Landscape Irrigation Water Saving Strategies
Presented by
California Dept. of Water Resources – California Center for Urban Horticulture at UC Davis
and the Cities of
Modesto – Manteca – Ceres – Turlock – Oakdale
May 19, 2016

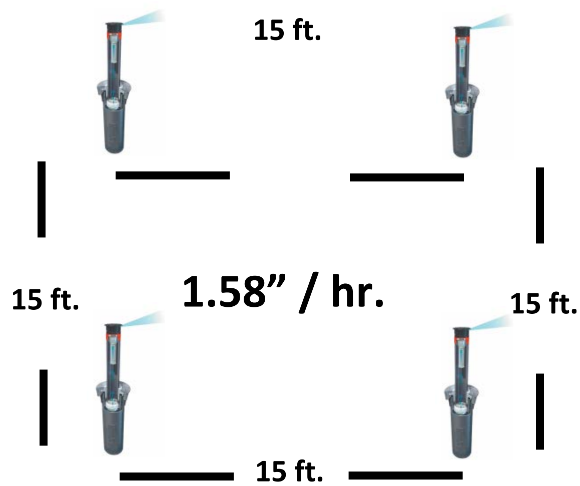
Sprinkler precipitation rates – the key to controlling irrigation runoff

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.

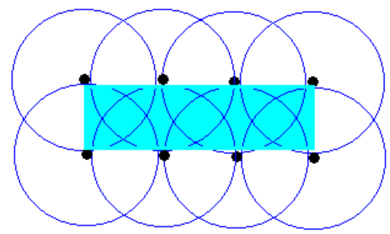
Rotor sprinklers rotate a single or multiple streams to achieve coverage. In general, the end of the stream from one sprinkler should hit right at the base of the adjacent sprinkler. The pressure requirement at the nozzle is dependent on the spacing and the nozzle installed in the sprinkler. Performance 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

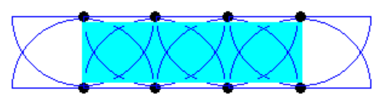
Nozzle	Pressure PSI	Radius ft.	Flow GPM	Precip in/hr ■	Precip in/hr ▲
1	30	28'	0.5	0.12	0.14
	40	29'	0.6	0.14	0.16
	50	**29'**	**0.7**	**0.16**	**0.19**
	60	30'	0.8	0.17	0.20
2	30	29'	0.7	0.16	0.19
	40	30'	0.8	0.17	0.20
	50	**30'**	**0.9**	**0.19**	**0.22**
	60	31'	1.0	0.20	0.23
3	30	30'	0.9	0.19	0.22
	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

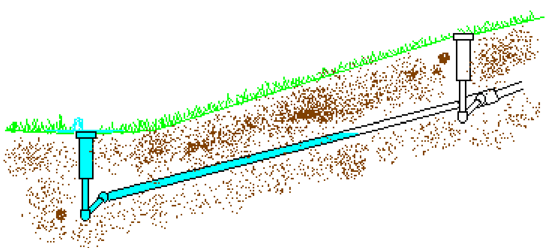
Suggested maximum run times on clay soil before runoff occurs (on flat surfaces) infiltration rate - 0.10" / hr

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

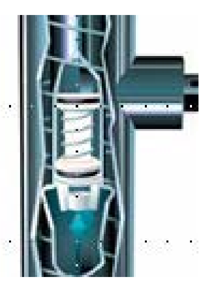
Low head drainage occurs in lateral sprinkler piping after the irrigation valve has shut down. When heavy clay soils are being irrigated, multiple cycles (usually 6-8) must occur every day that irrigation takes place. This necessary cycling process introduces the problem of low head drainage. This problem 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 manages 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.

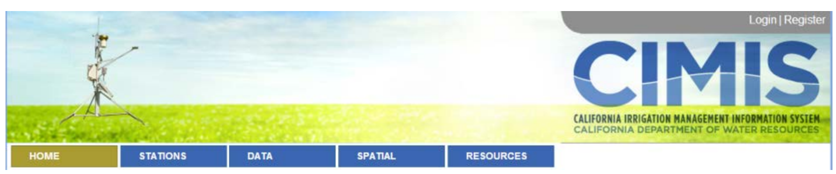
Monthly Average ETo Report

California Irrigation Management Information System (CIMIS)
Rendered in ENGLISH Units.
Printed on Sunday, May 15, 2016

Average ETo Values by Station

Stn Id	Stn Name	CIMIS Region	Jan (in)	Feb (in)	Mar (in)	Apr (in)	May (in)	Jun (in)	Jul (in)	Aug (in)	Sep (in)	Oct (in)	Nov (in)	Dec (in)	Total (in)
71	Modesto	SJV	1.10	1.90	3.60	5.27	6.75	7.88	7.95	6.91	5.09	3.40	1.71	1.09	52.65

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 biggest 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 (7.95") x K_L (0.70 for cs turf) = 5.57" / month

July ET_L in a drought year – ET_O (7.95") x K_L (0.60 for cs turf) = 4.77" / month

The water savings associated with this recommendation will save 0.80" 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 (plant water requirement) In the month of July, in Modesto, we have an ET_L of 4.77". The objective is to establish an average daily ET_L which in this case is 0.154" per day (4.77" / 31 = 0.154"). The replacement for every 4^{th} day watering for turf in a typical July is 0.62 inches (4x 0.154). 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 8 cycles or start times (8 x 0.08 = 0.64). Since most programs have only 4-6 start times, it will be necessary to utilize two programs (A & B) to have an adequate number of start times on this watering day to avoid runoff.

Daily ET_L	Sun	Mon	Tues	Weds	Thurs	Fri	Sat
	0.154	0.154	0.154	0.154	0.154	0.154	0.154

Water Sunday a.m. replace 0.62" (4 days x 0.154")	Water Wednesday a.m. replace 0.46" (3 days x 0.154")

On Sunday the turf water requirement is 0.62". 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. <u>The sprinkler does not dictate the number of repeats rather it is the soil type!</u> So the number of cycles required is 8 (0.62 /0.08 = 7.5 so we round up to 8). We will have to use 2 programs here because of the limitations of start times available per program on most controllers at four. If the irrigation controller does not have adequate starts or a cycle soak feature you'll have to upgrade to a smart controller with these

		PROGRAM A	PROGRAM B
DAY OF THE WEEK		MO TU WE TH FR SA **SU**	MO TU WE TH FR SA **SU**
INTERVAL (Choose 1 to 31 days)			
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**
1	*Front Lawn - Sprays*		
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 Sunday ET_L so the run time is as follows ET_L (0.62) / PR (1.58) x 60 = 24 minutes. The run time of 24 minutes is divisible by 8 cycles, so we'll run the sprinklers 3 minutes per cycle (8 x 3 = 24) On Program A we'll water 3 minutes per cycle x 4 starts = 12 minutes. On B we'll water 3 min. / cycle x 4 starts which is 12 minutes.

		PROGRAM A	PROGRAM B
DAY OF THE WEEK		MO TU WE TH FR SA **SU**	MO TU WE TH FR SA **SU**
INTERVAL (Choose 1 to 31 days)			
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**
1	*Front Lawn - Sprays*	*3 min.*	*3 min.*
2			
		(4 x 3 min = 12 minutes)	*(4 x 3 min = 12 minutes)*

(plant water requirement)

(constant)

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

(precipitation rate)

EWING

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 (0.62") requires 8 repeats (cycle starts) and utilized the capabilities of both the A and B programs using all of the available eight starts.

The water requirement for Wednesday morning replaces 3 days of turf water use or 0.46 inches of water. Since the water requirement is different on Wednesday,0.46", as opposed to 0.62" on Sunday, we'll have a different run time so a different program is required. We'll use the final program, program C, for station 1 on Wednesday. The amount of water required on Wednesday replaces turf water use of 0.46". The run time for program C (Wednesday) is $RT = ET_L / PR \times 60$ (0.46/ 1.58 x 60) = 18 min. It is not possible to divide this into even cycles as 18 is not divisible into equal parts. Our best option is to water 20 minutes which allows us to use the 4 cycle starts. Five minutes is probably the maximum run time we can allow on a clay soil and not have runoff.

Since we utilized programs A, B, and C and 12 start times for the turf stations, the drip and shrub stations will have to water on the same days and start times as the lawns. Under such extreme programming requirements it makes sense to replace the controller with a smart controller that has "cycle/soak"

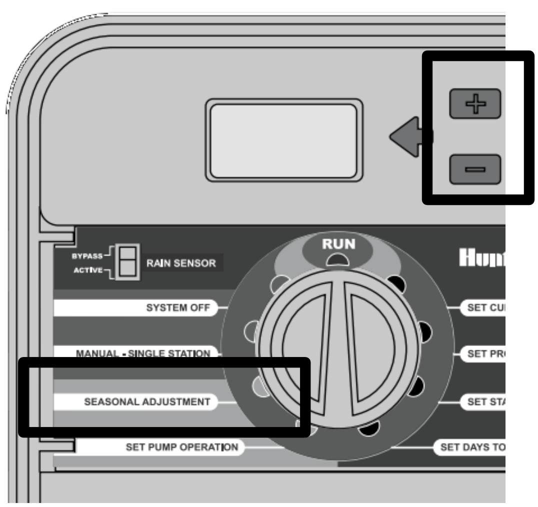
		PROGRAM A							PROGRAM B							PROGRAM C						
DAY OF THE WEEK		MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU
INTERVAL (Choose 1 to 31 days)																						
PROGRAM START TIMES	1	9:30 p.m.							1:30 a.m.							10:30 p.m.						
	2	10:30 p.m.							2:30 a.m.							12:30 a.m.						
	3	11:30 p.m.							3:30 a.m.							2:30 a.m.						
	4	12:30 a.m.							4:30 a.m.							4:30 a.m.						
STATION	LOCATION	STATION RUN TIME							STATION RUN TIME							STATION RUN TIME						
1	*Front Lawn - Sprays*	3 min.							3 min.							5 min.						
2																						
		(4 x 3 min = 12 minutes)							(4 x 3 min = 12 minutes)							(4 x 3 min = 20 minutes)						

The previous special program addresses the water needs of the plant material on the designated day schedule of two days per week which is the 2016 guideline for Modesto. The cities of Manteca, Oakdale and Turlock are on a similar schedule. The only exception to this is the city of Tracy

The previous schedule is what is known as a "lower boundary" of watering time which does not reflect typical spray irrigation systems which have problems with uniform coverage and have poor distribution uniformity

A landscape water audit would reveal the distribution uniformity DU_{LQ} of the system and once this is known we can develop a scheduling or system multiplier. The spray system we audited for this example had a DU_{LO} of 56 percent or 0.56. A scheduling or run time multiplier indicates how much we will have to increase the lower boundary run times to deliver adequate water to the drier parts of the irrigation circuit. The run time or scheduling multiplier for 56 percent is 1.36. The Wednesday run time on the lower boundary was 18 minutes which was increased to 20 minutes with four five minute cycles. The 18 minute run time would be increased 1.36 times to compensate for poor uniformity which is 23 minutes rounded to 24 minutes. The upper boundary of run time for Tuesday is 4 cycles of 6 minutes. This run time would likely result in runoff so it is necessary to reduce the run time or upgrade the controller to a model that has at least six starts per program

One important feature of more modern controllers is the percentage or seasonal 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 3 minute run time that needs a 10% reduction. The controller times in 1 minute increments so the % key only works for 33% changes (3 minutes reduced to 2 minutes is a 33% change). The only options we have with these short run times is to eliminate a start time or decrease a run time. This is exactly why rotors, with their lower precipitation rates, and longer run times are a better option than sprays. If the rotor station was set for four 10 minute cycles a 90% adjust would reduce the run time to 9 minutes!



Ultimately we need to be very creative in dealing with drought conditions where reduced watering days may be imposed by cities or water agencies. There are many limitations to controller programming when this occurs and they are acutely felt during a drought. Another serious limitation in the more arid regions of the state is the limitation of the water meter to apply water in two days that would normally be applied in 4 to 7 days per week!

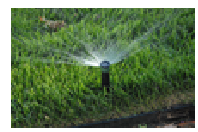
Irrigation Schedule Modesto, CA

(Schedule based on CIMIS station 71 - Modesto, CA)

Pop Up Spray Heads / Cool Season Turf

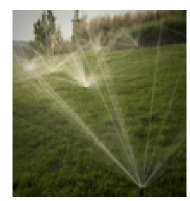
Cool Season Turf with a K_T species factor (maximum stress) 0.60

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



		Modesto ET_O Avg Monthly	Modesto ET_O Avg. daily	Modesto CS Turf Req't daily	Every 4th day watering: Lower Bndry. Run Time min.	Every 4th day watering: Upper Bndry. Run Time min.	Every 3rd day watering: Lower Bndry. Run Time min.	Every 3rd day watering: Upper Bndry. Run Time min.
31	Mar	3.57	0.1152	0.0691	10	14	8	11
30	Apr	5.23	0.1743	0.1046	16	22	12	16
31	May	6.98	0.2252	0.1351	21	28	15	21
30	Jun	7.87	0.2623	0.1574	24	33	18	24
31	Jul	7.95	0.2565	0.1539	23	32	18	24
31	Aug	6.89	0.2223	0.1334	20	28	15	21
30	Sep	5.1	0.1700	0.1020	15	21	12	16
31	Oct	3.4	0.1097	0.0658	10	14	7	10
		46.99						

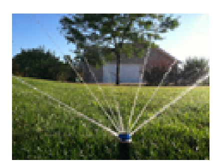
MP Rotators / Cool Season Turf



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	

		Modesto ET_O Avg Monthly	Modesto ET_O Avg. daily	Modesto CS Turf Req't daily	Every 4th day watering: Lower Bndry. Run Time min.	Every 4th day watering: Upper Bndry. Run Time min.	Every 3rd day watering: Lower Bndry. Run Time min.	Every 3rd day watering: Upper Bndry. Run Time min.
31	Mar	3.57	0.1152	0.0691	39	46	29	35
30	Apr	5.23	0.1743	0.1046	58	70	44	53
31	May	6.98	0.2252	0.1351	75	90	57	68
30	Jun	7.87	0.2623	0.1574	88	105	66	79
31	Jul	7.95	0.2565	0.1539	86	103	64	77
31	Aug	6.89	0.2223	0.1334	74	89	56	67
30	Sep	5.1	0.1700	0.1020	57	68	43	51
31	Oct	3.4	0.1097	0.0658	37	44	28	33



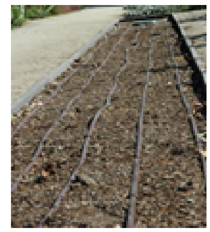
MAXIMUM CYCLE LENGTH (IN MINUTES) TO AVOID RUNOFF ON CLAY SOILS		
SPRAYS	4 MINUTES	(15 FT SQUARE SPACING)
ROTORS	14 MINUTES	(0.43" / HR PRECIP RATE)
LINE SOURCE DRIP	4 MINUTES	(0.9 GPH - 12" X 12" SPACING)

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	

		Modesto ET_O Avg Monthly	Modesto ET_O Avg. daily	Modesto Orn. Shrub Req't daily	Every 4th day watering: Lower Bndry. Run Time min.	Every 4th day watering: Upper Bndry. Run Time min.	Every 3rd day watering: Lower Bndry. Run Time min.	Every 3rd day watering: Upper Bndry. Run Time min.
31	Mar	3.57	0.1152	0.0461	8	8	6	6
30	Apr	5.23	0.1743	0.0697	12	12	9	9
31	May	6.98	0.2252	0.0901	15	16	11	12
30	Jun	7.87	0.2623	0.1049	18	19	13	14
31	Jul	7.95	0.2565	0.1026	17	18	13	14
31	Aug	6.89	0.2223	0.0889	15	16	11	12
30	Sep	5.1	0.1700	0.0680	11	12	9	9
31	Oct	3.4	0.1097	0.0439	7	8	6	6



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	

		Modesto ET_O Avg Monthly	Modesto ET_O Avg. daily	Modesto Orn. Shrub Req't daily	Every 4th day watering: Lower Bndry. Run Time min.	Every 4th day watering: Upper Bndry. Run Time min.	Every 3rd day watering: Lower Bndry. Run Time min.	Every 3rd day watering: Upper Bndry. Run Time min.
31	Mar	3.57	0.1152	0.0461	44	47	33	35
30	Apr	5.23	0.1743	0.0697	67	71	50	53
31	May	6.98	0.2252	0.0901	86	92	65	69
30	Jun	7.87	0.2623	0.1049	101	107	76	80
31	Jul	7.95	0.2565	0.1026	98	104	74	78
31	Aug	6.89	0.2223	0.0889	85	90	64	68
30	Sep	5.1	0.1700	0.0680	65	69	49	52
31	Oct	3.4	0.1097	0.0439	42	45	32	33

* 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

Irrigation Schedule Modesto, CA

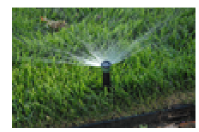
(Schedule based on CIMIS station 71 - Modesto, CA)

Pop Up Spray Heads / Warm Season Turf

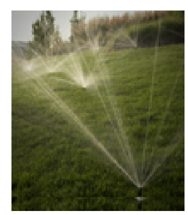
Warm Season Turf with a K_T species factor (maximum stress) 0.40

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

		Modesto ET_O Avg Monthly	Modesto ET_O Avg. daily	Modesto WS Turf Req't daily	Every 4th day watering: Lower Bndry. Run Time min.	Every 4th day watering: Upper Bndry. Run Time min.	Every 3rd day watering: Lower Bndry. Run Time min.	Every 3rd day watering: Upper Bndry. Run Time min.
31	Mar	3.57	0.1152	0.0461	7	10	5	7
30	Apr	5.23	0.1743	0.0697	11	14	8	11
31	May	6.98	0.2252	0.0901	14	19	10	14
30	Jun	7.87	0.2623	0.1049	16	22	12	16
31	Jul	7.95	0.2565	0.1026	16	21	12	16
31	Aug	6.89	0.2223	0.0889	14	18	10	14
30	Sep	5.1	0.1700	0.0680	10	14	8	11
31	Oct	3.4	0.1097	0.0439	7	9	5	7
		46.99						



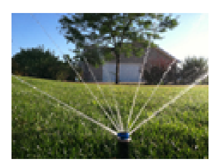
MP Rotators / Warm Season Turf



Warm Season Turf with a K_T species factor (maximum stress) 0.40

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

		Modesto ET_O Avg Monthly	Modesto ET_O Avg. daily	Modesto WS Turf Req't daily	Every 4th day watering: Lower Bndry. Run Time min.	Every 4th day watering: Upper Bndry. Run Time min.	Every 3rd day watering: Lower Bndry. Run Time min.	Every 3rd day watering: Upper Bndry. Run Time min.
31	Mar	3.57	0.1152	0.0461	26	31	19	23
30	Apr	5.23	0.1743	0.0697	39	47	29	35
31	May	6.98	0.2252	0.0901	50	60	38	45
30	Jun	7.87	0.2623	0.1049	59	70	44	53
31	Jul	7.95	0.2565	0.1026	57	69	43	52
31	Aug	6.89	0.2223	0.0889	50	60	37	45
30	Sep	5.1	0.1700	0.0680	38	46	28	34
31	Oct	3.4	0.1097	0.0439	24	29	18	22



MAXIMUM CYCLE LENGTH (IN MINUTES) TO AVOID RUNOFF ON CLAY SOILS

SPRAYS	4 MINUTES	(15 FT SQUARE SPACING)
ROTORS	14 MINUTES	(0.43" / HR PRECIP RATE)
LINE SOURCE DRIP	4 MINUTES	(0.9 GPH - 12" X 12" SPACING)

Drip/Micro – Low Volume Irrigation

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)

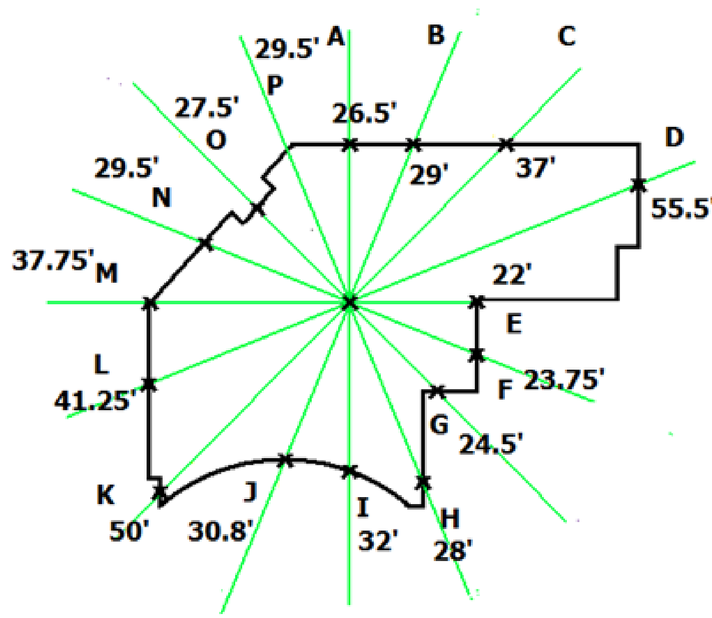
GENERAL GUIDELINES	TURF												SHRUB & GROUNDCOVER											
	CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL			CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL		
EMITTER FLOW	0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH			0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH		
EMITTER SPACING	18"			12"			12"			12"			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 drip zone canopy

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

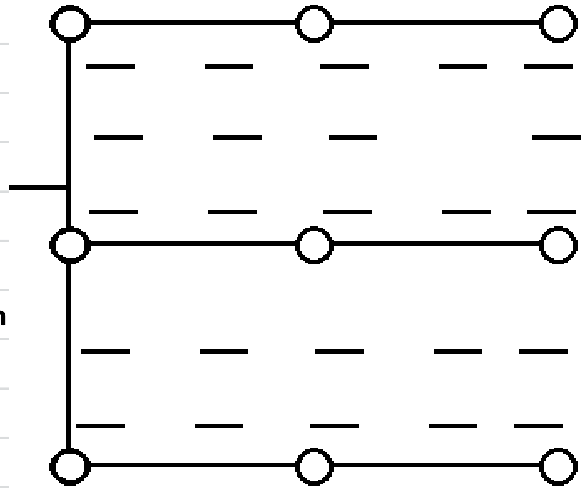
Conversion Chart - Average Radius to Square Feet (16 radii minimum)

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	

Once the canopy area of a specific drip irrigation zone has been measured, the flow to the zone must be obtained by operating the zone from the irrigation controller. Proceed to the water meter and observe the flow to the zone as the station is running. Allow a couple of minutes for the tubing to fill and come to full pressure before reading flow at the meter. Proceed to the precipitation rate chart and derive the
precipitation rate by matching area in square feet to meter flow in cubic feet per minute (CFM)

Also insure that there is adequate pressure to the last (and or highest) elevation emitter in the zone. Minimum psi for pressure compensating emitters is 10 psi and for drip line 15 psi.

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

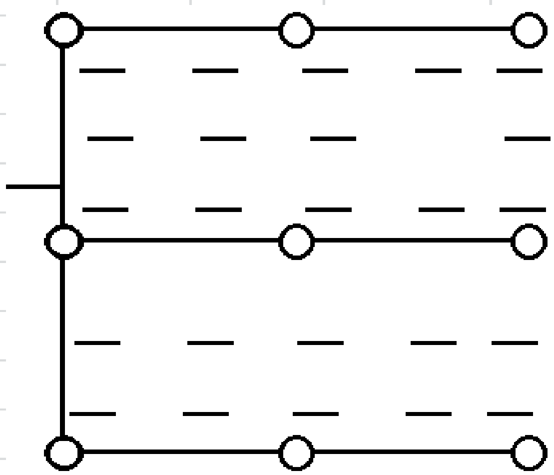
avg of 24

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!

Managing Landscape Water in the Drought of 2016

The State Water Resources Control Board directed Water Suppliers throughout California to reduce their water use dramatically in 2015. Each district was charged with a goal for reducing water use and it varied by district from 8 to 36%. As this handout is being prepared the state has yet to announce their final conservation goals for each water agency.

Whatever their final guidelines may be, the secret to achieving these reduction goals is to establish realistic expectations about what can be achieved in the landscape. In many cases significant areas of the landscape may have to be sacrificed to save higher value plant material such as trees.

Understand that the reductions in water use must take place immediately! Furthermore, the amount of landscape that can be irrigated in early spring will be far less than in the warmest month which is July. The ET_L or plant water requirement for cool season turf is only 4.05" per month in May in Modesto. In July, the ET_L is 4.77". Don't water any more square footage of landscape in May than you can keep alive in July. It is simply a waste of water!

In order to set meaningful goals you'll need the site water bills for 2013 and the square footage of the landscape. Let's work an example to help illustrate the process. Review the water bill for July 2013 and determine the CCF's or billing units of water used at the site. (A billing unit is 100 cubic feet or 748 gallons). Let's assume in this example the site water use is 112 units of water in July for this commercial site. You have been directed to reduce water use by 32%! Determine the water use goal for July 2015 and then we will determine how many square feet can be irrigated. We'll determine the new water use goals by factoring 68% against 112 units which is 76 units.(112 x 0.68 = 76) Seventy six (76) units of water is 56, 848 gallons. (76 x 748 = 56,848). Our 2013 use was 112 units or 83,776 gallons (112 x 748 = 83,776). The amount of water that must be saved is the difference between 2013 use 83,776 and 2015 goal of 56,848. **The amount of water that must be eliminated from July 2015 consumption is 26,928 gallons.**

All we have to understand now is how many gallons are required to keep one foot of either turf or ornamentals alive at acceptable quality in July. We use the average ET_O for the month of July for CIMIS station 71 in Modesto. We reduce the requirement for the plant material to account for the landscape coefficient and then increase according to an average DU_{LQ} For the sprinklers. We then convert inches to gallons per square foot.

	ET_O	Ldscp coeffic.	ET_L	56% DU_{LQ}	72% DU_{LQ}	90% DU_{LQ}
Turf (cool season)	7.95	0.6	4.77	6.4872 (4.02 x 1.36)	5.724 (4.02 x 1.20)	
Ornamentals	7.95	0.4	3.18			3.3708 (2.68 x 1.06)

DU_{LQ}	Gallons per square foot per month (inches * 0.6234)	
Sprays at 56%	4.04	for cs turf
Rotating Stream at 72%	3.57	for cs turf
Drip at 90%	2.10	for ornamentals

Let's assume that the entire site is sprays with the typical uniformity of 56% shown. The water requirement is 4.04 gallons per square foot and the amount to be save is 27,000 gallons. Simply divide the 27,000 by 4.04 which is 6,683 square feet of turf you'll have to eliminate from irrigation in 2016 starting now!

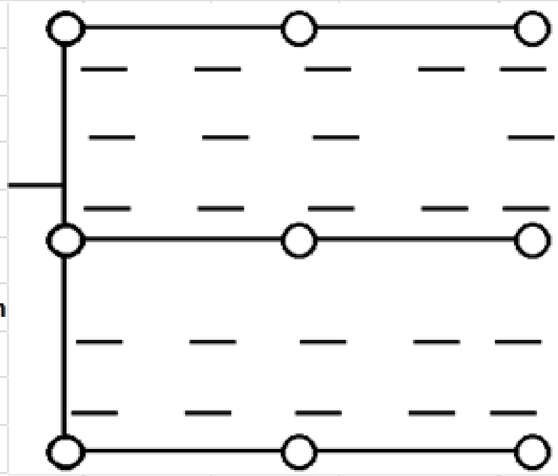
Another way to look at it is that you have an allocation of 56,848 square feet. How many square feet could be maintained with this water in July? The answer is 56,848 divided by 4.04 gal / sq. ft. which is **14, 071 square feet.**

Now let's assume you upgrade to MP Rotators and improve the uniformity. You'll be able to keep more area alive. The 56,848 gallons would irrigate more area due to the higher uniformity for an area of **15, 923 square feet!**

One thing to keep in mind is that you should not turn off lawn in a wholesale fashion as there are often trees in these lawns, that when deprived of lawn water will die. In these cases turn off all the nozzles except those under the canopy of the trees

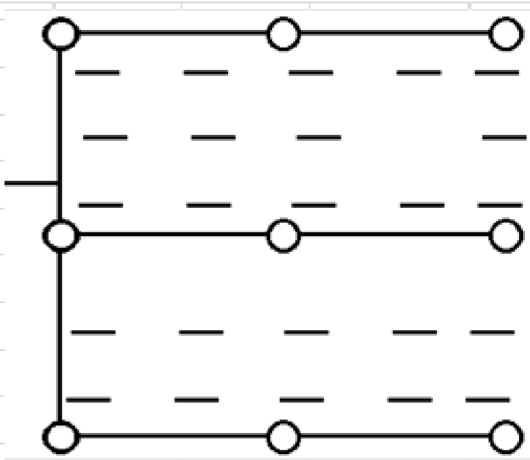
Ultimately the accuracy of this technique relies on careful site measurement. Utilize web sites such as google maps or Go I Lawn to remotely measure or utilize Ewing's 16 point measurement method for irregular shapes.

Spray Circuit - Audit Run Time (4 minutes)



___ psi			Driest 6 catches
___ gpm			___
___ cfm			Total ___
			Avg. ___
		psi ___	(total divided by 6)
DU_{LQ}	dry 6 ___		Total of 24 catch readings ___
	avg of 24 ___		avg.(total divided by 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			Driest 6 catches
___ gpm			___
___ cfm			Total ___
			Avg. ___
DU_{LQ}	dry 6 ___	psi ___	(total divided by 6)
	avg of 24 ___		Total of 24 catch readings ___
DU_{LQ} ___			avg.(total divided by 24) ___
		PR $= \frac{3.66 \times V_{avg}}{t_r \times 16.5}$	PR ___