Slope Irrigation

Irrigation System Design and Installation for Slopes

Little exists in the way of reference material regarding designing and installing irrigation systems for sloped areas, so determining guidelines and learning the "tricks of the trade" has been a trial-and-error process. Slope in this case can be defined as an area where low head drainage becomes a factor, or elevation change affects hydraulic calculations. This brief is intended to provide an overview of some of the basic requirements and considerations of installing sprinklers on a slope. It is meant as a general guideline only—make adjustments for local conditions, and be sure to adhere to local codes and the preferences of the site owner.

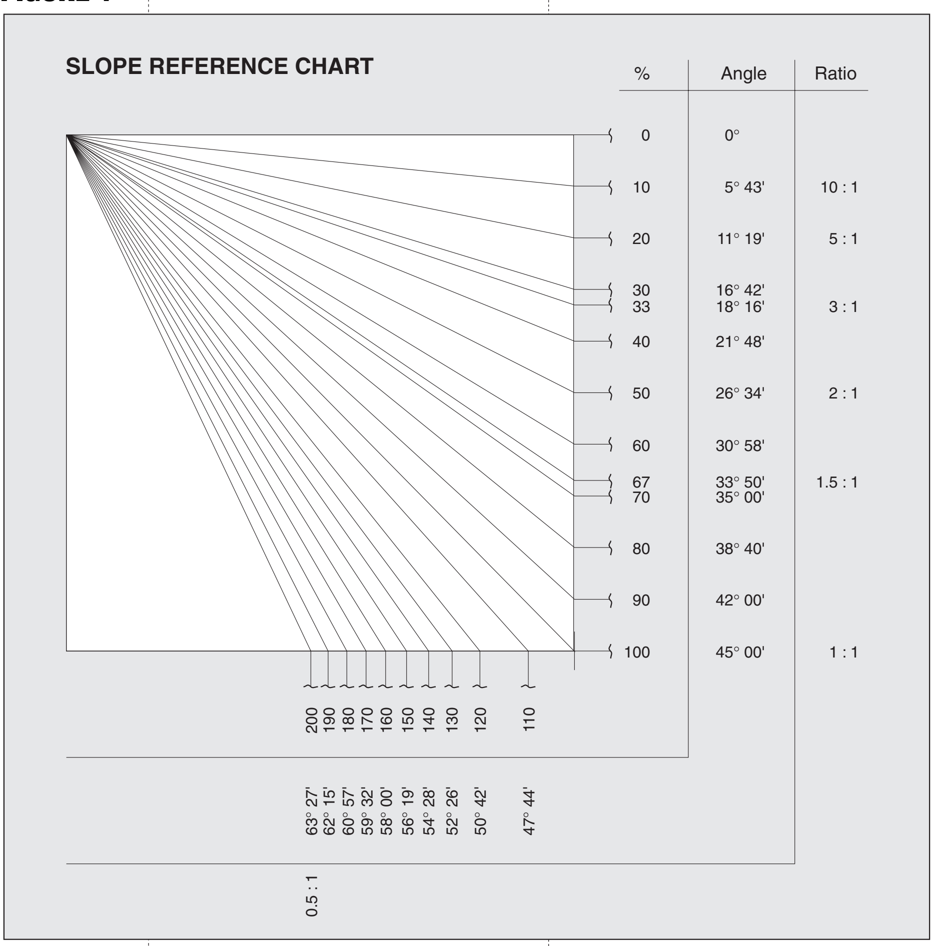
Ratio of Slope

Slope often is expressed as a ratio: *run* to *rise* (horizontal distance to increase in vertical elevation). For example, if over a distance of 100 feet, elevation increases 50 feet, you have a 2:1 slope.

Slope also can be expressed as a percentage. Percent slope is calculated as *rise* over *run*. Thus, a 50-ft. increase in elevation over a distance of 100 feet is a 50% slope.

Figure 1 displays various slopes; they are labeled in terms of percentages, angles, and ratios. This chart is useful when reviewing topographical plans.

FIGURE 1



When reading a slope irrigation plan, it is important to remember that you are reading from a flat surface: when measuring dimensions across a slope on a flat plan, you must allow for the angle of the slope.

To calculate the actual distance across the face of a slope from a flat plan, use the formula: $c^2 = a^2 + b^2$, where c is the distance across the face of the slope, a is the run measurement, and b is the rise measurement (Figure 2). For example, the calculation of the actual distance across a 2:1 slope that measures 100 feet on a slope irrigation plan would be: $c^2 = 100^2 + 50^2$. This is $c^2 = 10{,}000 + 2{,}500$, or $c^2 = 12{,}500$. Now, to get back to c, you need to calculate the square root of c^2 or, in the example, the square root of 12,500, which is 111.8; in round numbers, the distance across the slope face is 112 feet.

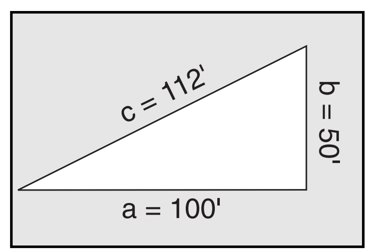


FIGURE 2

Sprinkler Selection and Installation

Ideally, the sprinklers should have precipitation rates that are no higher than the intake rate of the soil. However, since most slope installations include a variety of soil types and conditions, the more flexible the irrigation system, the simpler the adjustment for varied conditions.

Note: *Typical fixed-spray-type sprinklers have an applica-*

tion rate of 1.5 to 2 inches of water per hour, and may not be suitable for use on slopes. Many times, adjusting the sprinkler run times through the use of the cycle-and-soak feature on the controller (Hunter ICC Controllers) will sufficiently manage the application rate. Stream spray sprinklers or drip- or micro-irrigation technology may be a better choice in many sloped areas too small for rotary heads.

If possible, use low-angle (or flat) trajectory nozzles for zones near the top of the slope, to reduce wind drift. These low-angle heads will have less radius of throw (at the same pressure and discharge rate) than a standard 25°-trajectory sprinkler, so they should be spaced a little closer together. (This will increase precipitation rate.)

If low-angle nozzles are used for the top zones, the heads should be installed vertically (see the sprinkler labeled A in Figure 3).

If standard-trajectory nozzles are used at the top of the slope, the heads should be tilted toward the toe of the slope. They also should be installed slightly down from the top edge of the slope to decrease wind drift (see the sprinkler labeled B in Figure 3).

Mid-slope sprinkler heads should be installed at an angle into the slope. The recommended angle is halfway between vertical and perpendicular to the slope. (This is half of the angle of slope. For example, a 2:1 or 50% slope has an angle of 26 degrees, so tilt the head 13 degrees into the slope from the perpendicular.) See the sprinkler labeled C in Figure 3.

Slope installation is not an exact science. If low-trajectory heads are used in the middle or at the toe of the slope, these guidelines do not apply.

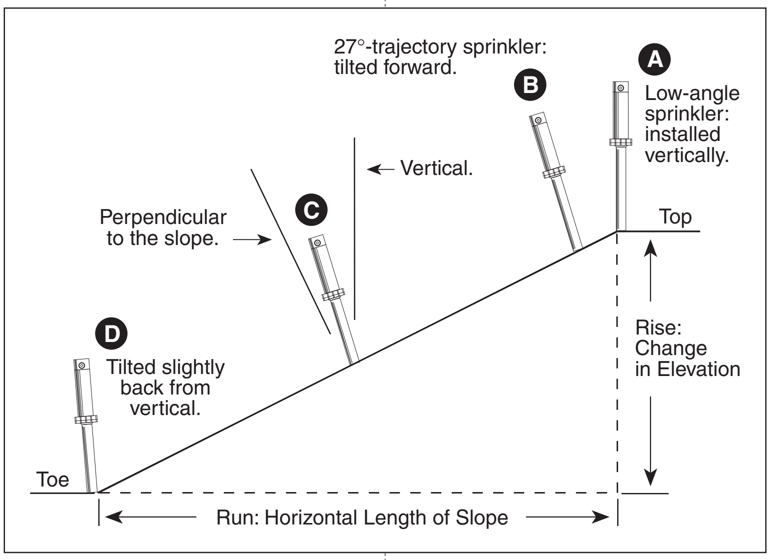
Heads installed at the toe of the slope should be tilted slightly away from the slope to avoid driving water into the slope directly in front of the sprinkler (see the sprinkler labeled D in Figure 3). Again, this is not an exact science: experimentation may be necessary to determine the appropriate tilt.

Further, if the top or toe of the slope is an area of pedestrian traffic, you should install pop-up type heads to prevent injury to pedestrians and damage to the system. Many manufacturers produce twelve-inch pop-up sprinklers for use with taller ground covers.

All pop-up slope-irrigation sprinklers should be installed on swing joints so you can adjust their angle to the slope without applying stress (through twisting) to the lateral lines (Figure 4A). With the shrub-type sprinklers, once the position of the riser and degree of tilt of the head is set, re-bar should be driven into the ground at the same angle and the sprinkler secured to this stake (Figure 4B). Some specifications require stainless-steel hose clamps for this. If so, be sure the screw is stainless as well or it will corrode. (Hunter has a convenient shrub staking kit, part number 46-3551, to secure the installation of shrub rotors on slopes and in shrub areas.)

Sprinklers installed on slopes will produce an elliptical wetted pattern; the downhill throw will be increased, while at the same time the uphill throw is decreased. Because of this, the spacing may have to be adjusted to provide uniform coverage. A general rule to follow is to decrease the row spacing across the slope by one percent

FIGURE 3



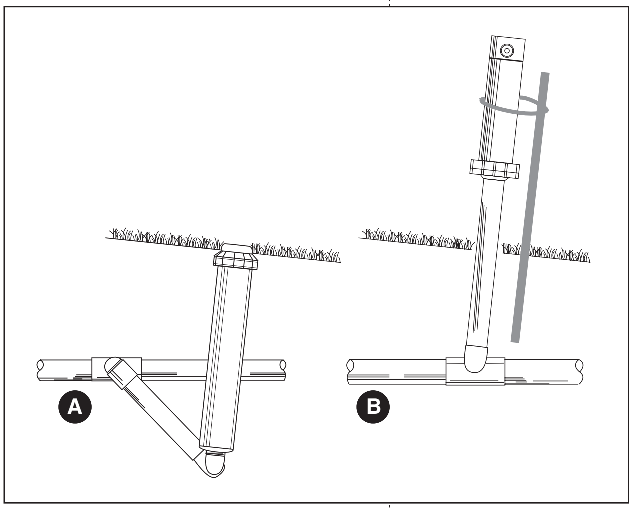


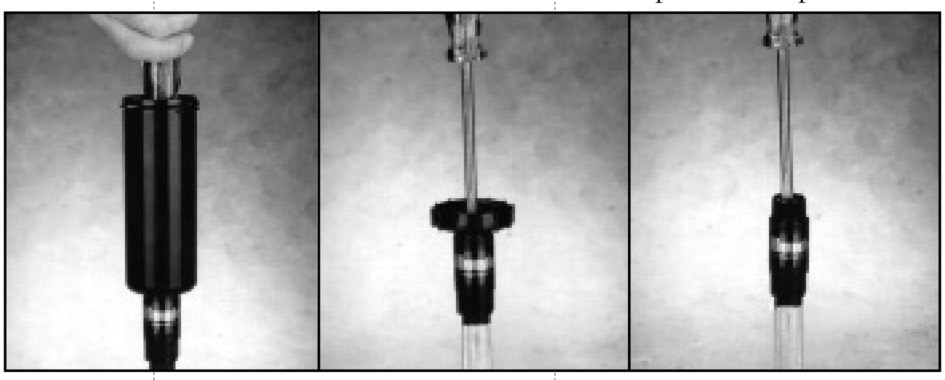
FIGURE 4

for every one percent increase in a slope over ten percent. For example, if the slope is 16 percent and the radius of the sprinklers is 50 feet, you would decrease the spacing by 6 percent, or 3 feet.

Additionally, the row of heads closest to the top row of sprinklers on the slope will throw short of their desired radius and the row of heads closest to the bottom row of sprinklers will throw beyond their desired radius. To correct for this, it is necessary to shift the interior rows of sprinklers toward the top row by the amount that the uphill throw is reduced.

These spacing alterations are in addition to any already made to adjust for wind conditions, relative humidity, or other site-related variables.

FIGURE 5



Low-Head Drainage

To eliminate water draining out of the lowest head in the system after each irrigation, a check valve should be installed on each riser. "Under-head" check valves are available in many shapes and sizes.

Most under-head check valves have an adjustment feature so you can adjust the amount of check to compensate for elevation changes.

Hunter Industries produces an under-head check valve, the HCV, that can be adjusted from the outlet port without removing the valve from the riser. The HCV can be adjusted simply by turning a plastic screw, either through the body, through the shrub base, or after the sprinkler head has been removed (see Figure 5).

Hunter also addresses the low-head drainage problem by manufacturing both shrub and pop-up sprinklers that include built-in check valves. For example, the standard check valve in the I-20 *Ultra* will prevent drainage caused by up to 10 feet of elevation change. Spring tension seals the rubber washer against the inlet of the sprinkler until the pressure of the water on the seal overcomes this tension.

Pipe Installation

The main irrigation line should be installed at the toe of the slope to reduce problems in the event of a break in the main line. If the main line must be installed on top of the slope, use metal pipe to reduce the chance of breakage. (The pros and cons of using metal pipe have been discussed in other publications.)

Install a high-flow/low-pressure device at the point of connection to shut off the flow of water in case of a line break. This device should be sized and installed according to manufacturer's guidelines. Be sure the flow capacity of any shut-off device is equal to the largest flow demand in the system.

All above-ground laterals should either be UV-resistant PVC or metal pipe. Lateral piping should be laid out and installed parallel to the slope. Laying pipe parallel to the curb line is unacceptable if there are elevation changes along the curb line.

Staking is required to anchor above-ground pipe to the slope. Contrary to what you might think, the spacing of stakes should be closer for smaller diameter pipe than for larger pipe to keep the pipe from looping or drooping. Take into consideration the weight of the water in the pipe and place stakes so as to provide enough support for that weight.

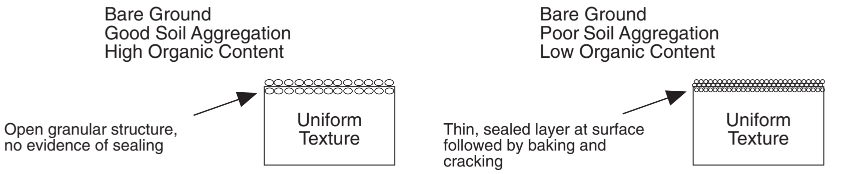
When designing the system and selecting pipe, be sure to take into consideration pressure loss (or gain) of 0.433 psi per foot of elevation change. You might find it useful to chart the friction factor for pipe size, based on elevation change, available system pressure, and distance to the highest head. (Refer to Hunter publication LIT-083, *Calculating Design Capacity and Working Pressure* for additional information.)

Other Components to be Considered

Consideration should be given to system operating pressure. Lower pressures (below 50 psi) increase droplet size, while higher pressures produce smaller droplets which are more susceptible to wind drift. Avoid pressures that are too low, as large water droplets can cause soil compaction and lead to increased run-off.

If moisture sensors are specified, there should be one installed for each zone of sprinklers, or at minimum, for each horizontal row of laterals.

Two bare-soil conditions.



	Basic Intake Rate:	For Poor Condition, Reduce by:
Coarse sand	0.75–1.00 in./hr. (19–25 mm/hr)	0.35 in./hr. (9 mm/hr)
Fine sands	0.50–0.75 in./hr. (13–19 mm/hr)	0.25 in./hr. (6 mm/hr)
Fine sandy loams	0.35–0.50 in./hr. (9–13 mm/hr)	0.20 in./hr. (5 mm/hr)
Silt loams	0.25–0.40 in./hr. (6–10 mm/hr)	0.12–0.15 in./hr. (3–4 mm/hr)
Clay loams	0.10–0.30 in./hr. (3–8 mm/hr)	0.04–0.10 in./hr. (1–3 mm/hr)

Note: Intake rates are dynamic during the irrigation cycle.

FIGURE 6

If the main is on top of the slope, spring check valves should be installed in the lateral lines or directly below each sprinkler head to keep water from draining out of the pipes. Lack of adequate check could cause erosion problems and in severe cases, a vacuum could be created, causing the pipe to collapse.

A master valve should be installed at the source to depressurize the main line on completion of each irrigation.

Ensure that slope installations have plenty of flexibility. Although you could zone top, middle and bottom together, that does not allow you to adjust for increased water requirements at the top of the slope where higher winds and greater exposure to sunlight will occur. Stretched spacing and overtaxed systems will only lead to problems later.

Also remember that most slope installations include a variety of soil types and conditions. They usually consist of cut and fill, and the more flexible the system, the easier it is to adjust for these varied conditions.

The experienced designer will take prevailing winds, north-vs-south-facing slope, plant types, etc. into consideration during the design phase.

Note: *Be sure you are aware of, and adhere to, local codes, as they vary from area to area.*

Scheduling Considerations

Soil texture alone does not determine intake rate, but it can provide a general idea of approximate rates (most slope installations will require soil testing, performed by a soil laboratory). Figure 6 can be used to determine approximate soil intake rates for bare ground.

If the sprinkler application rates are higher than the soil intake rates, be sure irrigation is scheduled over multiple run times. Use the "cycle-and-soak" method of scheduling: apply small amounts of water in multiple applications, with delays between the applications to allow the water to move into the soil.

Another scheduling consideration is that the lower portions of the slope will require less irrigation because they will receive supplemental water in the form of runoff from the zones at higher elevations. With high-application-rate sprinklers, you can compensate by decreasing individual run times from the top to the bottom of the slope.

For instance:

Top – 30 minutes per required irrigation.

Middle – 15 minutes per irrigation.

Bottom – 15 minutes every other irrigation.

You also could compensate by lowering the discharge rate of the sprinklers as you move down the slope.

It is important to be sure that the maintenance people taking over the system are aware of the factors considered during design and installation, particularly those pertaining to run times and application rates. Many times a well-designed and properly installed system becomes ineffective because of improper adjustment over a period of time.

(Refer to Hunter publications: ED-002.B, *Irrigation Hydraulics*, and LIT-088, *Scheduling Irrigation* for additional information.)

Various sources were consulted while preparing this document; contact Hunter Industries if you desire bibliographic information.