Irrigation Design Tip: How Soil Type Affects Irrigation Requirements

Soil absorbs and holds water in much the same way as a sponge. A given texture and volume of soil will hold a given amount of moisture. The intake rate of the soil will influence the precipitation rate and type of sprinkler that can be utilized. The ability of soil to hold moisture, and the amount of moisture it can hold, will greatly affect the irrigation operational schedule.

Soil is made up of sand, silt and clay particles. The percentage of each of these three particles is what determines the actual soil texture. Because the percentage of any one of these three particles can differ, there is virtually an unlimited number of soil types possible.

The simplest way to determine the soil type is to place a moistened soil sample in your hand and squeeze. Take the sample from a representative part of the site, and from approximately the same depth to which you will be watering. In other words, if you want to water to a depth of 6 in (15 cm), dig down 6 in (15 cm) to take your soil sample.

One of the most significant differences between different soil types is the way in which they absorb and hold water. Capillary action is the primary force in spreading water horizontally through the soil. Both gravity and capillary action influence vertical movement of water.

In coarser soils, water is more likely to be absorbed vertically, but will not spread very far horizontally. The opposite is true for finer soils.

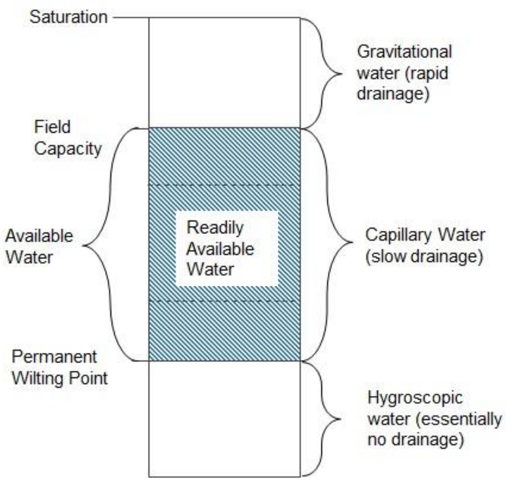
Note: Emitters should not be used in very course soils as water will percolate downward before it can spread far enough horizontally. Micro-sprays or conventional sprinkler irrigation may be more appropriate.

General characteristics of the three main soil types and how water is absorbed

SOIL TYPE	SOIL TEXTURE	SOIL COMPONENTS	INTAKE RATE	WATER RETENTION	DRAINAGE EROSION
Sandy soil	Coarse texture	Sand	Very high	Very low	Low erosion Good drainage
		Loamy sand	High	Low	
Loamy soil	Moderately coarse	Sandy loam	Moderately high	Moderately low	Low erosion Good drainage
		Fine loam	Moderately high	Moderately low	
	Medium texture	Very fine loam	Medium	Moderately high	Moderate drainage
		Loam	Medium	Moderately high	Moderate drainage
		Silty loam	Medium	Moderately high	Moderate drainage
		Silt	Medium	Moderately high	Moderate drainage
	Moderately fine	Clay loam	Moderately low	High	
		Sandy clay loam	Moderately low	High	
		Silty clay loam	Moderately low	High	
Clay soil	Fine texture	Sandy clay	Low	High	Drainage
		Silty clay	Low	High	Severe erosion
		Clay			

The moisture held in soil can be classified in three ways:

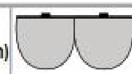
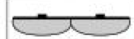
- **Hygroscopic water** is moisture that is held too tightly in the soil to be used by plants.
- **Capillary water** is moisture that is held in the pore spaces of the soil and can be used by plants.
- **Gravitational water** drains rapidly from the soil and is not readily available to be used by plants.



The permanent wilting point represents the boundary between capillary water and hygroscopic water. Because hygroscopic water is not usable by plants, continuous soil moisture levels below the Permanent Wilting Point will result in the death of the plants.

Field capacity represents the boundary between gravitational water and capillary water. It is the upper limit for soil moisture that is usable by plants.

Maximum wetting patterns show the relationship between vertical and horizontal movement of water in the soil up to the maximum wetted diameter. Once the maximum wetted diameter is reached, water movement is downward, forming the traditional "carrot," "onion," and "radish" profiles.

Soil Type	Wetting Pattern	Maximum Wetted Diameter	Available Water (AW)
Coarse (sandy loam)		1.0 – 3.0 ft 0,3 – 0,9 m	1.4 in/ft 12 mm/m
Medium (loam)		2.0 – 4.0 ft 0,6 – 1,2 m	2.0 in/ft 17 mm/m
Fine (clay loam)		3.0 – 6.0 ft 0,9 – 1,8 m	2.5 in/ft 21 mm/m

- Maximum wetted diameter is the greatest distance water will spread horizontally from an emitter.
- Available water (AW) is the amount of water that is readily available for use by plants.

Different soil types are outlined on the soil characteristics chart (previous page) along with properties that influence the irrigation design. Take note of the information in the last three columns. The soil's intake rate, or how fast it absorbs water dictates how quickly water can be applied by the irrigation system.

Coarse, sandy soil absorbs water very quickly while silts and clays have a very low intake rate. The fine textured soils, once wet, retain moisture longer than do the coarse-grained soils.

Determining soil type

Coarse

Soil particles are loose. Squeezed in the hand when dry, it falls apart when pressure is released. Squeezed when moist, it will form a cast, but will crumble easily when touched.

Medium

Has a moderate amount of fine grains of sand and very little clay. When dry, it can be readily broken. Squeezed when wet, it will form a cast that can be easily handled.

Fine

When dry, may form hard lumps or clods. When wet, the soil is quite plastic and flexible. When squeezed between the thumb and forefinger, the soil will form a ribbon that will not crack.

The main problem we wish to avoid is applying water faster than the soil can receive it. This causes runoff, erosion or soil puddling, which waste water and can cause damage.

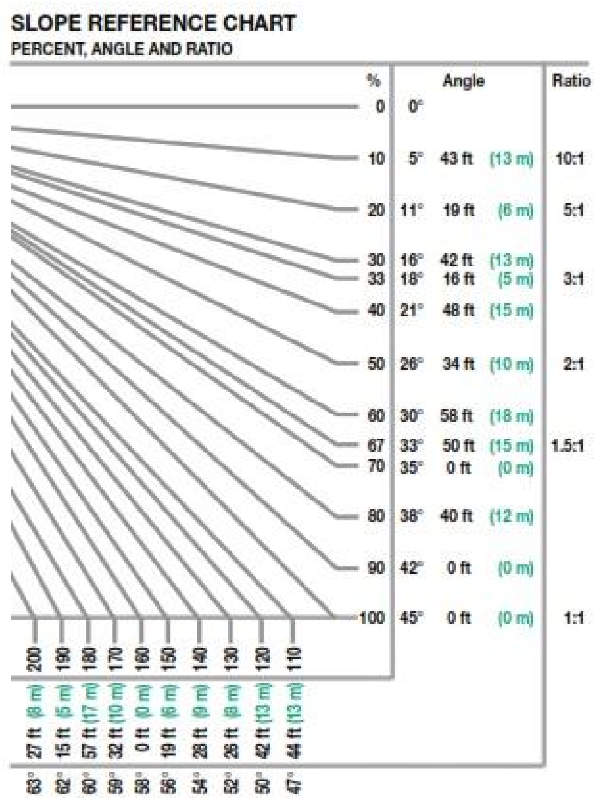
Rolling terrain further complicates the problem of matching the application rate from the sprinklers with the intake rate of the soil. As the angle of slope increases, the intake rate decreases because of the higher potential for runoff.

The “Maximum Precipitation Rates for Slopes” chart lists the United States Department of Agriculture’s recommendations for the maximum PR values for certain soil types with respect to soil plant cover and percent of slope.

In the upper left section of the rate columns, the rate for coarse, sandy soil that presents a flat surface is 2.00 or 2 in/h (51 mm/h). In the other extreme, heavy clay soil with a surface slope of 12% will accept water only at or below 0.06 in (2 mm). This means that irrigation equipment could easily cause run off or erosion if not specified and spaced correctly.

The “Slope Reference” chart explains the relationship of angle, percent and ratio of slopes. Depending on how the information has been given to the designer, they may need to convert the data to the slope reference with which they are most comfortable or familiar for drawing purposes.

Keeping the above factors in mind, the designer determines, either in inches per week or inches per day (centimeters per week or millimeters per day), the irrigation requirement for the project. When this estimate is established, he is ready to go on to the next step in the design procedure, which is determining the water and power supply available to the site.



SOIL TEXTURE	MAXIMUM PRECIPITATION RATES: INCHES PER HOUR (MILLIMETERS PER HOUR)							
	0 to 5% slope		5 to 8% slope		8 to 12% slope		12%+ slope	
	cover	bare	cover	bare	cover	bare	cover	bare
Course sandy soils	2.00 (51)	2.00 (51)	2.00 (51)	1.50 (38)	1.50 (38)	1.00 (25)	1.00 (25)	0.50 (13)
Course sandy soils over compact subsoils	1.75 (44)	1.50 (38)	1.25 (32)	1.00 (25)	1.00 (25)	0.75 (19)	0.75 (19)	0.40 (10)
Light sandy loams uniform	1.75 (44)	1.00 (25)	1.25 (32)	0.80 (20)	1.00 (25)	0.60 (15)	0.75 (19)	0.40 (10)
Light sandy loams over compact subsoils	1.25 (32)	0.75 (19)	1.00 (25)	0.50 (13)	0.75 (19)	0.40 (10)	0.50 (13)	0.30 (8)
Uniform silt loams	1.00 (25)	0.50 (13)	0.80 (20)	0.40 (10)	0.60 (15)	0.30 (8)	0.40 (10)	0.20 (5)
Silt loams over compact subsoil	0.60 (15)	0.30 (8)	0.50 (13)	0.25 (6)	0.40 (10)	0.15 (4)	0.30 (8)	0.10 (3)
Heavy clay or clay loam	0.20 (5)	0.15 (4)	0.15 (4)	0.10 (3)	0.12 (3)	0.08 (2)	0.10 (3)	0.06 (2)