curve of the scalped area of the baselines, gradually slide through the parallelogram patterns to triangular behind second base, and continue sliding back through the patterns to rectangular again behind first base. This sliding method of spacing the sprinklers would continue right out to the part-circle sprinklers along the outfield fence.

If the designer knows how many inches (millimeters) of water per week or per day will be required to properly maintain the plant material for the project, the next thing to know is the rate at which the sprinklers will apply the water. The precipitation rate of the sprinklers selected should be calculated to determine first if the rate exceeds the soil's intake rate (which it shouldn't) and, secondly, if the rate will apply enough water during acceptable operating times to meet the irrigation requirement (which it should).

The average precipitation rate is expressed in inches per hour (millimeters per hour). A simple formula is used to calculate precipitation rates for sprinklers using the area inside the sprinkler spacing and the gallons per minute (cubic meters per hour) being applied to that area. The formula looks like this:

$$PR = \frac{96.3 \times \text{gpm (applied to the area)}}{S \times L}$$

$$\left(PR = \frac{1000 \times \text{m}^3\text{/h [applied to the area]}}{S \times L} \right)$$

Where:

PR	=	the average precipitation rate in inches per hour	PR	=	the average precipitation rate in millimeters per hour
96.3	=	a constant which incorporates inches per square foot per hour	1000	=	a constant which converts meters to millimeters
gpm	=	the total gpm applied to the area by the sprinklers	m^3/h	=	the total m^3/h applied to the area by the sprinklers
S	=	the spacing between sprinklers	S	=	the spacing between sprinklers
L	=	the spacing between rows of sprinklers	L	=	the spacing between rows of sprinklers

The constant of 96.3 (1000) is derived as follows:

1 gal water = 231 in^3 1 ft^2 = 144 in^2
(1000 mm = 1 m)

Question: If one gallon of water was applied to 1 ft^2 how deep in inches would the water be?

$$\frac{231 \text{ in}^3\text{/gal}}{144 \text{ in}^2\text{/ft}^2} = 1.604 \text{ in deep}$$

One of the multipliers in the upper half of the equation is the gallons per minute applied by the sprinklers. To convert this to gallons per hour we need to multiply by 60 minutes. To work this into the constant, we multiply 1.604 in x 60 min and we come up with the 96.3 for the formula. (In the International System Units version of the formula, because the multipliers already are in meters cubed per hour, you do not need to convert the 1000 before using it in the formula.)

Let's look at an example of a precipitation rate calculation for four full circle impact sprinklers. Each sprinkler has a radius of throw of 40 ft (12 m) at 40 psi (3 bar), a discharge of 4.4 gpm (1 m^3/h) and the sprinklers are spaced at 40 ft (12 m) square spacing. The diagram of the sprinkler pattern would look like Figure 43.

Each full circle sprinkler delivers only 1/4 of its flow into the area between the four sprinklers. The other 3/4 of each sprinkler's rotation pattern is outside the area. With 4.4 gpm (1 m^3/h) total per sprinkler, only 1.1 gpm (0,25 m^3/h) is delivered per sprinkler into the area between them. When four sprinklers delivering 1.1 gpm (0,25 m^3/h) each are added together, they are the equivalent of one full circle sprinkler or 4.4 gpm (1 m^3/h). With full circle sprinklers, you can use the equivalent of one sprinkler's discharge as the gallons per minute (meters cubed per hour) for the precipitation rate formula.

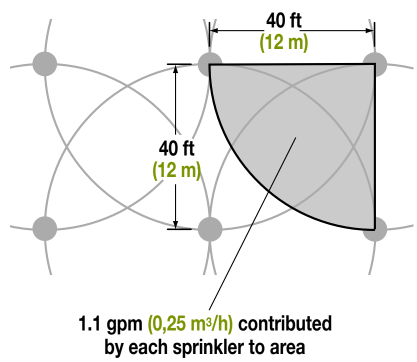


Figure 43: Square sprinkler spacing pattern with full circle sprinkler

The formula for this example would be:

$$PR = \frac{96.3 \times 4.4 \text{ gpm}}{40 \text{ ft} \times 40 \text{ ft}} = \frac{423.72}{1600} = .2648 \text{ in/h}$$

$$\left(PR = \frac{1000 \times 1 \text{ m}^3\text{/h}}{12 \text{ m} \times 12 \text{ m}} = \frac{1000}{144} = 6{,}94 \text{ mm/h} \right)$$

The above calculation tells the designer that the sprinklers at that spacing, if given the pressure required, will apply water at slightly more that 1/4 in (6,9 mm) per hour. Using the same 40 ft x 40 ft (12 m x 12 m) spacing that we used earlier, let's look at those same sprinklers in half circle configuration.

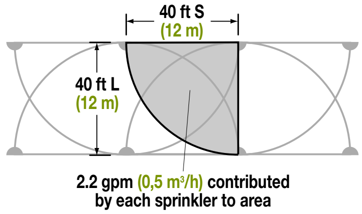


Figure 44: Square sprinkler spacing pattern with part circle sprinkler

With the same performance specs of 4.4 gpm (1 m^3/h) per sprinkler and all the sprinklers now set at half circle, the formula is:

$$PR = \frac{96.3 \times 8.8\ \text{gpm}}{40\ \text{ft} \times 40\ \text{ft}} = \frac{847.44}{1600} = .529\ \text{in/h}$$

$$\left(PR = \frac{1000 \times 2\ m^3/h}{12\ m \times 12\ m} = \frac{2000}{144} = 13{,}89\ mm/h \right)$$

Even though there are eight sprinklers in the diagram, we are only interested in the area between four adjacent sprinklers. The 8.8 gal (2 m^3/h) was determined by adding up the part of the discharge from each sprinkler that it contributed to the area. With each sprinkler in the half circle setting, one half of its flow was distributed into the square pattern while the other half went into the neighboring pattern. The amount of flow per sprinkler, then, was 2.2 gpm (0,5 m^3/h) multiplied by four sprinklers for a total of 8.8 gpm (2 m^3/h).

Spray sprinklers have fixed arcs of coverage and some have matched precipitation rates. Let's look at a PR calculation for four spray sprinklers in the corner of a lawn area with these statistics:

Spacing: S = 11 ft (3 m), L = 12 ft (4 m)
Operating pressure at the sprinklers = 25 psi (1,7 bar)
Radius of throw = 11 ft (3 m), regardless of pattern
Discharge: Full circle = 2.4 gpm (0,56 m^3/h)
Half circle = 1.2 gpm (0,28 m^3/h)
Quarter circle = .6 gpm (0,14 m^3/h)

The spacing pattern might look like this:

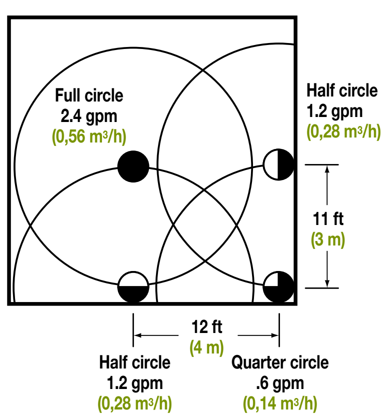


Figure 45: PR calculation for four spray heads

The total amount of water being applied to the area by these matched precipitation rate spray sprinklers is:

Full circle sprinkler	= 0.6 gpm (0,14 m^3/h) [1/4 of its discharge]
Half circle sprinkler	= 0.6 gpm (0,14 m^3/h) [1/2 of its discharge]
Half circle sprinkler	= 0.6 gpm (0,14 m^3/h) [1/2 of its discharge]
Quarter circle sprinkler	= 0.6 gpm (0,14 m^3/h) [all of its discharge]
Total	= 2.4 gpm (0,56 m^3/h) applied to the area

In calculating the rate for this example, the formula would be:

$$PR = \frac{96.3 \times 2.4\ \text{gpm}}{11 \times 12} = \frac{231.12}{132} = 1.75\ \text{in/h}$$

$$\left(PR = \frac{1000 \times ,56\ m^3/h}{3 \times 4} = \frac{560}{12} = 46{,}67\ mm/h \right)$$

Having completed the calculation, the designer knows to expect a precipitation rate of 1.75 in/h (47 mm/h).

Triangular spacing is just as easy to work with when calculating the precipitation rate as square or rectangular spacing. The main difference is calculating the height of the pattern before using it as one of the dimensions in the formula.

In this example, large size rotor pop-up sprinklers are spaced head-to-head at 70 ft (21 m) in a triangular pattern. The gallons per minute (meters cubed per second) from each of these full circle sprinklers is 27.9 (6,33 m^3/h). The pattern would look like this:

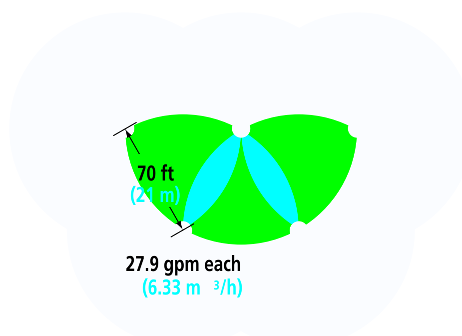


Figure 46: Calculating triangular sprinkler spacing

One dimension in the spacing pattern is 70 ft (21 m), the spacing between sprinklers, and the other is the height of the pattern, the spacing between rows of sprinklers. This height is the spacing multiplied by .866. In this case, we have a height calculation of 70 ft x .866 = 60.62 ft (21 m x .866 = 18,19 m). The dimensions to use in the PR formula for this situation are 70 ft x 60.62 ft (21 m x 18,19 m).

The easiest way to calculate the PR for triangular patterns is to treat them as parallelograms, using four sprinklers instead of three. When examining the pattern as a parallelogram, you can see that two of the sprinklers are contributing less of an arc (and therefore a smaller part of their flow to the area) than the other two. The other two, however, contribute proportionally larger flows so that the total flow matches that of four sprinklers in a rectangular pattern.

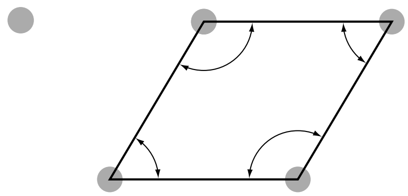


Figure 47: Calculating the PR for triangular sprinkler spacing patterns

The PR calculation for this example would be:

$$PR = \frac{96.3 \times 27.9 \text{ gpm}}{70 \text{ ft} \times 60.62 \text{ ft}} = \frac{2686.77}{4243.4} = .633 \text{ in/h}$$

$$\left(PR = \frac{1000 \times 6{,}33 \text{ m}^3\text{/h}}{21 \text{ m} \times 18{,}19 \text{ m}} = \frac{6330}{381{,}99} = 16{,}57 \text{ mm/h} \right)$$

Now that you have been exposed to calculating precipitation rates, see how you do on a few sample problems relating to what we have covered. Turn the page and complete the exercises, then compare your answers to those in the Solutions section on page 90.

Exercises on spacing sprinklers and calculating precipitation rates

Put an **X** after the correct answers below.

A. What is the maximum sprinkler spacing recommended in this manual when site conditions are near optimum (very limited irrigation interference from wind, heat, soil type, etc.) for good sprinkler coverage?

If you can see one sprinkler from its neighbor, that's close enough ____

Head-to-head spacing only 60% of the sprinkler's diameter of throw ____

The outer radius of throw from one sprinkler touching the outer radius of throw of the next sprinkler ____

B. Which spacing pattern below has a wind-fighting advantage as well as being adaptable to areas with straight borders and 90° corners?

Sliding pattern ____

Rectangular pattern ____

Triangular pattern ____

Square pattern ____

Elliptical pattern ____

C. If not designed carefully, which spacing pattern has the probability of a "weak spot?"

Sliding pattern ____

Rectangular pattern ____

Triangular pattern ____

Square pattern ____

Elliptical pattern ____

D. The flow in the precipitation rate formula is:

Always the equivalent of one full circle sprinkler ____

Never the equivalent of one full circle sprinkler ____

Only the flow entering the pattern we're checking ____

The grains per million of grit in the water ____

E. The 96.3 (1000) in the precipitation rate formula:

Is a constant ____

Converts minutes to hours ____

Is for full circle sprinklers only ____

Converts feet-of-head (meters-of-head) to psi (bar) ____

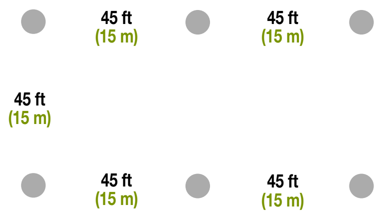
F. "S" and "L" in the precipitation rate formula refer to:

Sprinkler spacing and row spacing ____

Distance between sprinklers on a line and between that line and the next ____

"S" is spacing between sprinklers, "L" is for spacing between rows of sprinklers on their laterals ____

G. Calculate the precipitation rate for the sprinklers in the diagram below.



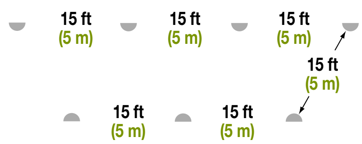
gpm (m^3/h) per sprinkler = 5 (2)
distance of throw = 45 ft (15 m)
type of sprinkler = impact (rotating sprinkler)
sprinkler setting = full circle

Fill in the formula and the PR.

$$\frac{96.3 \times ?\ \text{gpm} =}{? \times ?} \qquad \left(\frac{1000 \times ?\ \text{m}^3\text{/h} =}{? \times ?}\right)$$

H. The answer to the formula is in ________ per _________.

I. Answer the questions concerning the diagram below:



spacing pattern = equilateral triangle
gpm (m^3/h) per sprinkler = 2 (0,45)
radius of sprinkler = 15 ft (5 m)
type of sprinkler = half circle spray sprinkler

There are seven sprinklers in the diagram. In the procedure for calculating the PR for equilateral triangular spacing, this manual suggests using _________ as the number of heads in the pattern and treating the pattern like a ____________.

The height of the sprinkler pattern can be determined by multiplying 15 ft (5 m)times ____________ for an answer of ____________ ft (m).

Fill in the blanks of the formula for the precipitation rate of the sprinklers depicted in the above diagram.

$$\frac{96.3 \times ?\ \text{gpm} =}{? \times ?} \qquad \left(\frac{1000 \times ?\ \text{m}^3\text{/h} =}{? \times ?}\right)$$

Locating sprinklers on the plan

With all that has been covered concerning sprinkler performance, sprinkler spacing and calculating precipitation rates, we are now ready to use this information to properly locate sprinklers on the plan.

Properly locating the sprinklers is extremely important! An irrigation system is one of the few items that is purchased and then buried in the ground. Major problems are difficult to correct after a system has been installed, and even minor mistakes in the design or installation phases of the project can be costly to correct.

The goal in positioning the sprinklers is to make sure all areas that require irrigation have adequate sprinkler coverage. **Remember not to stretch the spacing between sprinklers beyond their recommended ranges.** The row of sprinklers on the project that might be eliminated because all the other rows were stretched, will cost the system owner many times the money saved on initial installation. To make up for poor coverage, the owner will likely apply more water. Over the life of the system, much money will be lost in water waste.

Here are some of the things to keep in mind after you have selected the sprinkler for a particular area:

1. Begin laying out sprinklers in trouble areas first. "Trouble areas" are those with odd shapes, prominent obstructions, confined spaces or other features that require special spacing considerations. After establishing the sprinkler locations in the "trouble areas," move out into the open areas by using sliding or staggered spacing.

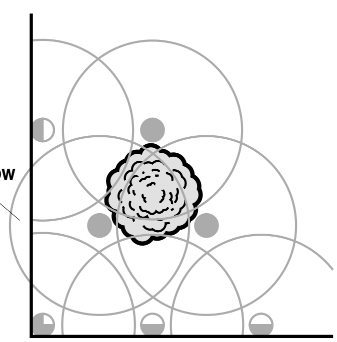


Figure 48: Sprinkler pattern for shrubs and trees

The exact locations of trees on (or to be planted on) the site are important so the designer can provide for them in sprinkler spacing. For trees or large bushes and hedges that are not to be irrigated separately, the sprinklers in the area should surround and throw into or under the plants. For the sprinklers spaced too near, this larger foliage acts as a barrier to good distribution. If the tree or large bush can be watered along with the turf or ground cover without over watering, surround it with at least three sprinklers so it doesn't affect coverage of the other plantings.

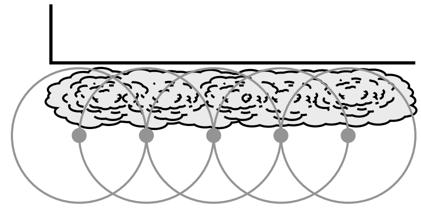


Figure 49: Sprinkler pattern for hedges

A dense hedge, if not to be watered by bubblers or drip irrigation, can often be thrown into by nearby sprinklers. If, instead, bubblers are to be used for trees or hedges, a low flow bubbler should be used (.25 gpm to .50 gpm [0,06 to 0,11 m^3/h or 0,02 to 0,03 L/s]) or a standard flow bubbler (1 gpm [0,23 m^3/h or 0,06 L/s] or more) using a basin to catch any runoff. For information on designing drip irrigation, see the Rain Bird Xerigation Design Manual (Catalog No. D39030C).

2. Where possible, use the same types of sprinklers over a given area. Remember the next step after plotting the sprinklers is to group them into valve circuits or laterals. If the turf area on your plan is covered by all spray sprinklers except for rotor pop-ups on one slightly wider spot, the rotors will have to be valved separately from those spray sprinklers. Try not to isolate three or four special sprinklers that will require their own valve if it really is not necessary.

3. After locating all the sprinklers on the plan, visually check the entire system for proper spacing and good coverage. This is the time to make any slight adjustments, add or delete sprinklers and check spacing before drawing in any pipe routing.

Let's look at some typical sprinkler-locating methods for handling various types of planting areas.

Small planters and **narrow planting beds** can usually be adequately irrigated with drip irrigation, flood bubblers, stream bubblers or short-radius spray sprinklers. If a planter is narrow with walled or bermed borders, flood bubblers can be used to fill the reservoir area under the plants. Slightly wider planting areas can use stream bubblers that can throw gentle streams out to a radius of 5 ft (1,5 m). Narrow lawn strips can be watered by short-radius spray sprinklers with strip pattern nozzles.

Let's see how the designer handled planters and narrow beds in the sample project (see Figure 50). From the designer's plan, we can see that low-flow drip irrigation has been used for the planting beds. The drip irrigation pipe is shown graphically by a single dashed line winding through the planting beds. The individual emitters that provide water to the plants are typically not shown on the designer's plan. Areas "D", "E" and "H" each represent individual drip laterals. The trees in the planting beds will use multi-outlet emitters, with four outlets open. The shrubs each have two single-outlet emitters. Because drip irrigation has very low flows, typically measured in gallons per hour (liters per hour) as opposed to gallons per minute (meters cubed per hour or liters per second), drip emitters and sprinklers are never mixed on the same valve.

In the planting beds of area "I," the designer has specified tiny micro-sprays, or xeri-sprays, that have been adapted to 12 in (30,5 cm) pop-up spray sprinklers. In the one isolated part of area "H", on the edge of the walkway between the houses, the designer chose flood bubblers mounted on risers for the climbing plants.

Landscaped strips can be irrigated in several ways. For strips that are 4 to 7 ft (1,22 to 2,13 m) wide, pop-ups for lawns and shrub sprinklers or high-pops for shrub areas can be used with center strip or end strip spray nozzles. These nozzles have a "bow tie" or half-bow tie pattern and are located down the center of the area. For strips with trees in the center of the shrub or lawn area, the side strip nozzle can cover the area from each edge of the strip instead of the center where the trees would block the spray. Wider strips, more than 6 to 7 ft (1,83 to 2,13 m) in dimension, can use half circle spray sprinklers throwing in from both edges.

Narrow strips and confined areas often use low-angle trajectory or flat-angle spray sprinklers to reduce the chances of over spraying the area. Many strips and planter areas are bordered by walkways, such as the common areas between apartments, condominiums and offices where overspray is unacceptable.

VAN, or variable arc nozzles, are used when the standard arc configuration does not provide adequate coverage. The unusual shape of area "G" lends itself to using VAN nozzles. Half circle nozzles would create overspray into other areas, third and quarter circle nozzles would not provide enough coverage. VANs are adjustable to any arc from 0° to 360°.

In the **wider lawn areas**, the designer is using standard arc spray patterns. In area "B," the designer has selected 12 ft radius (3,66 m radius) spray nozzles and in the narrow part of the lawn in area "C," he has switched to 10 ft radius (3,05 m radius) nozzles.

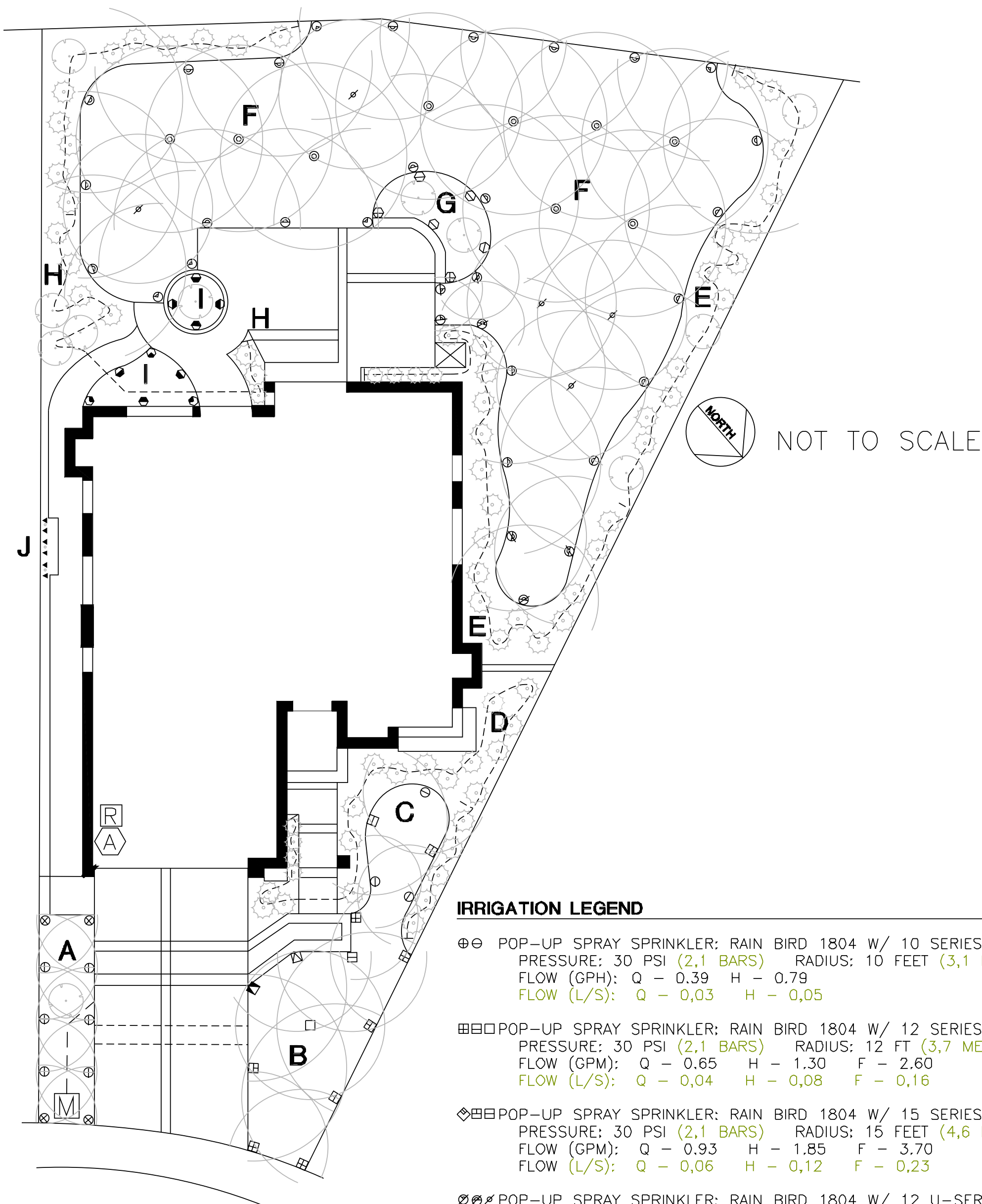
Area "E," the back lawn, has very few wide areas, so the designer has decided to irrigate the entire lawn with 4 in (10,2 cm) pop-up spray sprinklers rather than use rotor pop-ups. Because it is subjected to more wind, the U-Series nozzle was selected for the back lawn. This nozzle is less susceptible to wind drift, an important consideration since the prevailing wind is toward the house.

On the irrigation plan, the designer has shown the check arcs for the sprinklers. Check arcs represent the maximum effective radius for the sprinkler. Showing the check arcs on the plan gives the designer a visual indication that all areas are effectively covered. They also point out any areas where over spray may occur. Sprinklers which exhibit over spray can be adjusted in the field using the throw adjustment capability of the head.

Wider, more open areas are easier to design irrigation for than smaller more broken up areas. In the past, small impact sprinklers and rotor pop-up sprinklers had a radius of about 40 ft (12,19 m) with an adjustment range down to the mid-30 ft (10,67 m) range. Spray sprinklers were used where the area to be watered was 30 ft (9,14 m) wide or less. The 30 ft (9,14 m) wide area was commonly handled by three rows of 15 ft (4,57 m) radius spray sprinklers — a row of half circle sprinklers down each edge of the area, and a row of full circle sprinklers down the center.

With the advent of the small turf area rotor pop-ups and small, light-impact sprinklers that have a range from 17 to 40 ft (5,18 to 12,19 m), the designer has a decision to make for areas in the 20 ft (6,10 m) range. Beyond 15 ft (4,57 m) or so, two rows of spray sprinklers would be stretched too far. However, simply switching to a larger radius may not be the best design answer either. A decision between using three rows of spray sprinklers, or switching to a two-row design with rotating sprinklers, may be influenced by any number of factors.

If low trees would obstruct the longer, higher throw of the rotating sprinkler, perhaps the spray sprinklers are more appropriate for watering the area. Spray sprinklers are often more appropriate for areas that have lots of curving edges. It may be difficult to avoid overthrow or gain complete coverage with a larger radius sprinkler. If low precipitation rates were required for this medium-wide area, then rotating sprinklers delivering less than .75 in (19 mm) of water per hour would be better than spray sprinklers delivering over 2 in (51 mm) of water per hour. Perhaps the higher cost per unit of rotating sprinklers would be more than offset by elimination of the middle row of spray sprinklers because the installation expense of



IRRIGATION LEGEND

POP-UP SPRAY SPRINKLER: RAIN BIRD 1804 W/ 10 SERIES NOZZLE
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 10 FEET (3,1 METERS)
FLOW (GPH): Q – 0.39 H – 0.79
FLOW (L/S): Q – 0,03 H – 0,05

POP-UP SPRAY SPRINKLER: RAIN BIRD 1804 W/ 12 SERIES NOZZLE
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 12 FT (3,7 METERS)
FLOW (GPM): Q – 0.65 H – 1.30 F – 2.60
FLOW (L/S): Q – 0,04 H – 0,08 F – 0,16

POP-UP SPRAY SPRINKLER: RAIN BIRD 1804 W/ 15 SERIES NOZZLE
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 15 FEET (4,6 METERS)
FLOW (GPM): Q – 0.93 H – 1.85 F – 3.70
FLOW (L/S): Q – 0,06 H – 0,12 F – 0,23

POP-UP SPRAY SPRINKLER: RAIN BIRD 1804 W/ 12 U-SERIES NOZZLE
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 12 FEET (3,7 METERS)
FLOW (GPM): Q – 0.65 H – 1.30 F – 2.60
FLOW (L/S): Q – 0,04 H – 0,08 F – 0,16

POP-UP SPRAY SPRINKLER: RAIN BIRD 1804 W/ 15 U-SERIES NOZZLE
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 15 FEET (4,6 METERS)
FLOW (GPM): Q – 0.93 H – 1.85 F – 3.70
FLOW (L/S): Q – 0,06 H – 0,12 F – 0,23

POP-UP SPRAY SPRINKLER: RAIN BIRD 1812 W/ 10 SERIES VAN NOZZLE
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 10 FEET (3,1 METERS)
FLOW (GPM): Q – 0.50 H – 1.02 F – 1.96
FLOW (L/S): Q – 0,05 H – 0,09 F – 0,16

XERI-SPRAY ON RAIN BIRD 1812 SPRINKLER
PRESSURE: 30 PSI (2,1 BARS) RADIUS: 10 FEET (3,1 METERS)
FLOW (GPH): XS-090 – 31.0 XS-180 – 31.0
FLOW (L/H): XS-090 – 117,49 XS-180 – 117,49

▲ PRESSURE COMPENSATING BUBBLER ASSEMBLY: RAIN BIRD 1404
PRESSURE: 30 PSI (2,1 BARS) FLOW: 0.5 GPM (0,03 L/S)

Figure 50: Plan, locating sprinklers

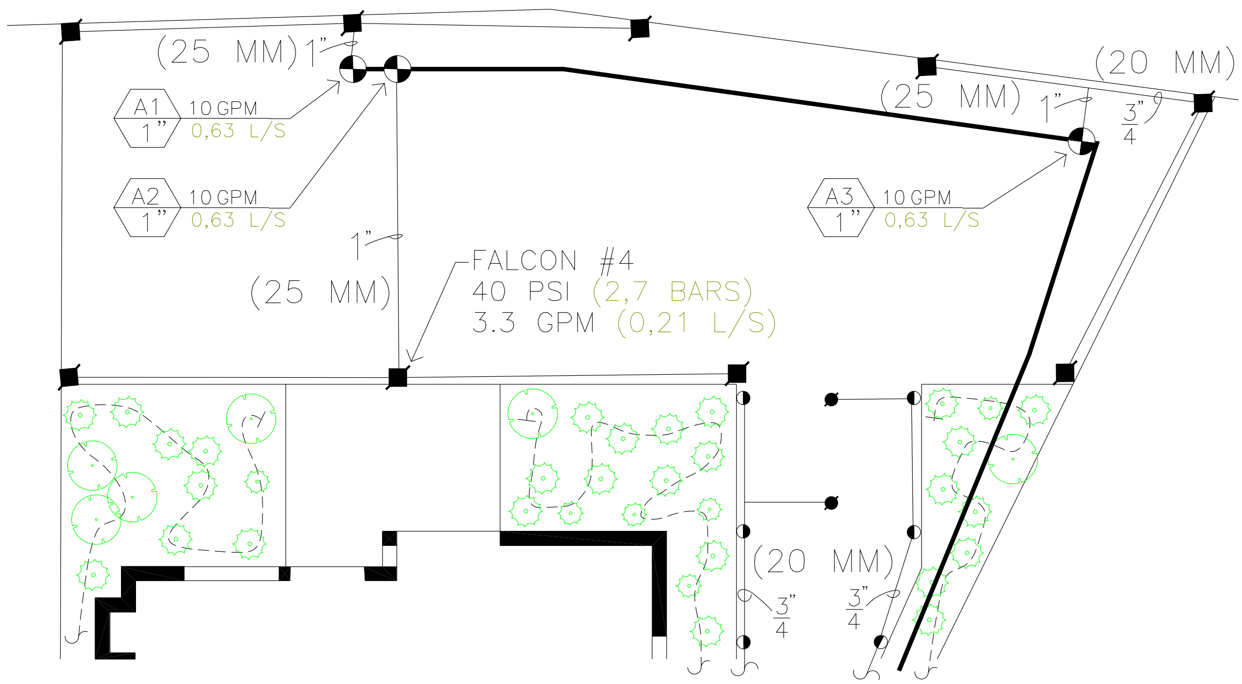


Figure 51: Plan, alternate backyard

trenching and installation would go down. The decision is up to the designer, who takes into account the special needs of the site along with practical experience.

In the "Alternate Back Yard" illustration (see Figure 51) you can see what the sprinkler locations would have been if the landscape plan for our sample project had a wider, more open, lawn area. Note how few rotor pop-up sprinklers are required for the large area and how low the lateral flows might have changed.

This particular project did not require rotor pop-ups, not just because of moderate lawn width, but also because the high-angle throw of the rotors might drift to the back windows in the constant wind.

Very large, open areas are the domain of the rotating sprinkler. Large lawns, sports fields, vast shrub or ground cover areas, slopes, parks, schools, golf courses and agricultural fields allow for the efficient use of large radius sprinklers. The more common rectangular, parallelogram and triangular spacing patterns can be used for maximum spacing and wind resistance.

At this point in the design process, the drawing of the irrigation plan should show every area to be irrigated and designed with properly spaced sprinklers. With this accomplished, the designer is ready to proceed with the next step, which is to group the sprinklers into valve groups. Before we proceed to that step, complete the exercises on page 52, then check your answers in the Solutions section on page 90.

Exercises on locating sprinklers

Put an **X** after each correct answer to the multiple choice questions.

A. For a shrub bed that is 14 ft (4,3 m) wide, which spray sprinkler listed below would be spaced closest to its "60% stretch rule" across the shrub bed if there was a row of the heads down each side?

A 15 ft (4,5 m) radius spray sprinkler ____

A 12 ft (3,6 m) radius spray sprinkler ____

A 10 ft (3,0 m) radius spray sprinkler ____

An 8 ft (2,4 m) radius spray sprinkler ____

A 6 ft (1,5 m) radius spray sprinkler ____

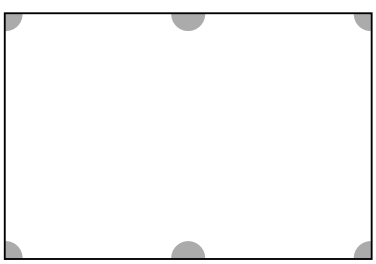
B. In the spacing illustration below, if the area were a lawn and the lawn dimensions were 12 ft x 24 ft (3,6 m x 7,2 m), what type of sprinkler should be plotted at the locations shown?

A 15 ft (4,5 m) radius shrub sprinkler ___

A 30 ft (9,0 m) radius impact sprinkler ____

A 12 ft (3,6 m) radius pop-up spray sprinkler ____

An 8 ft (2,4 m) radius pop-up spray sprinkler ____



C. If the area in the illustration was 30 ft x 60 ft (9,0 m x 18,0 m) and the owner of the property had mistakenly installed only six 15 ft (4,5 m) radius spray sprinklers in the positions shown, plot the positions on the drawing where additional 15 ft (4,5 m) radius sprinklers would be required for head-to-head coverage.

D. What was the total number of sprinklers required for the illustration in question "C?"

8 sprinklers ____
10 sprinklers ____
12 sprinklers ____
13 sprinklers ____
14 sprinklers ____
15 sprinklers ____

E. If the original six sprinklers for the question "C" illustration were 30 ft (9,0 m) radius rotor pop-up sprinklers, how many would be required for head-to-head coverage?

6 sprinklers ____
8 sprinklers ____
10 sprinklers ____
12 sprinklers ____

F. Which spacing pattern would the 30 ft (9,0 m) radius rotor pop-ups in question "E" be using?

Square ____
Sliding ____
Triangular ____
Rectangular ____

G. If a tree or large bush in the center of a lawn area can tolerate the same amount of water as the turfgrass, it is best to plot the sprinklers to _______________ the bush or tree to avoid blocking the sprinklers' coverage of the lawn.

H. A single tree rose with a basin dug out around its base could be watered efficiently by which two items below?

A bubbler ____
An impact sprinkler ____
A rotor pop-up ____
An emitter ____
A side strip ____

I. Without knowing any other information about the site, what type of sprinkler listed below would most likely be best for a large slope application?

Bubbler ____
Impact sprinkler ____
Side strip ____
Fan spray sprinkler ____