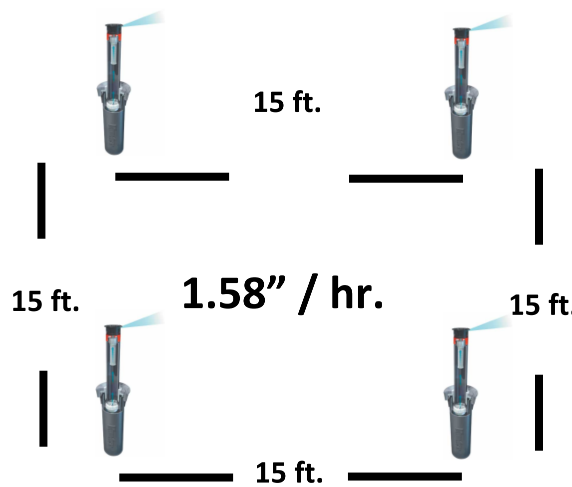
Sprinkler precipitation rates – the key to controlling irrigation runoff

Spray nozzles have a high precipitation rate that frequently results in irrigation runoff. The precipitation rate will vary with pressure and spacing. At 30 psi and spaced in a square pattern the precipitation rate is 1.58" per hour. The triangular pattern has slightly higher precipitation rates due to the tighter row spacing of 13 ft. at 1.83"

15 Series MPR

30° Trajectory

Nozzle	Pressure psi	Radius ft.	Flow GPM	■ Precip In/h	▲ Precip In/h
15F	15	11	2.60	2.07	2.39
	20	12	3.00	2.01	2.32
	25	14	3.30	1.62	1.87
	30	15	3.70	1.58	1.83
15H	15	11	1.30	2.07	2.39
	20	12	1.50	2.01	2.32
	25	14	1.65	1.62	1.87
	30	15	1.85	1.58	1.83



Verify the working water pressure at the spray nozzle to be a minimum of 30 psi. In the case of the 15 Series nozzle, any pressure less than 30 psi requires a closer spacing than 15 ft. If the sprinklers are operating at 20 - 25 psi and spaced at 15 ft there will be serious coverage (uniformity) problems. Measure water pressure as the circuit operates at the first and last sprinkler on the circuit. Verify spacing to be no greater than the radius. Sprinklers should be spaced in a square or triangular pattern with consistent spacing between heads.

Test working water pressure at the first and last sprinkler with a pressure tee and gauge.

Verify spacing between heads with a tape measure. At 30 psi spray heads should be spaced at no greater than their series, i.e 15 series at 15 ft, 12 series at 12 ft, etc.

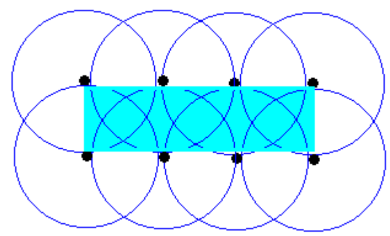
Rotor sprinklers rotate a single or multiple streams to achieve coverage. In general, the end of the stream from one sprinkler should hit right at the base of the adjacent sprinkler. The pressure requirement at the nozzle is dependent on the spacing and the nozzle installed in the sprinkler. Performance charts indicate a radius(spacing interval) that can be achieved with a particular nozzle at varying pressures. Generally, these sprinklers have a higher pressure requirement than spray nozzles. As a consequence low nozzle pressure is a common problem. Pressure, along with spacing must be verified in the field. Precipitation rate data may only be relied upon when pressure, nozzle, and spacing agree with nozzle performance data. These sprinklers have lower precipitation rates than sprays and therefore can be run for longer periods before runoff occurs.

PGP Red Standard Nozzle Performance Data

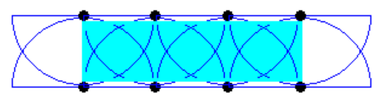
Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
1	30	28'	0.5	0.12	0.14
	40	29'	0.6	0.14	0.16
	50	**29'**	**0.7**	**0.16**	**0.19**
	60	30'	0.8	0.17	0.20
2	30	29'	0.7	0.16	0.19
	40	30'	0.8	0.17	0.20
	50	**30'**	**0.9**	**0.19**	**0.22**
	60	31'	1.0	0.20	0.23
3	30	30'	0.9	0.19	0.22
	40	31'	1.0	0.20	0.23
	50	**31'**	**1.2**	**0.24**	**0.28**
	60	32'	1.3	0.24	0.28
4	30	32'	1.2	0.23	0.26
	40	33'	1.4	0.25	0.29
	50	**34'**	**1.6**	**0.27**	**0.31**
	60	34'	1.8	0.30	0.35
5	30	34'	1.6	0.27	0.31
	40	36'	1.8	0.27	0.31
	50	**38'**	**2.0**	**0.27**	**0.31**
	60	38'	2.2	0.29	0.34
6	30	34'	2.0	0.33	0.38
	40	36'	2.4	0.36	0.41
	50	**38'**	**2.7**	**0.36**	**0.42**
	60	38'	2.9	0.39	0.45

These charts represent precipitation rates at half circle or 180 degree setting. For full circle operation divide the chart values by 2!

38 ft. square spacing



#5 noz. - 2.0 gpm @ 50 psi at 360 deg
precipitation rate = 0.135" / hr



#5 noz - 2.0 gpm @50 psi at 180 deg (half circle)
precipitation rate = 0.27" / hr.

The pitot tube and pressure gauge are used to measure nozzle pressure which is evaluated against nozzle performance charts

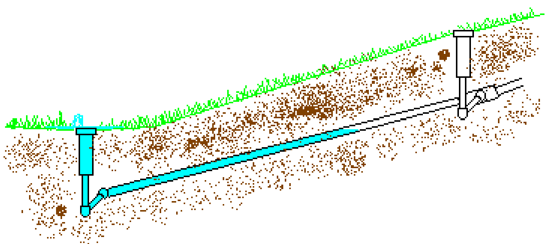
Suggested maximum run times on clay soil before runoff occurs
(on flat surfaces)
infiltration rate - 0.10" / hr

spray	spray	spray	rotors	rotors	rotors	rotors	rotor
1.6" / hr	1.8" / hr	2" / hr	0.25"/hr	0.35" / hr	0.45"/hr	0.55"/hr	0.65"/hr
4 min	4 min	4 min	24 min	17 min	13 min	11 min	9 min

Suggested maximum run times on clay loam soil before runoff occurs
(on flat surfaces)
infiltration rate - 0.16" / hr

spray	spray	spray	rotors	rotors	rotors	rotors	rotor
1.6" / hr	1.8" / hr	2" / hr	0.25"/hr	0.35" / hr	0.45"/hr	0.55"/hr	0.65"/hr
6 min	5 min	4 min	38 min	27 min	21 min	17 min	14 min

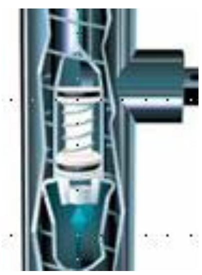
Low head drainage occurs in lateral sprinkler piping after the irrigation valve has shut down. When heavy clay soils are being irrigated, multiple cycles (usually 6-8) must occur every day that irrigation takes place. This necessary cycling process introduces the problem of low head drainage. This problem may be resolved with addition of check valves which may be retrofitted into the base of spray head bodies.



It is not unusual to find irrigation valves with spray and rotor type sprinklers plumbed together. This is never acceptable and should be corrected because of the different precipitation rates of the two types!

While low pressure at spray nozzles is frequently encountered, it is not unusual to find spray systems with excessive pressure. When pressure exceeds 45 psi, the sprinkler body should have a pressure regulating feature. This feature, like the anti-drain check valve, may be retrofitted into an existing spray body without digging up the sprinkler When sprinkler inlet pressures exceed 75 psi a regulator must be installed at the valve or backflow prevention device location.

Spray heads operating at 90 psi. This problem was corrected with the addition of a regulator feature on the valve.



Internal pressure regulating device is designed for inlet pressures between 45 and 75 psi

Same circuit operating at 30 psi!

Managing the Irrigation Controller in a Drought

The amount of irrigation water applied to the landscape varies with the type of plant material and the precipitation rate of the sprinklers. The environmental factors that drive plant water use are temperature, wind, solar radiation, humidity, and ground temperature and collectively they generate a number known as Evapotranspiration (ET). These factors are nearly impossible for the landscape manager to evaluate in the field. The State of California has a network of computerized weather stations linked to a free website in a program known as CIMIS (California Irrigation Management Information System). There are nearly 200 of these stations throughout the state. They provide the landscape manager with a number that represents the inches of water plants generally need in a month, week or day. The number available from the local weather station is known as ET_O or reference ET. There are many regions of the state that lack a local weather station. In these instances tables are available providing monthly averages in the Water Efficient Landscape Ordinance (WELO) which is also available on line.

Number	Name	Region
131	Fair Oaks	Sacramento Valley

Stn	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
131	1.59	2.20	3.66	5.08	6.83	7.80	8.67	7.81	5.67	4.03	2.13	1.59

http://wwwcimis.water.ca.gov/

http://ucanr.edu/sites/WUCOLS/

Water Efficient Landscape Ordinance (WELO)
http://www.water.ca.gov/wateruseefficiency/landscapeordinance/

Every plant has a different water requirement relative to ET_O based upon the landscape coefficient or K_L. The primary factor that drives that landscape coefficient is the species factor. Our primary concern in the drought is the water requirement for turfgrass as it consumes the bulk of the landscape water. The plant water requirement ET_L is obtained for any period by multiplying the ET_O x K_L. In a traditional year cool season turfgrass such as fescue, Kentucky Bluegrass, or rye have a species factor of 70 percent or 0.70. In a drought we reduce this species factor and in turn the landscape coefficient (K_L) to 60 percent or 0.60. This follows guidelines developed by turfgrass experts at the University of California at Davis and Riverside.

July ET_L in a traditional year – ET_O (8.67") x K_L (0.70 for cs turf) = 6.06" / month

July ET_L in a drought year – ET_O (8.67") x K_L (0.60 for cs turf) = 5.20" / month

The water savings associated with this recommendation will save 0.86" in the peak month of July which is a 14% reduction in water use!

The development of an irrigation schedule is based on the average daily ET_L. In the month of July we have a ET_L of 5.20". The objective is to establish an average daily ET_L which in this case is 0.17" per day (5.20" / 31 = 0.17'). The replacement for every other day watering for turf in a typical July is 0.34 inches. If we were watering on a flat clay surface the infiltration rate or maximum intake rate of the soil is 0.08 inches per hour. It would be necessary to have 4 cycles. This could typically be achieved on one program.

Daily	**Sun**	**Mon**	**Tue**	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**	**Mon**	**Tue**
ET_L	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**
			Water Tues a.m. 0.34"		**Water Thurs a.m. 0.34"**		**Water Sat a.m. 0.34"**		**Water Mon a.m. 0.34"**	

Many local water agencies will have watering restrictions that will allow watering two days per week in July. This means more water will have to be applied each irrigation day requiring more cycles

ET_L Daily

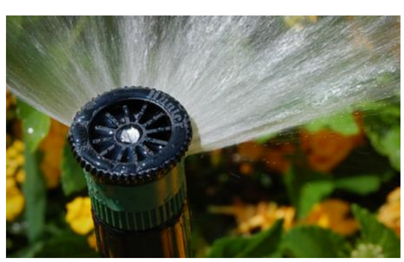
Tue	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**	**Mon**
0.17	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**
	Water Wed a.m. replace 0.51" (3 days x 0.17")				**Water Sun a.m. replace 0.68" (4 days x 0.17")**	

On Sunday the turf water requirement is 0.68. Regardless of the type of sprinkler, the soil infiltration or intake rate of 0.08” for clay (in this case) dictates the maximum amount of water applied to be 0.08” before runoff. Some sprinklers such as rotors and drip apply water more slowly and can have longer run times. Spray type sprinklers have a much higher precipitation rate so their run times to reach runoff are shorter. The sprinkler does not dictate the number of repeats rather it is the soil type! So the number of cycles required is 8 (0.68 /0.08 = 8.5) We are using 8 cycles here because of the limitations of start times available on most controllers.

WATERING SCHEDULE FORM EXAMPLE

		PROGRAM A	PROGRAM B	PROGRAM C
DAY OF THE WEEK		M T W T F S S	M T W T F S S	M T W T F S S
ODD/ EVEN or INTERVAL		x	x	
PROGRAM START TIMES		9:30 p.m.	1:30 a.m.	
		10:30 p.m.	2:30 a.m.	
		11:30 p.m.	3:30 a.m.	
		12:30 a.m.	4:30 a.m.	
STATION	LOCATION	STATION RUN TIME	STATION RUN TIME	STATION RUN TIME
1				
2				

The next step in scheduling is to determine the run time in minutes required for Sunday. We use a simple run time formula RT = ET_L (turf water requirement) / PR (precipitation rate) x 60 (constant). In this example the sprinkler is a 15 ft spray spaced square at 30 psi with a precipitation rate of 1.58” / hr. Recall the Wednesday ET_L so the run time is as follows ET_L (0.68) / PR (1.58) x 60 = 26 minutes. The problem is that the number is not divisible by 8, but we can have different run times to make this work. On Program A we’ll water 4 minutes per cycle x 4 starts = 16 minutes. If we did this on program B as well we would be watering 32 minutes. On program B we’ll water 3 minutes for a total of 12 minutes run time (4 cycles x 3 min = 12 min)



(plant water requirement)

(constant)

$$RT = \frac{ET_L}{PR} \times 60$$

(precipitation rate)

		PROGRAM A							PROGRAM B							PROGRAM C						
DAY OF THE WEEK		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
ODD/ EVEN or INTERVAL								X							X							
PROGRAM START TIMES	1	9:30 p.m.							1:30 a.m.													
	2	10:30 p.m.							2:30 a.m.													
	3	11:30 p.m.							3:30 a.m.													
	4	12:30 a.m.							4:30 a.m.													
STATION	LOCATION	STATION RUN TIME							STATION RUN TIME							STATION RUN TIME						
1	sprays front lawn	*4 min*							*3 min*													
2																						

(4 min x 4 cycles) = 16 min (3 min x 4 cycles) - 12 min.

16 min + 12 min = 28 min run time

We've completed the schedule for station 1 for the spray heads on the turf for Sunday. The irrigation water that we had to apply (0.68') requires 8 repeats and utilized the capabilities of both the A and B programs. The water requirement for Wednesday morning replaces 3 days of turf water use or 0.51 inches of water). On the majority of controllers in the field there are only three programs. We'll use the final program, program C, for station 1 on Wednesday. This is the hottest month of the year and the run time is not ideal but the best that we can do with the flexibility of most controllers. ***If you have a controller with only two programs or less than three starts per program then replace it.*** The run time for Wednesday is RT = ETL / PR x 60 (0.51 / 1.58 x 60) = 19.4 min. We'll round up the time to twenty minutes which will give us four, five minute cycles (4 starts x 5 min = 20 min).

		PROGRAM A							PROGRAM B							PROGRAM C						
DAY OF THE WEEK		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
ODD/ EVEN or INTERVAL								X							X			X				
PROGRAM START TIMES	1	9:30 p.m.							1:30 a.m.							9:30 p.m.						
	2	10:30 p.m.							2:30 a.m.							10:30 p.m.						
	3	11:30 p.m.							3:30 a.m.							11:30 p.m.						
	4	12:30 a.m.							4:30 a.m.							12:30 a.m.						
STATION	LOCATION	STATION RUN TIME							STATION RUN TIME							STATION RUN TIME						
1	sprays front lawn	*4 min*							*3 min*							*5 min*						
2																						

(5 min x 4 cycles) = 20 min

One important feature of more modern controller is the percentage adjust key or +/- key. It allows adjustment of an entire program by percentages. Heavy clay soils and spray heads render this a meaningless feature. Imagine that there is a 4 minute run time that needs a 10% reduction. The controllers times in 1 minute increments so the % key only works for 25% changes (4 minutes reduces to 3 minutes is a 25% change). In the example we have provided. If we wanted to reduce the time by 10 % we would eliminate one of the start times on program B. This would reduce the run tine on Sunday from 28 minutes to 25 minutes.

Ultimately we need to be very creative in dealing with reduced watering days. There are many limitations to controller programming and they are acutely felt during a drought. Another serious limitation which will be addressed is the limitation of the water meter to apply water in two days that would normally be applied in 3 to 7 days per week!

Irrigation Schedule
Fair Oaks, CA

Pop Up Spray Heads / Cool Season Turf

Cool Season Turf with a K_T species factor (maximum stress) **0.60**

DU_{LQ}	**0.56**	
PR Rate	**1.58**	**inches / hr.**
RTM	**1.36**	

Every 4th day watering — **Every 3rd day watering**

		Fair Oaks ET_O Avg Monthly	**Fair Oaks ET_O Avg. daily**	**Fair Oaks CS Turf Req't daily**	**Lower Bndry. Run Time min.** (Every 4th day)	**Upper Bndry. Run Time min.** (Every 4th day)	**Lower Bndry. Run Time min.** (Every 3rd day)	**Upper Bndry. Run Time min.** (Every 3rd day)
31	**Mar**	**3.66**	0.1181	0.0708	11	15	8	11
30	**Apr**	**5.08**	0.1693	0.1016	15	21	12	16
31	**May**	**6.83**	0.2203	0.1322	20	27	15	20
30	**Jun**	**7.8**	0.2600	0.1560	24	32	18	24
31	**Jul**	**8.67**	0.2797	0.1678	25	35	19	26
31	**Aug**	**7.81**	0.2519	0.1512	23	31	17	23
30	**Sep**	**5.67**	0.1890	0.1134	17	23	13	18
31	**Oct**	**4.03**	0.1300	0.0780	12	16	9	12
		49.55						

MP Rotators / Cool Season Turf

Cool Season Turf with a K_T species factor (maximum stress) **0.60**

DU_{LQ}	**0.72**	
PR Rate	**0.43**	**inches / hr.**
RTM	**1.2**	

Every 4th day watering — **Every 3rd day watering**

		Fair Oaks ET_O Avg Monthly	**Fair Oaks ET_O Avg. daily**	**Fair Oaks CS Turf Req't daily**	**Lower Bndry. Run Time min.** (Every 4th day)	**Upper Bndry. Run Time min.** (Every 4th day)	**Lower Bndry. Run Time min.** (Every 3rd day)	**Upper Bndry. Run Time min.** (Every 3rd day)
31	**Mar**	**3.66**	0.1181	0.0708	40	47	30	36
30	**Apr**	**5.08**	0.1693	0.1016	57	68	43	51
31	**May**	**6.83**	0.2203	0.1322	74	89	55	66
30	**Jun**	**7.8**	0.2600	0.1560	87	104	65	78
31	**Jul**	**8.67**	0.2797	0.1678	94	112	70	84
31	**Aug**	**7.81**	0.2519	0.1512	84	101	63	76
30	**Sep**	**5.67**	0.1890	0.1134	63	76	47	57
31	**Oct**	**4.03**	0.1300	0.0780	44	52	33	39

Drip / Line Source - 0.9 GPH - 12" x 12" spacing

Ornamental Shrubs with a species factor K_P (max stress) 0.40

DU_{LQ}	**0.9**	
PR Rate	**1.42**	**inches / hr.**
RTM	**1.06**	

					Every 4th day watering		Every 3rd day watering	
		Fair Oaks ET_O Avg Monthly	Fair Oaks ET_O Avg. daily	Fair Oaks Orn. Shrub Req't daily	Lower Bndry. Run Time min.	Upper Bndry. Run Time min.	Lower Bndry. Run Time min.	Upper Bndry. Run Time min.
31	**Mar**	**3.66**	0.1181	0.0472	8	10	6	6
30	**Apr**	**5.08**	0.1693	0.0677	11	14	9	9
31	**May**	**6.83**	0.2203	0.0881	15	18	11	12
30	**Jun**	**7.8**	0.2600	0.1040	18	21	13	14
31	**Jul**	**8.67**	0.2797	0.1119	19	23	14	15
31	**Aug**	**7.81**	0.2519	0.1008	17	20	13	14
30	**Sep**	**5.67**	0.1890	0.0756	13	15	10	10
31	**Oct**	**4.03**	0.1300	0.0520	9	11	7	7

Drip / Point Source - random spacing - 0.25" / hr. PR

Ornamental Shrubs with a species factor K_P (max stress) 0.40

DU_{LQ}	**0.9**	
PR Rate	**0.25**	**inches / hr.**
RTM	**1.06**	

					Every 4th day watering		Every 3rd day watering	
		Fair Oaks ET_O Avg Monthly	Fair Oaks ET_O Avg. daily	Fair Oaks Orn. Shrub Req't daily	Lower Bndry. Run Time min.	Upper Bndry. Run Time min.	Lower Bndry. Run Time min.	Upper Bndry. Run Time min.
31	**Mar**	**3.66**	0.1181	0.0472	45	54	34	36
30	**Apr**	**5.08**	0.1693	0.0677	65	78	49	52
31	**May**	**6.83**	0.2203	0.0881	85	102	63	67
30	**Jun**	**7.8**	0.2600	0.1040	100	120	75	79
31	**Jul**	**8.67**	0.2797	0.1119	107	129	81	85
31	**Aug**	**7.81**	0.2519	0.1008	97	116	73	77
30	**Sep**	**5.67**	0.1890	0.0756	73	87	54	58
31	**Oct**	**4.03**	0.1300	0.0520	50	60	37	40

* lower boundary represents a water time that assumes a high uniformity of application DU_{LQ}

* upper boundary increases run time to account for normal sprinkler uniformity deficiencies

Precipitation Rate Tables - Low Volume/Drip-Micro Irrigation

Point Source Emiiters or Micro Spray

(METER FLOW)

AREA IN SQUARE FEET(CANOPY AREA)

CFM	GPM	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700
0.03	0.25	0.48	0.32	0.24	0.19	0.16	0.14	0.12	0.11	0.10	0.09	0.08																
0.07	0.50	0.96	0.64	0.48	0.39	0.32	0.28	0.24	0.21	0.19	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08					
0.10	0.75	1.44	0.96	0.72	0.58	0.48	0.41	0.36	0.32	0.29	0.26	0.24	0.22	0.21	0.19	0.18	0.17	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.10
0.13	1.00	1.93	1.28	0.96	0.77	0.64	0.55	0.48	0.43	0.39	0.35	0.32	0.30	0.28	0.26	0.24	0.23	0.21	0.20	0.19	0.18	0.18	0.17	0.16	0.15	0.15	0.14	0.14
0.17	1.25	2.41	1.61	1.20	0.96	0.80	0.69	0.60	0.54	0.48	0.44	0.40	0.37	0.34	0.32	0.30	0.28	0.27	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.19	0.18	0.17
0.20	1.50	2.89	1.93	1.44	1.16	0.96	0.83	0.72	0.64	0.58	0.53	0.48	0.44	0.41	0.39	0.36	0.34	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.22	0.21	0.21
0.23	1.75	3.37	2.25	1.69	1.35	1.12	0.96	0.84	0.75	0.67	0.61	0.56	0.52	0.48	0.45	0.42	0.40	0.37	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.24
0.27	2.00	3.85	2.57	1.93	1.54	1.28	1.10	0.96	0.86	0.77	0.70	0.64	0.59	0.55	0.51	0.48	0.45	0.43	0.41	0.39	0.37	0.35	0.33	0.32	0.31	0.30	0.29	0.28
0.30	2.25	4.33	2.89	2.17	1.73	1.44	1.24	1.08	0.96	0.87	0.79	0.72	0.67	0.62	0.58	0.54	0.51	0.48	0.46	0.43	0.41	0.39	0.38	0.36	0.35	0.33	0.32	0.31
0.33	2.50	4.82	3.21	2.41	1.93	1.61	1.38	1.20	1.07	0.96	0.88	0.80	0.74	0.69	0.64	0.60	0.57	0.54	0.51	0.48	0.46	0.44	0.42	0.40	0.39	0.37	0.36	0.34
0.37	2.75	5.30	3.53	2.65	2.12	1.77	1.51	1.32	1.18	1.06	0.96	0.88	0.81	0.76	0.71	0.66	0.62	0.59	0.56	0.53	0.50	0.48	0.46	0.44	0.42	0.41	0.39	0.38
0.40	3.00	5.78	3.85	2.89	2.31	1.93	1.65	1.44	1.28	1.16	1.05	0.96	0.89	0.83	0.77	0.72	0.68	0.64	0.61	0.58	0.55	0.53	0.50	0.48	0.46	0.44	0.43	0.41
0.43	3.25	6.26	4.17	3.13	2.50	2.09	1.79	1.56	1.39	1.25	1.14	1.04	0.96	0.89	0.83	0.78	0.74	0.70	0.66	0.63	0.60	0.57	0.54	0.52	0.50	0.48	0.46	0.45
0.47	3.50	6.74	4.49	3.37	2.70	2.25	1.93	1.69	1.50	1.35	1.23	1.12	1.04	0.96	0.90	0.84	0.79	0.75	0.71	0.67	0.64	0.61	0.59	0.56	0.54	0.52	0.50	0.48
0.50	3.75	7.22	4.82	3.61	2.89	2.41	2.06	1.81	1.61	1.44	1.31	1.20	1.11	1.03	0.96	0.90	0.85	0.80	0.76	0.72	0.69	0.66	0.63	0.60	0.58	0.56	0.54	0.52
0.53	4.00	7.70	5.14	3.85	3.08	2.57	2.20	1.93	1.71	1.54	1.40	1.28	1.19	1.10	1.03	0.96	0.91	0.86	0.81	0.77	0.73	0.70	0.67	0.64	0.62	0.59	0.57	0.55
0.57	4.25	8.19	5.46	4.09	3.27	2.73	2.34	2.05	1.82	1.64	1.49	1.36	1.26	1.17	1.09	1.02	0.96	0.91	0.86	0.82	0.78	0.74	0.71	0.68	0.65	0.63	0.61	0.58
0.60	4.50	8.67	5.78	4.33	3.47	2.89	2.48	2.17	1.93	1.73	1.58	1.44	1.33	1.24	1.16	1.08	1.02	0.96	0.91	0.87	0.83	0.79	0.75	0.72	0.69	0.67	0.64	0.62
0.64	4.75	9.15	6.10	4.57	3.66	3.05	2.61	2.29	2.03	1.83	1.66	1.52	1.41	1.31	1.22	1.14	1.08	1.02	0.96	0.91	0.87	0.83	0.80	0.76	0.73	0.70	0.68	0.65
0.67	5.00	9.63	6.42	4.82	3.85	3.21	2.75	2.41	2.14	1.93	1.75	1.61	1.48	1.38	1.28	1.20	1.13	1.07	1.01	0.96	0.92	0.88	0.84	0.80	0.77	0.74	0.71	0.69

** Obtain flow to the area by reading water meter. Calculate canopy area using Ewing's "16 point" measuring system for irregularly shaped areas.*

In-Line Drip Tubing Flow Precipitation Rates (Netafim)

GENERAL GUIDELINES	TURF												SHRUB & GROUNDCOVER											
	CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL			CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL		
EMITTER FLOW	0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH			0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH		
EMITTER SPACING	18"			12"			12"			12"			18"			18"			12"			12"		
LATERAL (ROW) SPACING	18"	20"	22"	18"	20"	22"	12"	14"	16"	12"	14"	16"	18"	21"	24"	18"	21"	24"	16"	18"	20"	16"	18"	20"
BURIAL DEPTH	Bury evenly throughout the zone from 4" to 6"												On-surface or bury evenly throughout the zone to a maximum of 6"											
APPLICATION RATE (INCHES/HOUR)	0.19	0.17	0.15	0.45	0.41	0.37	0.96	0.83	0.72	1.44	1.24	1.08	0.19	0.16	0.14	0.29	0.24	0.21	0.72	0.64	0.58	1.08	0.96	0.87
TIME TO APPLY ¼" OF WATER (MINUTES)	81	90	99	33	37	41	16	18	21	10	12	14	81	94	108	53	61	70	21	23	26	14	16	17

Following these maximum spacing guidelines, emitter flow selection can be increased if desired by the designer.
0.9 GPH flow rate available for areas requiring higher infiltration rates, such as coarse sandy soils.

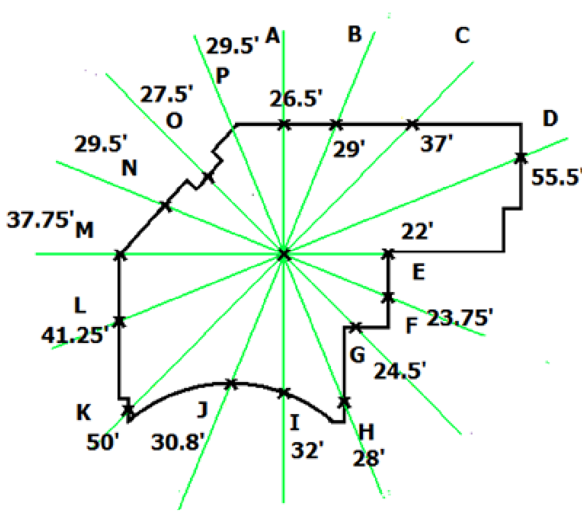
Note: 0.4, 0.6 and 0.9 GPH are nominal flow rates. Actual flow rates used in the calculations are 0.42, 0.61 and 0.92 GPH.

Measuring irregularly shaped areas

Calibration is critical to the effective and safe application of pesticides. Equipment calibration is just part of the process. The often overlooked aspect of calibration is the calculation of the area to be treated. In this regard pesticide application is not unlike area estimation for water use or landscape pre construction

When the geometry of an area is complex, the area can be measured by treating it as a circle. The formula for the area of a circle is Pi (3.14) x radius (squared) = A. We can determine the average radius of any shape by measuring the distance from near the center to the perimeter 16 times using a 100 foot tape. We then total these measurements and divide by 16 to obtain the average.

In the field use a fabricated 2 x 2 plywood sheet with a hole in the center for a screwdriver and place this sheet near the approximate center of the area to be measured. Create 16 permanent radii from the center at 22.5 degree increments on the plywood sheet. Use these as a guide and measure to the perimeter.



A	26.5'
B	29'
C	37'
D	55.5'
E	22'
F	23.75'
G	24.5'
H	28'
I	32'
J	30.8'
K	50'
L	41.25'
M	37.75'
N	29.5'
O	27.5'
P	29.5'

524.55

524.55 /16 = 32.78

Figure 1- Measuring an irregularly shaped landscape area

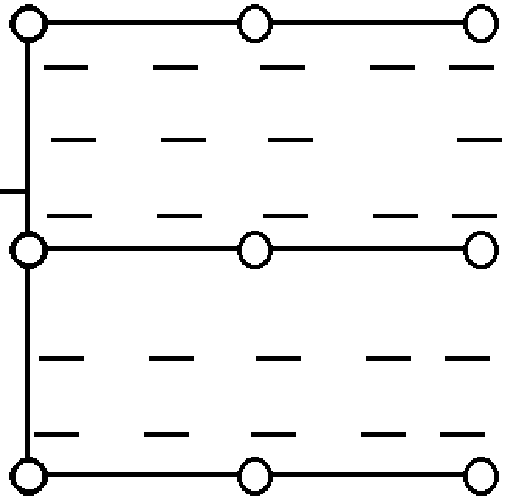
For simplicity of calculation inches are converted to a decimal equivalent. A conversion chart for inches to decimal equivalent may be found on the right side of the table on the reverse side of this page.

This shape has a total of 524.55 feet. The average radius is therefore 32.78 (524.5/16). Find the average radius on the reverse table. We have to interpolate to determine that the area is 3,346 sq. ft

Conversion Chart - Average Radius to Square Feet (16 radii minimum)

Avergage Radius (feet)	Area (square feet)	Avergage Radius (feet)	Area (square feet)	Avergage Radius (feet)	Area (square feet)	Avergage Radius (feet)	Area (square feet)
10.00	314	22.00	1,521	43.00	5,809	66.50	13,893
10.25	330	22.50	1,590	43.50	5,945	66.00	13,685
10.50	346	22.75	1,626	44.00	6,082	66.50	13,893
10.75	363	23.00	1,662	44.50	6,221	67.00	14,103
11.00	380	23.25	1,698	45.00	6,362	67.50	14,314
11.25	398	23.50	1,735	45.50	6,504	68.00	14,527
11.50	415	23.75	1,772	46.00	6,648	68.50	14,741
11.75	434	24.00	1,810	46.50	6,793	69.00	14,957
12.00	452	24.25	1,847	47.00	6,940	69.50	15,175
12.25	471	24.50	1,886	47.50	7,088	70.00	15,394
12.50	491	24.75	1,924	48.00	7,238	70.50	15,615
12.75	511	25.00	1,963	48.50	7,390	71.00	15,837
13.00	531	25.50	2,043	49.00	7,543	71.50	16,061
13.25	552	26.00	2,124	49.50	7,698	72.00	16,286
13.50	573	26.50	2,206	50.00	7,854	72.50	16,513
13.75	594	27.00	2,290	50.50	8,012	73.00	16,742
14.00	616	27.50	2,376	51.00	8,171	73.50	16,972
14.25	638	28.00	2,463	51.50	8,332	74.00	17,203
14.50	661	28.50	2,552	52.00	8,495	74.50	17,437
14.75	683	29.00	2,642	52.50	8,659	75.00	17,671
15.00	707	29.50	2,734	53.00	8,825	75.50	17,908
15.25	731	30.00	2,827	53.50	8,992	76.00	18,146
15.50	755	30.50	2,922	54.00	9,161	76.50	18,385
15.75	779	31.00	3,019	54.50	9,331	77.00	18,627
16.00	804	31.50	3,117	55.00	9,503	77.50	18,869
16.25	830	32.00	3,217	55.50	9,677	78.00	19,113
16.50	855	32.50	3,318	56.00	9,852	78.50	19,359
16.75	881	33.00	3,421	56.50	10,029	79.00	19,607
17.00	908	33.50	3,526	57.00	10,207	79.50	19,856
17.25	935	34.00	3,632	57.50	10,387	80.00	20,106
17.50	962	34.50	3,739	58.00	10,568		
18.00	1,018	35.00	3,848	58.50	10,751	Decimal Equival.	
18.25	1,046	35.50	3,959	59.00	10,936	inches	decimal
18.50	1,075	36.00	4,072	59.50	11,122		
18.75	1,104	36.50	4,185	60.00	11,310	1	0.08
19.00	1,134	37.00	4,301	60.50	11,499	2	0.17
19.25	1,164	37.50	4,418	61.00	11,690	3	0.25
19.50	1,195	38.00	4,536	61.50	11,882	4	0.33
19.75	1,225	38.50	4,657	62.00	12,076	5	0.42
20.00	1,257	39.00	4,778	62.50	12,272	6	0.50
20.25	1,288	39.50	4,902	63.00	12,469	7	0.58
20.50	1,320	40.00	5,027	63.50	12,668	8	0.67
20.75	1,353	40.50	5,153	64.00	12,868	9	0.75
21.00	1,385	41.00	5,281	64.50	13,070	10	0.83
21.25	1,419	41.50	5,411	65.00	13,273	11	0.92
21.50	1,452	42.00	5,542	65.50	13,478		
21.75	1,486	42.50	5,675	66.00	13,685	c. 2009 Ewing Irrigation Produ	

Spray Circuit - Audit Run Time (4 minutes)



psi

gpm

cfm

Driest 6 catches

Total

Avg.

psi (total divided by 6)

Total of 24 catch readings

avg.(total divided by 24)

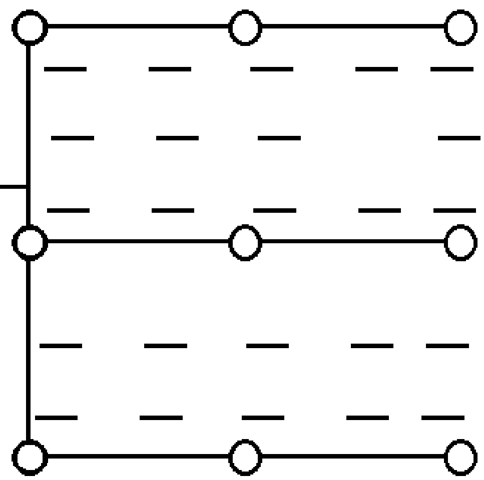
DU_{LQ} = dry 6 / avg of 24

DU_{LQ}

$$PR = \frac{3.66 \times V_{avg}}{t_r \times 16.5}$$

PR

Rotating Stream Circuit - Audit Run Time (10 minutes)



psi

gpm

cfm

Driest 6 catches

Total

Avg.

psi (total divided by 6)

Total of 24 catch readings

avg.(total divided by 24)

DU_{LQ} = dry 6 / avg of 24

DU_{LQ}

$$PR = \frac{3.66 \times V_{avg}}{t_r \times 16.5}$$

PR

Estimating Irregularly shaped Areas

Measurement

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	

TOTAL	
AVG/16	
SQ. FT	

METER

FLOW

CFM	

PR Rate	

EMITTER FLOW (TIME TO FILL 2" CAP)

EMITTER TYPE	GPH	FILL TIME
POINT SOURCE	2.00	56 SECONDS
POINT SOURCE	1.00	1 MIN 52 SECONDS
LINE SOURCE	0.92	2 MIN 2 SECONDS
LINE SOURCE	0.61	3 MIN 4 SECONDS
POINT SOURCE	0.50	3 MIN 45 SECONDS
LINE SOURCE	0.42	4 MIN 26 SECONDS

The water meter is an important management tool during the drought. As a landscape professional you can provide a very important service for your customers by monitoring their water use. If you are performing landscape maintenance at a site, then you are visiting it on a weekly basis and it will take just a few minutes to provide this service. Your primary objective in this regard is to look for leaks. Open the valve meter box when you arrive for maintenance and watch the meter for a few moments. There is a low flow indicator on the meter. If the meter is not dedicated to the landscape there may be a flow of potable to the residence or building. Try to check for leaks when no one is present in the building. If the irrigation system is off and no one is home the low flow indicator should not be moving. Observe it for a few seconds to see if it is turning. It may not be turning, but there still may be a leak. Note the position of the needle and the reading on the total flow which looks like a car's odometer. Check this before you leave the site to see if there has been any flow during your maintenance period. Calculate the flow of the leak per hour and multiply by 8,760 (hours per year to determine the amount of water loss per year.

At each maintenance visit check the low flow indicator and the position of the needle and total flow to determine if there is a slow leak. Take a digital image with your phone camera to document any leaks as well as the meter number. This is a great low cost service that you can provide to your customers during the drought!

The water meter is usually located between the curb and the backflow prevention device. Most commercial sites have dedicated landscape meters but this is not always the case. Meters record water volume in gallons or cubic feet, but most water agencies provide meters that record in cubic feet. A cubic foot of water is 7.48 gallons and is a 12"x12"x12" cube. Customers are billed in what is known as ccf's or hundred cubic foot units of 748 gallons.

Each full revolution of the dial on commercial meters (1 ½" and larger) represents a flow of ten cubic feet or 74.8 gallons

Each full revolution of the dial on a residential meter (5/8", 3,4" and 1") represents a flow of one cubic foot or 7.48 gallons

The water meter limits the amount of water that can be delivered to the site. Most irrigation systems were designed with the expectation that they would apply water anywhere from three to seven days per week. Take the system that in non-drought years was able to water six days per week and nine hours per day in the month of July. This is a total watering time of 3,240 minutes (6 x 9 x 60). Let's assume this is a 2" meter providing 50 gallons per minute. Under these conditions the meter could provide up to 162,000 gallons per week. (This 50 gpm flow is an average as some stations such as drip have far less flow and others such as large turf rotors have more)

Now, transition to a drought where watering is allowed two days per week for a maximum of thirty hours per week. The amount of water that could be delivered to the site would be 90,000 gallons (1,800 minutes x 50 = 90,000. Given this shortfall it is likely the site manager will have to set priorities on landscape watering and it is possible that some areas of the landscape may not survive. Invest the landscape water in large trees and shrubs which have the greatest value in the landscape!

meter size	**meter flow**	**Max. deliverable water in 30 hrs.**	**Sq. ft of turf that may be irrigated in 1 week**
			(1.5" application)
5/8"	**15**	**27,000**	**28,892**
3/4"	**22**	**39,600**	**42,376**
1"	**37**	**66,600**	**71,268**
1 1/2"	**75**	**135,000**	**144,462**
2"	**120**	**216,000**	**231,140**
3"	**225**	**405,000**	**433,387**

Zz

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Sacramento Tree Foundation

Building healthy, livable communities in the Sacramento region by growing the best urban forest in the nation.

- Air Quality
- Energy conservation
- Water Quality
- Climate change

- Comfort
- Habitat
- Public Health
- Economy $$$

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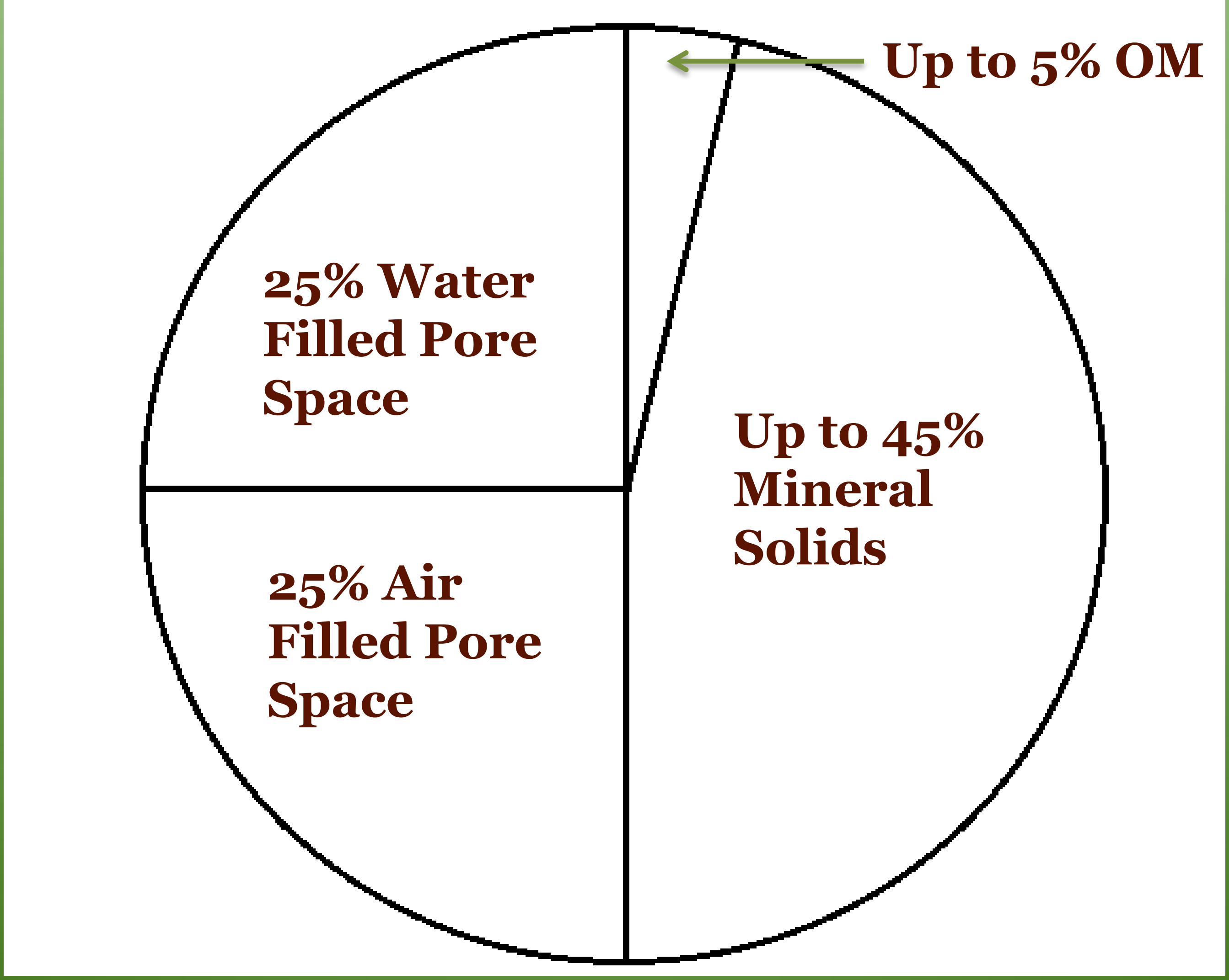
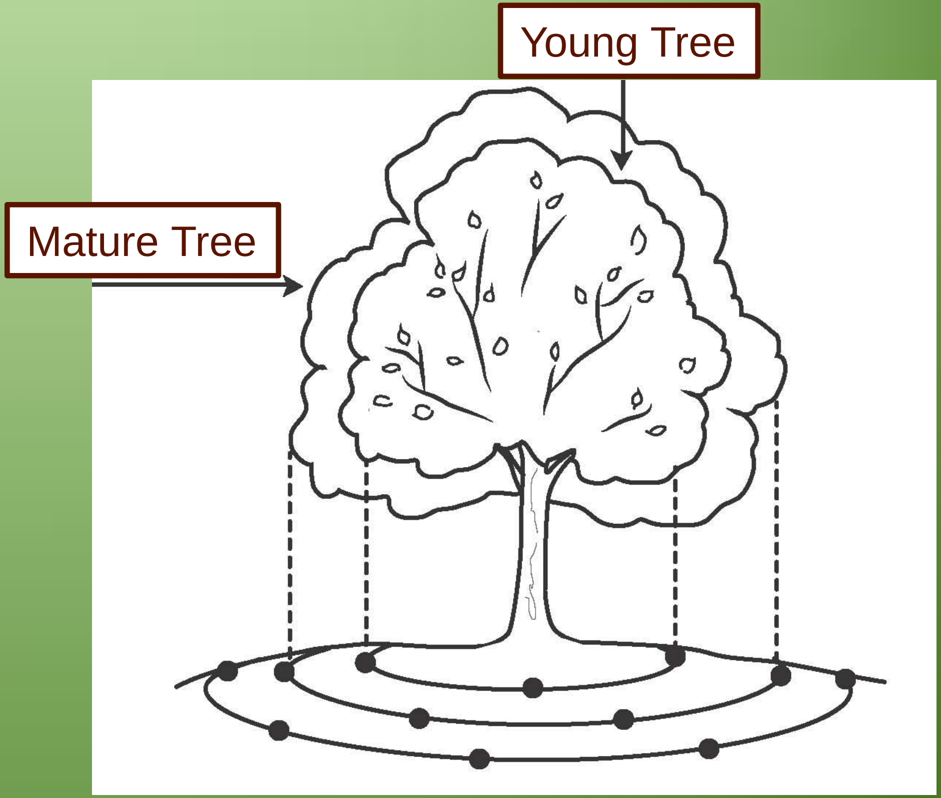
Ideal Soil Moisture at Root Uptake Area



Tree watering systems are temporary structures



- Trees have many benefits
- Water monitoring is essential
- Irrigation structure for trees is temporary

Thank you!
Luanne Leineke
Stewardship Coordinator
Sacramento Tree Foundation
www.sactree.com

SACRAMENTO TREE FOUNDATION

Caring for Trees in a Drought

Trees are generally the most valuable asset in the home and business landscape and when their health declines, the most difficult and expensive to replace. Considering their value, and the time needed to grow to maturity, ensuring the survival of shade trees should be a top priority for landscape professionals. According to local certified arborists, a typical large tree in the Sacramento valley has a replacement value ranging from several to tens of thousands of dollars. During times of drought, landscape retention decisions should be made based on value, risk assessments and the cost and ease of replacing assets of equivalent size.

A typical large tree in the Sacramento valley has a replacement value ranging from several to tens of thousands of dollars.

With Governor Brown's recent declaration "This [is an] emergency and I'm calling all Californians to conserve water in every way possible."It is imperative that professionals are able to both meet his call to action as well as preserve the irreplaceable mature tree canopy.

STEPS FOR CONSERVING WATER AND GROWING HEALTHY TREES

Whether trees are planted in turf, mixed beds, or alone, the following steps will help to conserve water while also improving the tree's ability to utilize the water it is offered.

CHOOSE SPECIES WISELY

Whenever possible, select species that are well adapted to arid climates. Native plants are not always drought resistant, so base decisions on water needs, and not necessarily on origin of the species.

IMPROVE SOIL STRUCTURE

Properly aerated soil is an essential factor for the functioning of a tree's root system and water permeability.

- Remove excess soils burying the flare of the tree trunk in a careful manner to minimize damage to the root system.
- Remove rocks and other impervious materials from beneath the tree canopy.
- Aerate the lawn so that roots of mature trees are better able to access water and oxygen.

REDUCE COMPETITION

- Remove all weeds and grass within three feet of the base of young trees. For trees planted alone or in mixed beds, this is also recommended.

MULCH

Leaves and ground wood are ideal mulch materials. Organic mulch will break down and create nutrient-rich compost that will keep soil evenly moist, conserve water, and insulate roots while providing essential nutrients for the tree.

- Place mulch 4 to 6″ deep, keeping it 4″ away from the trunk, around all trees where the landscape allows.

MONITOR SOIL MOISTURE

Place a shovel, small spade or a screw driver into the soil to a depth of 6–8″ (near the trunk for a young tree and under the drip line for a mature tree). Squeeze a handful of soil, if it feels dry and crumbly add water.

Sacramento Tree Foundation

Recently Governor Brown proclaimed, "This year, we celebrate Arbor Day as the state confronts one of the most severe droughts on record. In the spirit of preserving trees for future generations, Californians are advised to honor this occasion by planting drought-tolerant trees and learning best practices in caring for trees during a water shortage."

All trees need regular, deep watering when soil moisture is low. The best watering solution is a dual system of drip emitters and sprinklers which maximizes irrigation efficiency for young and maturing trees. However, as water restrictions increase we must utilize other watering techniques to ensure trees, whether newly planted or mature, receive the water they require to survive.

As water restrictions increase we must utilize watering techniques to ensure trees, whether newly planted or mature, receive the water they require to survive.

YOUNG SAPLINGS *(between one and three years of age)* and **MATURING TREES** *(ages 4 to 15)*

It is imperative that young trees receive water regularly to their root ball throughout their first three years in the ground.

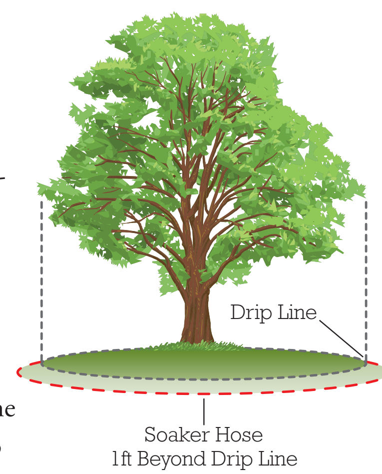
- Apply five to ten gallons of water per week during mild weather. During the hot summer months, young trees may require up to 15 gallons of water per week. Lawn watering does not provide sufficient water for a young tree as the root area is not extensive enough to absorb water irrigated over a large area.
- The best way to focus water on the tree's rootball is to form a small temporary earthen berm/watering well around the tree, about 2–3 feet in diameter and about 4–6 inches high. Fill it slowly by placing a garden hose near the base of the trunk and set it at a slow flow.

- As trees grow, expand the temporary earthen berm to cover the enlarged root system or apply water to the soil outside the edge of the root ball to one foot beyond the drip line (the soil beneath the edge of the leaf canopy). Increase the amount of water to soak the expanding root area to a depth of at least 8 inches.
- Trees do not grow or fair well in soil that is constantly wet — it is best to let the ground dry out between waterings. As the daytime temperatures increase water more frequently. Check the moisture of the soil before watering.

MATURE TREES *(A mature tree is defined as fifteen years or older.)*

Mature trees vary widely in their need for water, depending on size, age, species, soil types and slope. The water needs of most tree species planted in turf are generally met by the relative high water needs of turf. With restricted water use, it is likely turf will no longer be irrigated. This could have drastic effects on mature trees that are used to regular lawn watering. During this time, it is very important to deeply water the tree.

- The best way to water a mature tree is to apply the water slowly and uniformly using low-volume application equipment. One option is to use a soaker hose — spreading it around the tree to at least one foot beyond the drip line (the soil beneath the edge of the leaf canopy) and allowing the water to penetrate so that the soil under the tree becomes saturated to a depth of about 8–12".



- The general rule for mature trees is deep, infrequent irrigation. Frequency of watering depends on temperature, shade cover and presence of mulch. Trees need oxygen as much as water. Allow the soil to dry between waterings — for most mature trees one deep watering per month is adequate.

If you are concerned about the health of a mature tree, your best choice is to hire a Certified Arborist. A list of Certified Arborists by zip code can be found listed at www.treesaregood.org.