Scheduling Irrigation

How Much and When

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Your Sustainable Backyard
Low Water Use Landscaping
UC Davis
November 8, 2014

UC Cooperative Extension | University of California Agriculture and Natural Resources
UC DAVIS UNIVERSITY OF CALIFORNIA

Learning Objectives

- How to calculate a schedule
  - Irrigation system factors
  - Why is soil important in scheduling?
  - Climate
  - Landscape factors
- Understanding other factors that influence irrigation management
- Is drip better?

Irrigation Objectives

- Provide water to plants
  - only when it is needed
  - only the amount that will be used
  - only where it can be used

Irrigation System Objectives

- Delivery
- Control

Irrigation System Objectives

- Delivery
  - Place water where it can be used
  - Uniformly or in the desired pattern
  - Apply water so the soil can absorb it

Irrigation System Objectives

- Delivery
- Control
  - When
    - Start irrigation
  - How much
    - Stop irrigation
- Focus on timer controllers

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients
  - Climate (Water Use Rates)

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity (0.65)

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
    - How fast water is applied

Precipitation Rate

- Calculating PR
  - Average of all (Avg_T), mL
  - Catch can throat area (C), sq.in
    - This is 16.6 sq. in. for the ones used
  - Valve on duration (T), minutes
    - Let's set this at 4 minutes

	mL
	36
	29
	18
	19
	26
	33
	16
	22
	38
	22
	14
	21
Avg_T =	24.5

$$PR = \frac{Avg_T}{C\ x\ T} \times 3.66 = \frac{24.5}{16.6\ x\ 4} \times 3.66 = 1.35\ in/hr$$

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
    - Plant available water

Soil Texture

Soil Texture		Infiltration Rate (in/hr)	Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**
Coarse	sand / fine sand	1.5	0.05	0.3
	loamy sand	1	0.07	0.42
Moderately Coarse	sandy loam	0.8	0.11	0.66
Medium	loam	0.4	0.16	0.96
	silty loam	0.25	0.2	1.2
	silt	0.3	0.2	1.2
Moderately Fine	sandy clay loam	0.1	0.15	0.9
	clay loam	0.07	0.16	0.96
	silty clay loam	0.05	0.18	1.08
Fine	sandy clay	0.08	0.12	0.72
	silty clay	0.05	0.14	0.84
	clay	0.05	0.15	0.9

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth

Soil Texture

Soil Texture		Infiltration Rate (in/hr)	Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**
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Medium	loam	0.4	0.16	0.96
	silty loam	0.25	0.2	1.2
	silt	0.3	0.2	1.2

Irrig to wet to depth

Desired depth to wet = 12”

Plant avail water = 0.2

Assume 50% dry down

= 12” x 0.2 x 50% = 1.2”

*Irrigation Association Landscape Irrigation Auditor Manual page 177

**assume 50% dry down (managed allowable depletion) and 12 inch wetted depth

Run-time, Part 1

	Soil Texture	Infiltration Rate (in/hr)	Plant Avail Water (cm/cm)*	Irrig to Wet to Depth (in)**
Medium	silty loam	0.25	0.2	1.2

- Calculating Run-time
  - **Lower Boundary (LB)**
    - PR = 1.35 in/hr
    - Irrigation to wet to depth = 1.2”

$$LB = \frac{Irrig\ to\ Wet\ to\ Depth}{PR} \text{ x } 60 = \frac{1.2}{1.35} \text{ x } 60 = 53 \text{ min}$$

Run-time, Part 2

- Calculating Run-time with DU
  - **Upper Boundary (UB)**
    - Scheduling multiplier (SM)
      - DU = 0.65
    - Lower boundary (LB) = 53 min.

$$SM = \frac{1}{0.4+(0.6 \times DU)} = \frac{1}{0.4+(0.6 \times 0.65)} = 1.26$$

UB = LB x SM = 53 x 1.26 = 67 min

Developing An Irrigation Schedule

- Things you know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture

Developing An Irrigation Schedule

- Things you know
  - Distribution uniformity = 0.65
  - Precipitation rate = 1.35 in/hr
  - Soil texture
    - Lower boundary = 53 min
    - Upper boundary = 67 min
- This is **how much** to water
- Now we need to know **when** to irrigate

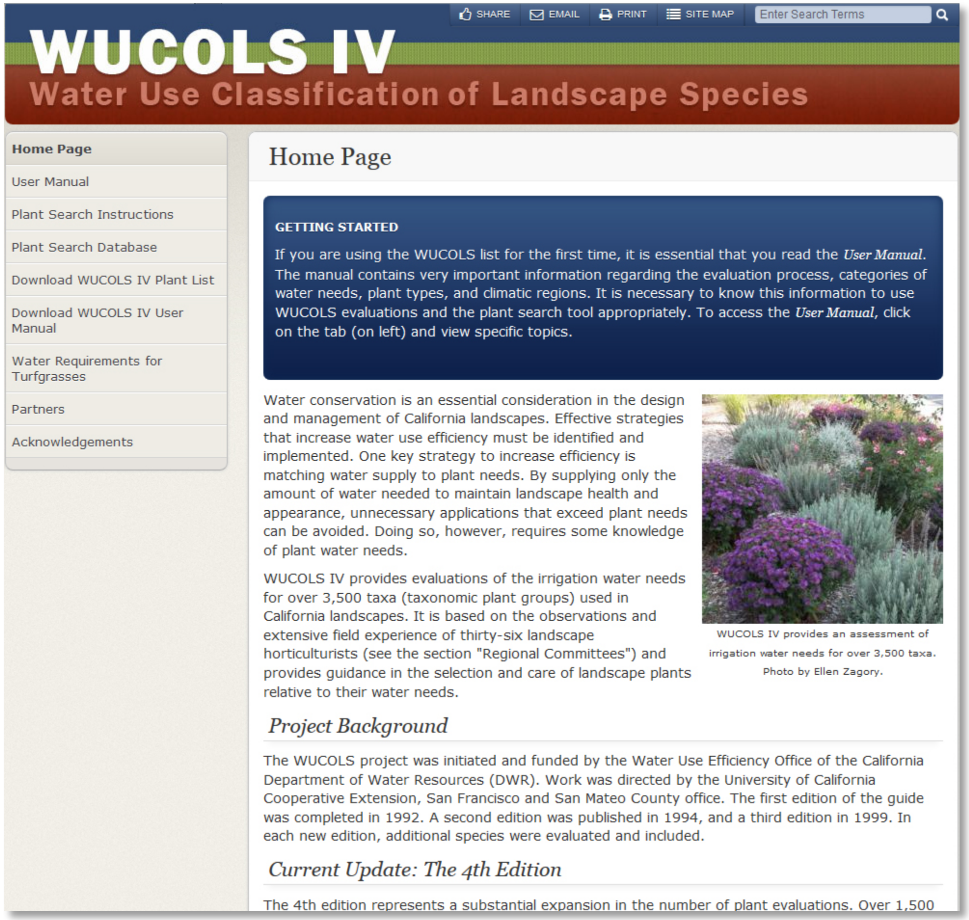
Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients (K_L)

Landscape Coefficients

- Information on plant water use
  - WUCOLS

www.ucanr.sites/WUCOLS



Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients (K_L)
  - Climate (ET_0)

CIMIS

C alifornia
I rrigation
M anagement
I nformation
S ystem

- Collects weather info
- Estimates plant water use
- More than 120 stations

Water use reports are used with a crop or landscape coefficient to estimate site water use

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

Climate

- Water use models
  - Based on weather data
  - Requires previous research
  - Crop specific
  - Easy to use

Climate

- Water use models

Reference ET (ET_0) is reported (CIMIS)

Crop coefficient (K_c) is necessary

Determine ET_{crop} (ET_c) to estimate crop water use

so, $ET_c = ET_0 \times K_c$

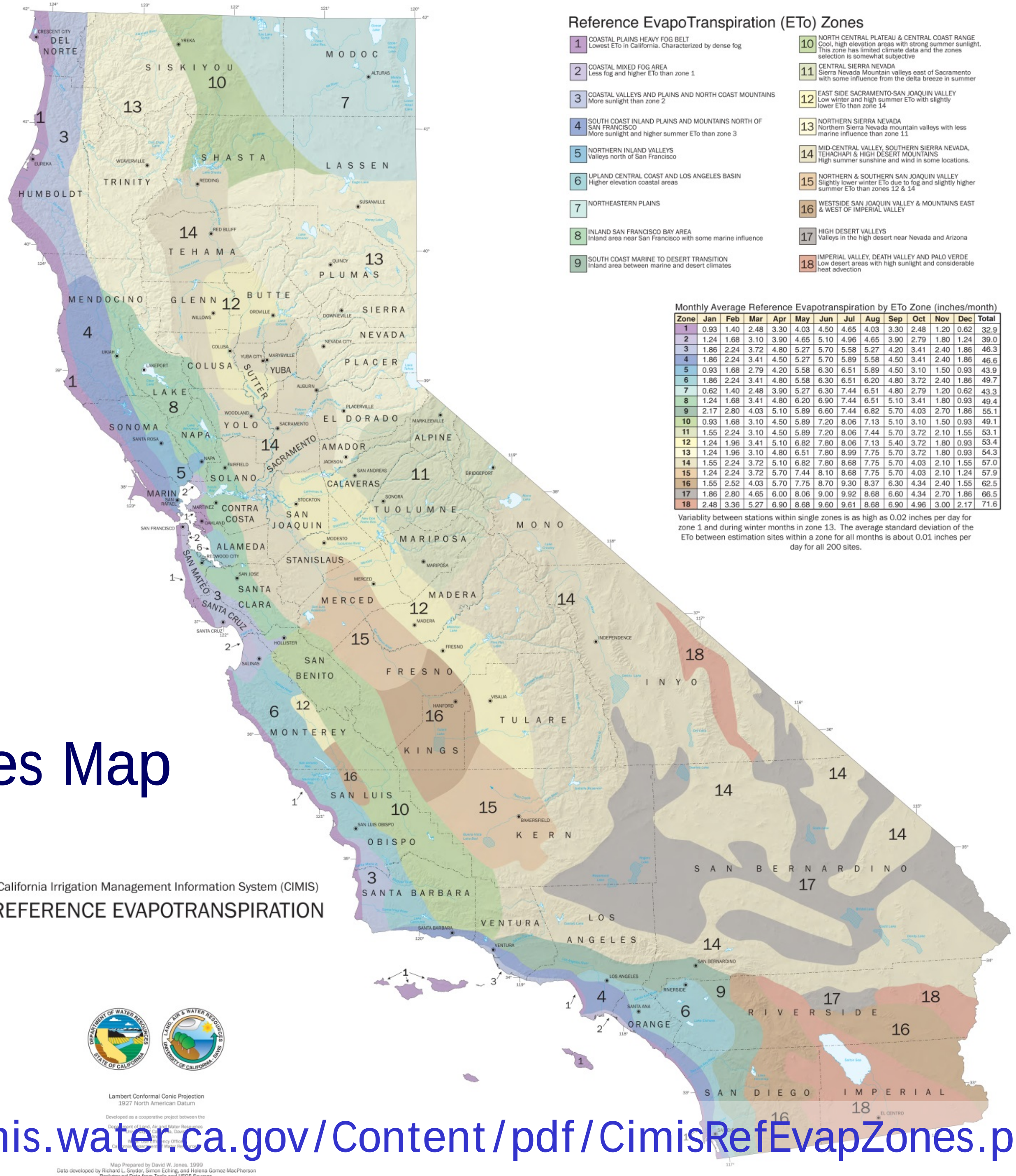
Example: citrus orchard

$K_c = 0.65$

If $ET_0 = 0.5$”, then

crop water use is 0.325”
(0.325=0.5 x 0.65)

ETo Zones Map



Reference EvapoTranspiration (ETo) Zones

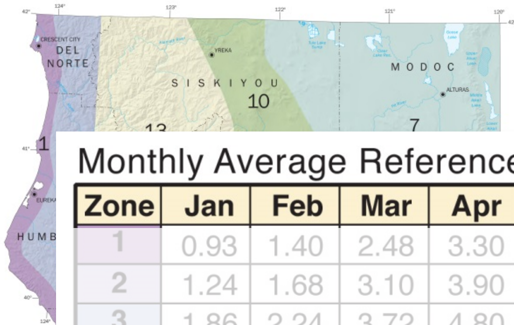
1. COASTAL PLAINS HEAVY FOG BELT — Lowest ETo in California. Characterized by dense fog
2. COASTAL MIXED FOG AREA — Less fog and higher ETo than zone 1
3. COASTAL VALLEYS AND PLAINS AND NORTH COAST MOUNTAINS — More sunlight than zone 2
4. SOUTH COAST INLAND PLAINS AND MOUNTAINS NORTH OF SAN FRANCISCO — More sunlight and higher summer ETo than zone 3
5. NORTHERN INLAND VALLEYS — Valleys north of San Francisco
6. UPLAND CENTRAL COAST AND LOS ANGELES BASIN — Higher elevation coastal areas
7. NORTHEASTERN PLAINS
8. INLAND SAN FRANCISCO BAY AREA — Inland area near San Francisco with some marine influence
9. SOUTH COAST MARINE TO DESERT TRANSITION — Inland area between marine and desert climates
10. NORTH CENTRAL PLATEAU & CENTRAL COAST RANGE — Cool, high elevation areas with strong summer sunlight. This zone has limited climate data and the zones selection is somewhat subjective
11. CENTRAL SIERRA NEVADA — Sierra Nevada Mountain valleys east of Sacramento with some influence from the delta breeze in summer
12. EAST SIDE SACRAMENTO-SAN JOAQUIN VALLEY — Low winter and high summer ETo with slightly lower ETo than zone 14
13. NORTHERN SIERRA NEVADA — Northern Sierra Nevada mountain valleys with less marine influence than zone 11
14. MID-CENTRAL VALLEY, SOUTHERN SIERRA NEVADA, TEHACHAPI & HIGH DESERT MOUNTAINS — High summer sunshine and wind in some locations.
15. NORTHERN & SOUTHERN SAN JOAQUIN VALLEY — Slightly lower winter ETo due to fog and slightly higher summer ETo than zones 12 & 14
16. WESTSIDE SAN JOAQUIN VALLEY & MOUNTAINS EAST & WEST OF IMPERIAL VALLEY
17. HIGH DESERT VALLEYS — Valleys in the high desert near Nevada and Arizona
18. IMPERIAL VALLEY, DEATH VALLEY AND PALO VERDE — Low desert areas with high sunlight and considerable heat advection

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	32.9
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.3
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.1
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.4
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

http://wwwcimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf



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Cool, high elevation areas with strong summer sunlight. This zone has limited climate data and the zones selection is somewhat subjective

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Sierra Nevada Mountain valleys east of Sacramento with some influence from the delta breeze in summer

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Low winter and high summer ETo with slightly lower ETo than zone 14

ETo Zones

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2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
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6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
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12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.4
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

California
REFER...

Lambert Conformal Conic Projection
1927 North American Datum

http://wwwcimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf

Developing An Irrigation Schedule

- So,
  - We know how much to apply (1.2 in)
  - Replaces ½ of field capacity
- Then,
  - We need to estimate when that amount of water is used
  - We know our plants
  - We have info about the climate

Developing An Irrigation Schedule

- Landscape and plant coefficients (K_L)
  - For this example, 0.4
- Climate (Water Use Rates)

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0

  - For this example, we'll use October = 4.03 in/month
  - ET_{day} = 4.03 in ÷ 31 days = 0.13 in/day

Developing An Irrigation Schedule

- How fast is our landscape using water?
  - $ET_L = ET_{day} \times K_L$
  - $ET_{day} = 0.13$ in/day
  - $K_L = 0.4$

$$ET_L = 0.13 \times 0.4 = 0.07 \text{ in/day}$$

Developing An Irrigation Schedule

- Determine when to irrigate
  - Irrigation application = 1.2 in
  - ET_L = 0.07 in/day
- Accumulate ET_L
- When accumulated total reaches 1.2 in
- Irrigate!

Developing An Irrigation Schedule

ET_{day} = 0.13
K_L = 0.4
ET_L = 0.07
Irrig = 1.2

October

Day	Total ET_L	Day	Total ET_L
1	0.07	11	0.77
2	0.14	12	0.84
3	0.21	13	0.91
4	0.28	14	0.98
5	0.35	15	1.05
6	0.42	16	1.12
7	0.49	17	1.19
8	0.56	18	1.26
9	0.63	19	0.32
10	0.70	20	0.40

1.19
+ 0.07 (ET_L)
= 1.26

Developing An Irrigation Schedule

ET_{day} = 0.13
K_L = 0.4
ET_L = 0.07
Irrig = 1.2

October

Day	Total ET_L	Day	Total ET_L
1	0.07	11	0.77
2	0.14	12	0.84
3	0.21	13	0.91
4	0.28	14	0.98
5	0.35	15	1.05
6	0.42	16	1.12
7	0.49	17	1.19
8	0.56	18	0.06
9	0.63	19	0.13
10	0.70	20	0.20

1.19
+ 0.07 (ET_L)
= 1.26
- 1.20 (Irrig)
= 0.06

Developing An Irrigation Schedule

ET_{day} = 0.13
K_L = 0.4
ET_L = 0.07
Irrig = 1.2

October

Day	Total ET_L	Day	Total ET_L	Day	Total ET_L
1	0.07	11	0.77	21	0.27
2	0.14	12	0.84	22	0.34
3	0.21	13	0.91	23	0.41
4	0.28	14	0.98	24	0.48
5	0.35	15	1.05	25	0.55
6	0.42	16	1.12	26	0.62
7	0.49	17	1.19	27	0.69
8	0.56	18	0.06	28	0.76
9	0.63	19	0.13	29	0.83
10	0.70	20	0.20	30	0.90

Developing An Irrigation Schedule

ET_{day} = 0.13
K_L = 0.4
ET_L = 0.07
Irrig = 1.2

October

Day	Total ET_L
1	0.07
2	0.14
3	0.21
4	0.28
5	0.35
6	0.42
7	0.49
8	0.56
9	0.63
10	0.70

- For more accuracy
  - Use actual daily ET
  - Obtain from CIMIS
  - Calculate & accumulate actual rather than historical ET_L

Developing An Irrigation Schedule

- Things you need to know
  - Distribution uniformity
  - Precipitation rate
  - Soil texture
  - Landscape and plant coefficients (K_L)
  - Climate (ET_0)

More Things to Consider

- Adjust controllers monthly
  - Program for monthly changes in ET_{day}
- Interval vs. duration
  - Increase interval between irrigations
  - DO NOT reduce run times
  - Affects wetting depth

Precipitation Rates

- Precipitation rate
  - How fast water is applied
- Infiltration rates
  - How fast water enters soil

Precipitation > Infiltration = RUNOFF

Precipitation Rates

- Note interval when runoff occurs
- Example:
  - Duration to runoff is 6 minutes
  - Upper boundary is 30 minutes
  - 6 minute duration, 5 times
  - “Cycle-Soak” or “Pulsing”

Precipitation > Infiltration = RUNOFF

Delivery Method

- Upgrade sprinklers if possible
- At three study sites upgrades resulted in DU increases of 21%, 24%, and 18%

Photos: D. Franklin, Hunter

Time of Day

- Why early in the day?
  - Lower temperatures
  - Less wind

Deep irrigation

- Deep irrigation
  - Fills a larger volume of soil to provide water to plants
- Use a soil probe to check wetting depth

Photo: B. Baker

Drip Irrigation

- Can it save water?
- Does it save water?

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"			18"			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	0.30	0.27	0.25	0.98	0.84	0.73	1.48	1.27	1.11	0.19	0.16	0.14	0.30	0.26	0.23	0.73	0.65	0.59	1.11	0.99	0.89
TIME TO APPLY ¼" OF WATER (MINUTES)	80	89	97	50	55	61	15	18	20	10	12	13	80	93	106	50	58	66	20	23	26	13	15	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.

Drip Irrigation

- Precipitation rates approach those of overhead
- Proper management is key

GENERAL GUIDELINES	TURF											
	CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL		
EMITTER FLOW	0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH		
EMITTER SPACING	18″			18″			12″			12″		
LATERAL (ROW) SPACING	18″	20″	22″	18″	20″	22″	12″	14″	16″	12″	14″	16″
BURIAL DEPTH	Bury evenly throughout the zone from 4″ to 6″											
APPLICATION RATE (INCHES/HOUR)	0.19	0.17	0.15	0.30	0.27	0.25	0.98	0.84	0.73	1.48	1.27	1.11
TIME TO APPLY ¼″ OF WATER (MINUTES)	80	89	97	50	55	61	15	18	20	10	12	13

Drip I

- Precipitation rate
  overhead
- Proper managem

Drip Irrigation

Even More Things To Consider

- Prioritize plants that receive water
- Know water stress symptoms
- Precondition to enhance survival
- Manage salinity

Managing Irrigation

- It's a "piece of cake"
  - There are a lot of ingredients needed to make the cake
  - There are several, distinct steps to put the ingredients together properly
  - Each has to be managed as part of a program
  - Changing one affects another
- The short version: "It's complex"

Managing Irrigation

- Anyone can do a mediocre (or less) job
- Doing it well requires diligence
- We've gotten away with "good enough" because water supply wasn't an issue. Now it is.
- The question that will be asked:
  - Are the rewards worth the effort?

Photo: L.Oki

Fate of Irrigation Water

- Surface runoff
  - Carries pesticides and fertilizer to storm drains.
- Deep percolation
  - Water draining below the root zone.
  - Carries soluble pollutants into groundwater.
- Root Zone
  - A portion is available for use by plants.
- Evaporation
  - From the soil surface or during application.