Irrigation requirements

Contents

What is needed for optimal run times and how often to run the sprinkler system?

1) The local climate is one of the main factors that influences how much water is needed to maintain good plant growth.
2) The plant water requirements include the water lost by evaporation into the atmosphere from the soil and the soil surface, and by transpiration, which is the amount of water used by the plant. The combination of these is evapotranspiration (ET).
3) ET_0 stands for reference ET, which is the maximum average rate of water for plants in a given climate.
4) ET_0 is multiplied by a crop coefficient to obtain the ET rate for a specific plant or turf.3

Climate Potential Evapotranspiration (PET)

CLIMATE	INCHES (MILLIMETERS) DAILY
COOL HUMID	.10 to .15 in (3 to 4 mm)
COOL DRY	.15 to .20 in (4 to 5 mm)
WARM HUMID	.15 to .20 in (4 to 5 mm)
WARM DRY	.20 to .25 in (5 to 6 mm)
HOT HUMID	.25 to .30 in (6 to 8 mm)
HOT DRY	.30 to .45 in (8 to 11 mm) “worst case”

	NOTE
COOL	= **Under 70° F (21° C) as an average midsummer high**
WARM	= between 70° and 90° F (21° and 32° C) as midsummer highs
HOT	= over 90° F (32° C)
HUMID	= over 50% as average midsummer relative humidity [dry = under 50%]

The hotter the climate, the more water loss is expected. Other major factors are humidity and wind speed. If the air is humid, evaporation will be lower as compared to a climate with the same average temperature but drier air.

To help determine in which climate your project is located, consult the notes on “hot”, “warm”, or “cool” that are listed on the PET table. Also listed are the humidity ranges that establish the “humid” and “dry” classifications.

Soil type

A given texture and volume of soil will hold a given amount of moisture. The ability of the 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.

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.

Soil Characteristics

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 soil's intake rate, or how fast it absorbs water, dictates how quickly water can be applied by the irrigation system. Course, 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. The main problem we wish to avoid is applying water faster than the soil can receive it. This causes runoff, erosion, or soil puddling, all of which will waste water and can cause damage.

SOIL TYPE	CHARACTERISTICS
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.

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 the slope increases, the intake rate decreases because of the higher potential for runoff.

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)

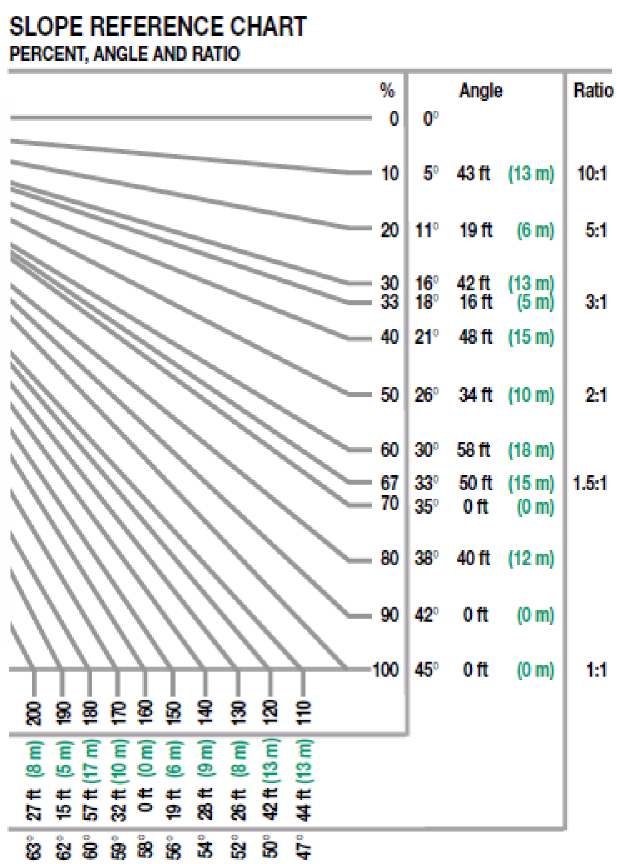

Figure 16: Slope reference

In the upper left section of the rate columns, the rate of the 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 (2mm). This means that irrigation equipment could easily run off or erosion if not specified and spaced correctly.

The rate at which the sprinklers will apply the water.

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.

Precipitation Rate

The precipitation rate (PR) 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 the PR 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:

$$PR = \frac{96.3 * gpm\ (applied\ to\ the\ area)}{Total\ Area}$$

Where:

PR	**=** The average precipitation rate in inches per hour
96.3	= a constant which incorporates inches per square foot per hour
Gpm	= the total gpm applied to the area by the sprinklers
Total Area	= The given irrigated area in square feet

Minimum Precipitation Rate

The following formula is used to determine the minimum precipitation rate that can be used to deliver the required water during the peak period of water usage.

$$Minimum\ PR = \frac{ET * Total\ Acres}{Hours\ Avail. * Acre\ per\ section * valves * Efficiency}$$

Where:

ET	**=** amount of water to be applied in inches per day, including crop coefficient
Total acres	= the area to be irrigated in acres
Hours Avail.	= hours available for irrigation each day
Acres per section	= average area covered by one control valves in acres
Valves	= number of valves operating at one time
Efficiency	= system operating efficiency in decimal equivalent of percent

Operating Time

A simple formula applied to each type of circuit will help determine the daily average operating time needed.

$$OT = \frac{I * 60}{PR * DA}$$

Where:

OT	**=** Circuit operating time in minutes per day
60	= Constant conversion factor of 60 min/h
I	= System irrigation requirement in inches (millimeters) per week in the “worst case” season
PR	= Circuit precipitation rate in inches (millimeters) per hour
DA	= Days available for irrigation per week

Once the operating time for each type of circuit is established, the next step is to add up all the circuits on the system and check this total against the hours of irrigation time available each day. The time period available for irrigation is called the water window.

Irrigation Frequency

The following formula calculates the maximum interval allowed between irrigation cycles. This irrigation interval is dependent on soil type, root zone depth, and water lost by evapotranspiration of a specific crop. The frequency, or “set days to water”, is calculated using the following formula:

$$F = \frac{AWHC * RZ * MAD}{ET_0 * K_c}$$

Where:

AWHC	**=** Available Water Holding Capacity is the moisture level in the soil, which is above the plant’s permanent wilting point, and below the soil’s field capacity, in inches per foot
RZ	= root zone, in feet
MAD	= Management Allowable Depletion of water from the AWHC percent. MAD of 30-50% will sustain a healthy landscape.
ET_0	= reference evapotranspiration rate, in inches per day
K_c	= crop coefficient, decimal

Sprinkler Run Time

The following formula calculates the number of minutes required to apply enough water to replace the water lost by evapotranspiration for a specific crop irrigated with a system at a particular precipitation rate and efficiency.

$$T = \frac{60 * D * ET_0 * K_c}{PR * IE}$$

Where:

60	= constant for conversion of area, flow, inches per hour and inches per day into common units
D	= watering frequency in days
ET_0	= reference evapotranspiration rate, in inches per day
K_c	= crop coefficient, decimal
PR	= Precipitation rate of the area, in inches per hour
IE	= application efficiency of the system, percent

Landscape Factor

The following table provides a helpful reference for plant factors which should be used in calculating the landscape evapotranspiration requirement.

Plant Type	Maximum Appearance	Acceptable Appearance	Lean-Green Appearance
Cool Season Turf	0.80-0.85	0.70-0.75	0.60-0.65
Warm Season Turf	0.70-0.75	0.60-0.65	0.50-0.55
Trees	0.90-0.95	0.70-0.75	0.40-0.50
Shrubs	0.60-0.65	0.45-0.50	0.30-0.35
Ground Cover	0.70-0.80	0.50-0.60	0.30-0.40
Mix of Above	0.90-1.00	0.75-0.80	0.50-0.55
Desert Plants	0.40-0.45	0.30-0.35	0.20-0.25

Root Depth

The root zone is the depth or volume of soil from which plants extract water. Typically, this is the depth of the soil containing 80% of the plant roots. The following table shows potential effective rooting depths for different types of plants:

Plant Type	Minimum Depth (in)	Maximum Depth (in)
Cool Season Turf	4	8
Warm Season Turf	6	12
Trees	12	24
Shrubs	6	12
Ground Cover	4	6
Flowers	4	6

Historic ET_0 Reference for Texas

These averages were computed using climatic data over the entire period of record available from the National Weather Service and compared to ET_0 rates based on the standardized Penman-Monteith equation where available.

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Abilene	2.08	2.57	4.14	5.48	6.47	7.65	8.36	7.46	5.48	4.21	2.67	2.08
Amarillo	1.84	2.27	3.73	5.06	5.89	7.51	8.08	7.29	5.61	4.05	2.40	1.78
Austin	2.27	2.72	4.34	5.27	6.39	7.15	7.22	7.25	5.57	4.38	2.74	2.21
Brownsville	2.65	3.03	4.48	5.17	6.03	6.32	6.68	6.65	5.21	4.34	3.01	2.59
College Station	2.20	2.71	4.22	5.20	6.25	6.89	7.10	6.85	5.60	4.30	2.80	2.20
Corpus Christi	2.42	2.95	4.28	5.17	5.95	6.43	6.68	6.65	5.21	4.34	3.01	2.59
Dallas / Ft Worth	2.00	2.46	3.96	5.14	6.21	7.06	7.40	7.25	5.49	4.19	2.59	2.10
Del Rio	2.47	3.01	4.76	6.01	6.98	7.41	7.57	7.41	5.77	4.35	2.91	2.36
El Paso	2.74	3.53	6.07	8.19	9.83	11.12	9.19	8.94	7.69	5.89	3.58	2.49
Galveston	2.20	2.60	4.10	5.00	6.11	6.60	6.20	6.00	5.50	4.20	2.80	2.30
Houston	2.36	2.83	4.32	5.01	6.11	6.57	6.52	6.08	5.57	4.28	2.90	2.35
Lubbock	2.35	2.63	4.41	5.53	6.93	7.73	7.63	7.20	5.54	4.19	2.61	2.33
Midland	2.20	2.78	4.46	5.91	7.21	8.20	9.23	8.62	6.96	4.31	2.78	2.16
Port Arthur	2.25	2.63	3.95	5.09	6.12	6.60	5.81	5.61	5.46	4.18	2.76	2.23
San Angelo	2.88	3.13	5.31	7.01	8.48	9.16	9.29	8.49	6.60	5.08	3.37	2.54
San Antonio	2.42	2.90	4.42	5.47	6.47	6.97	7.31	6.99	5.64	4.44	2.85	2.36
Victoria	2.35	2.87	4.29	5.77	6.39	6.70	6.92	6.70	5.36	4.41	2.93	2.33
Waco	2.13	2.62	4.03	5.31	6.45	7.15	7.40	7.50	5.70	4.41	2.70	2.17
Wichita Falls	1.94	2.46	4.07	5.50	6.70	7.54	7.97	7.72	5.79	4.30	2.62	1.95

Plant water requirements

Turf grass

When irrigating turfgrass, the irrigator will try to predict the plant water requirements based on several factors such as potential ET, crop coefficient, an adjustment factor, and effective rainfall. The crop coefficient represents the percentage of ET that a real plant will use, expressed in decimal form, for maximum production in full sun conditions. An adjustment factor using professional judgement for the specific site conditions considering factors such as density, shade, sun, slope, wind, etc. The adjustment factor is 1.0 for normal situations. Another factor predicting water requirements is the average rainfall in the area to be irrigated. As much as 67% of long-term rainfall may be considered effective. Effective rainfall refers to that portion of rainfall that is of benefits to the plant.

The water requirement for turfgrass expressed as a formula considering effective rainfall is:

$$WR = (PET * CC * AF) - (AR * 0.67)$$

Where:

WR	**=** water requirement
PET	= Potential evapotranspiration (inches per month)
CC	= crop coefficient (decimal)
AF	= adjustment factor (decimal)
AR	= average monthly rainfall (inches per month)

	TURF / PLANT COEFFICIENT
TURF – WARM SEASON	0.6
TURF – COOL SEASON	0.8
PLANT COEFFICIENT	Frequent watering = 0.8 Occasional watering = 0.5 Natural rainfall = 0.3
ADJUSTMENT FACTOR	Maximum = 1.00 High = 0.80 Normal = 0.60 Low = 0.5 Minimum 0.4
EFFECTIVE RAINFALL	Needs to be calculated

Water holding capacity

The amount of water held in the soil and available to the plant for uptake is a function of soil texture and effective root zone depth. The managed allowable depletion (MAD) defines the amount of water the plant can deplete from the soil without causing stress in plants. Many plants can only extract about 50% of the total water available in the root zone without showing stress.

In irrigation scheduling, only about 50% of the soil water holding capacity is allowed to deplete between irrigations to ensure plants will have adequate moisture and be able to extract the water from the soil.

The plants available water expressed as a formula:

$$PAW = SWHC * D * MAD$$

Where:

PAW	= plant available water
SWHC	= soil water-holding capacity
D	= effective root zone depth
MAD	= managed allowable holding capacity (is 50% or 5.0)

Approximate water-holding capacity

Soil water holding capacity is the amount of water held in the soil between field capacity and the permanent wiling point. Plant Available Water (50% MAD) is when the plant available water is adjusted by the managed allowable depletion of 50%.

Soil Texture	Soil Water-Holding Capacity	Plant available Water (50% MAD)
Clay	0.18	0.09
Clay Loam	0.17	0.08
Silt Loam	0.15	0.08
Loam	0.14	0.07
Sandy Loam	0.12	0.06
Sand	0.07	0.04

Calculate Irrigation Frequency

Irrigation frequency is defined as the number of irrigation days per week. Irrigation frequency is a function of plant available water and plant water requirements. To determine irrigation frequency, use the following formula.

$$IF = \frac{WR}{PAW}$$

Where:

IF	**=** Irrigation Frequency (round to the nearest whole number)
WR	= Plant water requirement (inches per week)
PAW	= Plant available water

Calculate Zone Run Times

Irrigation scheduling must be done on a zone-by-zone basis, which takes into account specific plant and soil conditions, microclimates, and irrigation hardware performance. The irrigation zone run time is a function of the plant water requirements, the precipitation rate of the zone, and the irrigation frequency. To determine the zone run time, use the following formula:

$$RT = \frac{WR * 60}{IF * PR}$$

Where:

RT	**=** Zone run time (minutes per irrigation day)
WR	= Plant water requirements (inches per week)
IF	= Irrigation Frequency (irrigation days per week)
PR	= precipitation rate (inches per hour)
60	= constant to convert hours to minutes

Step to calculate zone run times

1. Calculate the plant water requirements
2. Calculate the irrigation frequency by calculating the plant available water
3. Calculate the precipitation rate
4. Finally, calculate the zone run time

Micro Irrigation Scheduling

To schedule the drip irrigation zones for the appropriate schedule, you will need to estimate the daily water requirements for various plant materials in the landscape. Individually or sparsely arranged plants will be irrigated by individual emitters or individual micro-bubblers. The water requirement for these plants is measured in gallons per day.

Groups of densely arranged plants will be irrigated by micro-sprays or inline emitter tubing (dripline) designed to distribute a precious amount of water over a fixed area. The water requirements for densely arranged plants are measured in inches per day.

You will use ET rates for the site location, application efficiency, and a crop coefficient factor based on the species, density, and microclimate to determine the water requirements of the plants on the landscape.

CLIMATE	INCHES (MILLIMETERS) DAILY	APPLICATION EFFICIENCY
COOL HUMID	.10 to .15 in (3 to 4 mm)	95%
COOL DRY	.15 to .20 in (4 to 5 mm)	95%
WARM HUMID	.15 to .20 in (4 to 5 mm)	90%
WARM DRY	.20 to .25 in (5 to 6 mm)	90%
HOT HUMID	.25 to .30 in (6 to 8 mm)	85%
HOT DRY	.30 to .45 in (8 to 11 mm) “worst case”	85%

	NOTE
COOL	= **Under 70° F (21° C) as an average midsummer high**
WARM	= between 70° and 90° F (21° and 32° C) as midsummer highs
HOT	= over 90° F (32° C)
HUMID	= over 50% as average midsummer relative humidity [dry = under 50%]

Dense Planting Zones

In a densely planted zone, first identify the “base plant”. The base plant is the plant that uses the least amount of water per day. This plant usually covers the majority of the planting area. Use the following plant schemes:

PLANTING SCHEME	BASE PLANT
GROUND COVER, TREES, AND SHRUBS	Ground Cover
SHRUBS ONLY	Shrubs
SHRUBS AND TREES	Shrubs
GROUND COVER AND SHRUBS	Ground cover
GROUND COVER AND TREES	Ground cover
GROUND COVER ONLY	Ground cover

Species factor

The species factor is an adjustment to the potential evapotranspiration rate that reflects the amount of water that a particular species of plant needs relative to turf grass. The range can be from 0.2 for plants like cacti and succulents that require little water, and up to 0.9 for plants like ferns that require a lot of water.

PLANT TYPE	LOW	AVERAGE	HIGH
MIXED TREES, SHRUBS, GROUND COVER	0.2	0.5	0.9
GROUND COVERS	0.2	0.5	0.7
SHRUBS	0.2	0.5	0.7
TREES	0.2	0.5	0.9

Density Factor

The density factor indicates how densely the plants are placed in the zone. As the density of the plants increases, so does the density factor.

PLANT TYPE	LOW	AVERAGE	HIGH
MIXED TREES, SHRUBS, GROUND COVER	0.6	1.1	1.1
GROUND COVERS	0.5	1.0	1.1
SHRUBS	0.5	1.0	1.1
TREES	0.5	1.0	1.3

Microclimate factor

A microclimate is a sub-climate such as areas in direct sunlight or total shade. Two areas may have identical plantings but different water requirements due to the microclimate.

PLANT TYPE	LOW	AVERAGE	HIGH
MIXED TREES, SHRUBS, GROUND COVER	0.5	1.0	1.4
GROUND COVERS	0.5	1.0	1.2
SHRUBS	0.5	1.0	1.3
TREES	0.5	1.0	1.4

Once you have collected all the information on the plants in the micro-irrigation zone and assigned values for the species, density, and microclimate factors, you can calculate the crop coefficient (CC) for each plant. The crop coefficient indicates the plant's need for water as it relates to the established potential evapotranspiration (PET) rate in the area.

To calculate the crop coefficient values, multiply each plant's species factor, times the density factor, times the microclimate factor. Round to the nearest tenth, and record the values as the CC.

$$CC = species\ factor * density\ factor * microclimate\ factor$$

Water requirements for the base plant in dense planting

The water requirements for the base plant in a densely planted micro-irrigation zone are measured in inches per day. To calculate the water requirement in inches per day, use the following formula:

$$WR = CC * PET$$

Where:

WR	= water requirement (inches per day)
CC	= crop coefficient
PET	= potential evapotranspiration (inches per day)

Calculate drip system run time

The process for calculating the irrigation schedule involves several steps:

1. Calculate the run time per day using the formula
2. Determine the maximum system run time
3. Determine the irrigation interval

The general formula for system run time is:

$$Run\ time\ per\ day = \frac{water\ requirement}{flow\ rate}$$

However, since the water requirements are measured differently, you will apply this general formula in a slightly different way for dense and sparse plantings.

Dense Planting system run time

The water requirement for dense planting zones is in inches per day. To calculate the system, run time, you must also measure the flow in inches per hour. The flow rate is called the “Emitter Discharge Rate” (EDR). EDR is measured in inches per hour.

$$EDR = \frac{231.0 * Q}{S * L}$$

Where:

Q	= Emitter flow rate (gallons per day)
S	= Emitter spacing (inches)
L	= Lateral spacing (inches)

The table below indicates the EDR for the most common types of dripline spacing schemes.

		Emitter Flow Rate	
Emitter Spacing	**Lateral Spacing**	**0.6 GPH**	**0.9 GPH**
24”	24”	0.24 in/hr	0.36 in/hr
18”	18”	0.43 in/hr	0.64 in/hr
12”	12”	0.96 in/hr	1.44 in/hr

Because the EDR formula and data are based on 100% application efficiency, you must adjust the EDR value by the application efficiency of the system in a particular climate. To accomplish this, multiply the EDR value by the application efficiency (%) of the specific climate. The result is the "adjusted EDR". The formula is:

$$Ajdusted\ EDR\ (inches\ per\ hour) = EDR * application\ efficiency$$

Calculate Dense planting run times

To calculate the system run time for densely planted base plants, use the following variation of the general formula:

$$Run\ time\ per\ day\ (hours) = \frac{water\ requirement\ (inches\ per\ day)}{adjusted\ EDR\ (inches\ per\ hour)}$$

If the controller is capable to be set in only minutes, you may convert to minutes by multiplying run times (in hours) by 60.

Calculate Sparse planting run times

The water requirement for sparsely planted zones is measured in gallons per day. Use the following formula:

$$Run\ time\ per\ day\ (hours) = \frac{water\ requirement\ (GPD)}{adjusted\ flow\ (GPH)}$$

The flow is the total flow of all emitters used to irrigate a single base plant. Since the flow amounts are based on 100% application efficiency, you must adjust the value by the application efficiency based upon the climate.

$$adjust\ flow = EDR * application\ efficiency$$

If the irrigation controller is capable of only minutes, you may convert to minutes by multiplying run times (in hours) by 60

Determine irrigation interval

The irrigation interval is a function of the calculated run time compared to the maximum run time in a particular type of soil. One of the most significant difference between soil types is the way in which they absorb and hold water.

SOIL TYPE	CHARACTERISTICS
FINE	The soil will form a ribbon when squeezed with the hand. When wet, the soil is plastic and flexible. May form hard lumps or clods when dry.
MEDIUM	When squeezed wet, it will form a cast that can be easily handled. It can be readily broken when dry. Has very little clay and a moderate number of fine grains of sand.
COARSE	When squeezed moist, it will form a cast, but will crumble when touched. The soil particles are loose. When dry and squeezed in the hand, it will fall apart when pressure is released.

The maximum run time is the length of time the system can run before you begin to waste water due to deep percolation loss below the desired watering depth. To determine the maximum system run time, you must know the flow rates of the emitters and the allowable depletion of the soil.

Allowable depletion is the percentage of soil moisture that you will allow the plants to deplete before irrigating again. If you select a lower allowable depletion percentage, you initiate a watering cycle when just a small amount of moisture has been depleted. Watering will occur more frequently but for less time at each irrigation cycle.

A higher allowable depletion will require less irrigation, providing more water at each irrigation. Generally, allowable depletion should not exceed 0-50% for a low-volume irrigation system.

Maximum run time for coarse soil

Watering Depth	Emitter Spacing	Emitter Flow	Maximum Run Time
3 – 9 inches	Use micro-sprays or conventional sprays		
12 inches	12 inches	0.5 (GPH)	37 minutes
		1.0 (GPH)	18 minutes
		2.0 (GPH)	9 minutes
18 inches	18 inches	0.5 (GPH)	145 minutes
		1.0 (GPH)	62 minutes
		2.0 (GPH)	31 minutes
24 inches	24 inches	0.5 (GPH)	296 minutes
		1.0 (GPH)	148 minutes
		2.0 (GPH)	74 minutes
Allowable depletion = 30% : Application Efficiency = 85% : Available Water = 1.4 in/ft			

Maximum run time for medium soil

Watering Depth	Emitter Spacing	Emitter Flow	Maximum Run Time
3 inches	Use micro-sprays or conventional sprays		
6 inches	12 inches	0.5 (GPH)	26 minutes
		1.0 (GPH)	13 minutes
		2.0 (GPH)	7 minutes
9 inches	18 inches	0.5 (GPH)	89 minutes
		1.0 (GPH)	45 minutes
		2.0 (GPH)	22 minutes
12 inches	12 inches	0.5 (GPH)	211 minutes
		1.0 (GPH)	106 minutes
		2.0 (GPH)	53 minutes
18 inches	18 inches	0.5 (GPH)	713 minutes
		1.0 (GPH)	357 minutes
		2.0 (GPH)	179 minutes
24 inches	48 inches	Use individual emitters	
Allowable depletion = 30% : Application Efficiency = 85% : Available Water = 1.4 in/ft			

Maximum run time for fine soil

Watering Depth	Emitter Spacing	Emitter Flow	Maximum Run Time
3 inches	12 inches	0.5 (GPH)	16 minutes
		1.0 (GPH)	8 minutes
		2.0 (GPH)	4 minutes
6 inches	24 inches	0.5 (GPH)	132 minutes
		1.0 (GPH)	66 minutes
		2.0 (GPH)	33 minutes
9 inches	36 inches	0.5 (GPH)	446 minutes
		1.0 (GPH)	223 minutes
		2.0 (GPH)	111 minutes
12 inches	48 inches	Use individual emitters	
Allowable depletion = 30% : Application Efficiency = 85% : Available Water = 1.4 in/ft			

Calculating the irrigation interval

The first step in determining the irrigation interval is to compare your calculated system run time per day to the maximum system run times for that particular type of soil. In most cases, the calculated run time per day will be less than the maximum run time. Use the following formula to determine the maximum irrigation interval, round to the nearest day:

$$Maximum\ irrigation\ interval\ (days) = \frac{maximum\ run\ time}{calculated\ run\ time\ per\ day}$$

Water usage and cost analysis

The purpose of proper management of an irrigation system is to conserve water and reduce costs of the water and the costs of the energy to produce and provide the water.

Calculating current water usage

To calculate the current water usage of the irrigation system, start by calculating each irrigation zone's weekly run time. The following formula is used:

$$WRT = RT * ID * IC * WB$$

Where:

WRT	= weekly run time (minutes)
RT	= run time per irrigation cycle (minutes)
ID	= irrigation days
IC	= Irrigation cycles per irrigation day
WB	= water budget (expressed as a decimal percent)

To determine the flow rate for each irrigation zone, use the following formula:

$$FR = \frac{end - start}{T}$$

Where:

FR	= flow rate (gpm)
End	= final reading of meter after flow test (gallons)
Start	= beginning reading of meter before test (gallons)
T	= test run times (minutes)

To determine weekly water-use for each zone, use the following formula:

$$WU = WRT * FR$$

Where:

WU	= weekly water usage
WRT	= weekly run time
FR	= flow rate of the zone (gpm)