

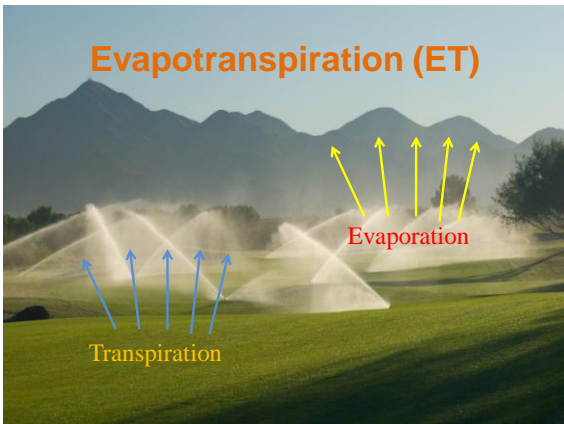
Turfgrass Water Relations and Irrigation



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- We would like it to be a sampler platter of
 - species water use rates,
 - their relative drought tolerance,
 - sample irrigation schedules for managing different species on different areas and also
 - importance of irrigation system auditing and system design and efficiency?

Evapotranspiration (ET)



Water Use Rates

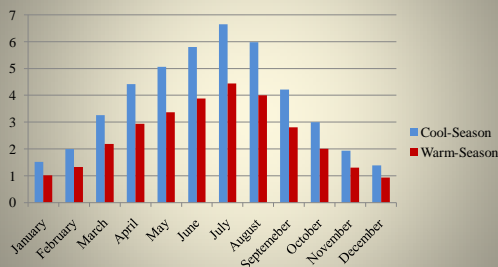
- Defined as the total water needed for a given turfgrass to grow plus the (ET) rate
- ET rates vary depending on available water and environmental conditions.
 - temperature, humidity, wind
 - cultivars and species
 - available water

Potential Evapotranspiration Rates for Major Turfgrasses

Relative Ranking	PET rate (inch/day)	Cool-Season	Warm-Season
Very Low	0.236		Buffalograss; 0.2 - 0.3
Low	0.24 - 0.276		Bermudagrass; 0.12 - 0.3 Centipedegrass; 0.15 - 0.33 Zoysiagrass; 0.14 - .3 Blue grama;
Medium	0.28 - 0.33	Hard Fescue; Chewings Fescue Red Fescue	Bahiagrass; 0.25 Seashore Paspalum; 0.25 - 0.31 St. Augustinegrass; 0.13 - 0.37
High	0.33 - 0.39	Perennial Ryegrass; 0.15 - 0.44	
Very High	> 0.39	Tall Fescue; 0.15 - 0.5 Creeping Bentgrass; 0.19 - 0.39 Annual Bluegrass Kentucky Bluegrass; 0.15 - 0.26 Annual Ryegrass	

Source: Beaul, 1986

Average ET Rates (in./month) 1994 - 2010 in Stillwater, OK



Source: Gary McManus, Oklahoma Mesonet

Daily ET Rates (Stillwater, OK)

Cool-season Warm-season

June	0.19 in/d	0.13 in/d
July	0.22	0.15
August	0.20	0.13

Note: High daily ET rate 0.27 in/d for warm-season & 0.35 in/d for cool-season turfgrass

Note: ET rate for Scottsdale, Arizona will exceed 0.5 inch / day

Source: Gary McManus, Oklahoma Mesonet

Drought Resistance

- **Drought Avoidance**
 - Deeper roots, more root hairs, waxy/hairy leaves, leaf rolling, less pores, etc.
- **Drought tolerance**
 - ability to withstand water deficits in tissue caused by insufficient water quantity. i.e. Dormancy
- **Escape**
 - allows for survival by the plant's completing its life cycle before serious plant water stress develops.

Source: Sifers, S.L., and J.B. Beard
Golf Course Management • September 1999

Drought Resistance

Avoidance

Tolerance

Escape

Evapotranspiration

Root Water Uptake

- Canopy resistance
- Leaf Area
- Stomata closure rate
- Epidermal wax formation
- Radiation absorption

- Root Depth
- Root Density
- Root Hair Development
- Hydraulic Conductance

- Maintenance of turgor
- Protoplasmic resistance
- Dormancy

Source: Sifers, S.L., and J.B. Beard
Golf Course Management • September 1999

Drought Resistance of Turfgrass

Drought Resistance	Cool-Season	Warm-Season
Excellent		Bahiagrass Blue grama Buffalograss Cm. Bermudagrass Zoysiagrass
Very Good		Hybrid Bermudagrass St. Augustinegrass
Good	Canadian Bluegrass Fine fescue Kentucky bluegrass Tall Fescue	Centipedegrass Seashore paspalum
Fair	Perennial Ryegrass	
Poor	Annual bluegrass Annual ryegrass Colonial Bentgrass Creeping Bentgrass	Carpetgrass

Irrigation Scheduling

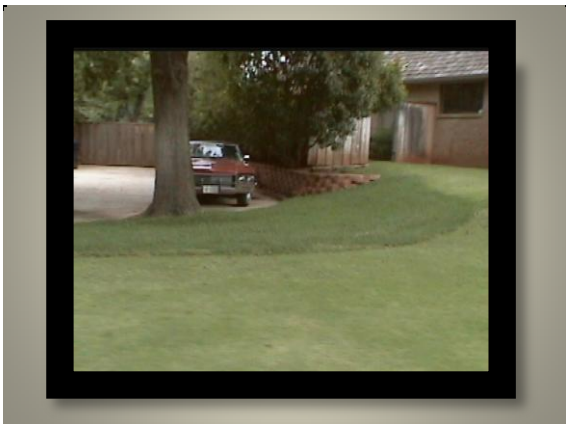
Why Schedule??

- Most managers over water
- Saves Water & Energy = \$\$\$\$
- More efficient fertilizers & chemical applications
- Turf Quality

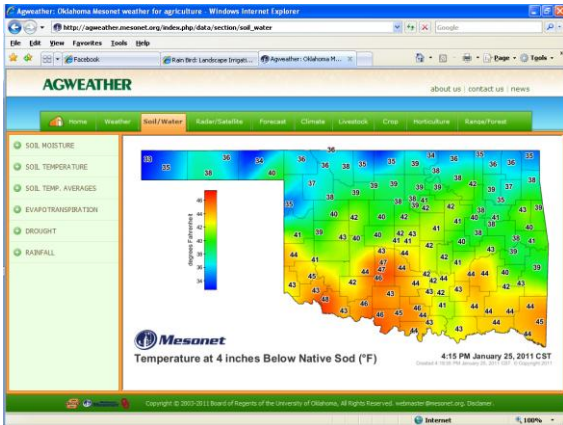


Plant Water Requirement

Item	Source		Value	Unit or Function
Plant water Requirement				
A. Plant Material	Audit or Planting Plan		CS	Classification
B. Reference Period	Judgment		31	Days
C. Reference ET (ET0)	Various sources		0.27	inches of water/day
Total ET for period			8.37	inches of water/period
Landscape Coefficient			0.8	plant specific multiplier
D. (KL) (optional) Allowable Stress	Ks x Kd x Kmc Kl x Kas		1	site specific multiplier
E. Plant Water Requirement	ET0 x Kl	C x D	6.70	inches







Plant Water Requirement

- $K_L = k_s \times k_d \times k_{mc}$
- K_L – Landscape Coefficient
 - k_s - Species Factor (CS = 0.8 & WS = 0.6)
 - k_d - Density
 - k_{mc} - Micro Climate

Item	Source	Value	Unit or Function
Plant water Requirement			
A Plant Material	Audit or Planting Plan	CS	Classification
B Reference Period	Judgment	31	Days
C Reference ET (ET ₀)	Various sources	0.27	inches of water/day
Total ET for period		8.37	inches of water/period
D Landscape Coefficient (KL)	$K_s \times K_d \times K_{mc}$	0.8	plant specific multiplier
(optional) Allowable Stress	$K_i \times K_{as}$	1	site specific multiplier
E Plant Water Requirement	$ET_0 \times K_L$	6.70	inches

Irrigation Water Requirement

Irrigation Water Requirement			
F. Precipitation Rate	Audit or calculation		1.67 inches per hour
G. Distribution Uniformity	Audit or Estimate		70.00% efficiency adjustment
H. Irrigation Water Requirement	Plant H2O requirement/DU	E/G	9.57 inches per period
I. Total Runtime per Period	Irrig. H2O requirement/PR	(H/F) x 60	344 minutes

Precipitation Rates

U12 Series					
2.2" Injetor	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
U-12F	15	9	1.80	2.14	2.47
	20	10	2.10	2.02	2.34
	25	11	2.40	1.91	2.21
	30	12	2.60	1.74	2.01
U-12G	15	9	1.25	2.14	2.47
	20	10	1.58	2.02	2.34
	25	11	1.80	1.91	2.21
	30	12	1.95	1.74	2.01
U-12HT	15	9	1.20	2.14	2.47
	20	10	1.40	2.02	2.34
	25	11	1.60	1.91	2.21
	30	12	1.74	1.74	2.01
U-12H	15	9	0.90	2.14	2.47
	20	10	1.05	2.02	2.34
	25	11	1.20	1.91	2.21
	30	12	1.30	1.74	2.01
U-12I	15	9	0.60	2.14	2.47
	20	10	0.70	2.02	2.34
	25	11	0.80	1.91	2.21
	30	12	0.87	1.74	2.01
U-12J	15	9	0.45	2.14	2.47
	20	10	0.53	2.02	2.34
	25	11	0.60	1.91	2.21
	30	12	0.65	1.74	2.01

U13 Series					
2.2" Injetor	Pressure psi	Radius ft.	Flow gpm	■ Precip In/h	▲ Precip In/h
U-13F	15	9	1.80	2.14	2.47
	20	10	2.10	2.02	2.34
	25	11	2.40	1.91	2.21
	30	12	2.60	1.74	2.01
U-13G	15	9	1.35	2.14	2.47
	20	10	1.58	2.02	2.34
	25	11	1.80	1.91	2.21
	30	12	1.95	1.74	2.01
U-13HT	15	9	1.20	2.14	2.47
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	25	11	0.60	1.91	2.21
	30	12	0.65	1.74	2.01

Irrigation Audit

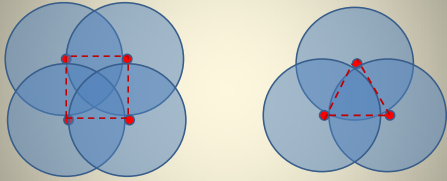




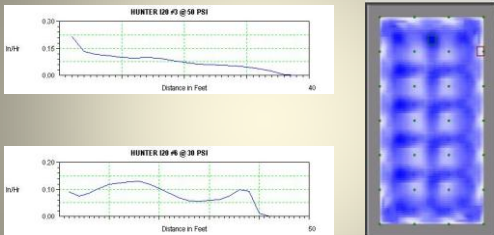


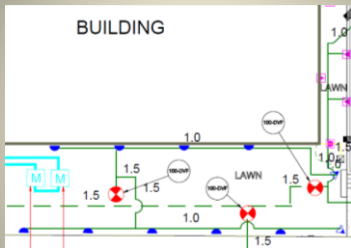


Types of Spacing



Spacing of Heads



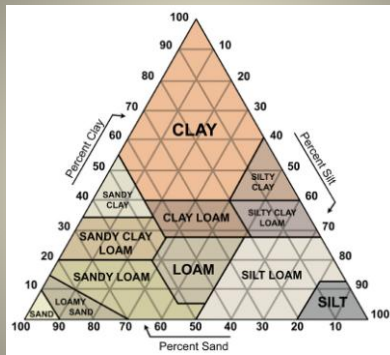


Irrigation Water Requirement

Irrigation Water Requirement			
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G. Distribution Uniformity	Audit or Estimate		70.00% efficiency adjustment
H. Irrigation Water Requirement	Plant H2O requirement/DU	E/G	9.57 inches per period
I. Total Runtime per Period	Irrig. H2O requirement/PR	(H/F) x 60	344 minutes

Scheduling Requirement

Scheduling Requirements			
J. Root Zone Soil Type	Audit or Estimate		clay loam classification
K. Avail. Water Hold. Capacity	Table		0.167 inches per inch of soil
L. Active Root Zone Depth	Audit or Estimate		8 inches
M. Root Zone Available Water	AWHC x active root zone	K x L	1.336 inches
N. Working Storage	RZAW x MAD (50%)		0.668 budget multiplier
O. Number of Irrigation Days	Plant H2O requirement/WS	E/N	10 days in a period
P. Total Runtime per Day	Total run-period/# irrig. Days	I/O	34 minutes
Q. Runtime per Cycle	Audit or Estimate		18 minutes
R. Cycles per Day	Total run-day/runtime-cycle	P/Q	2 repeats to avoid runoff




Available Water-holding Capacity of Soils

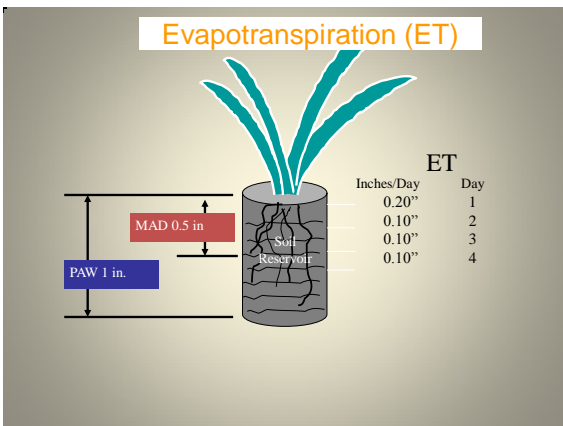
Soil Texture	Inches of available water of moist soil per foot / per inch	Permeability rate ¹ Inches/Hour
Sands and fine sands	0.5-0.75 (0.04-0.063)	1.0 - 10
Very fine sands, loamy sand	0.8 - 1.0 (0.067-0.083)	1.0 - 3
Sandy Loam	1.2 - 1.5 (0.1-0.125)	0.5 - 3
Loam	1.9 - 2.0 (0.158-0.167)	0.3 - 0.8
Silt loam, silt	2.0 (0.167)	0.2 - 0.4
Silty clay loam	1.9 - 2.0 (0.158-0.167)	0.01 - 0.2
Sandy clay loam, Clay loam	1.7 - 2.0 (0.142-0.167)	0.1 - 0.6

Note: Allowable depletion to avoid crop water stress is usually about 50% of available water holding capacity for plants.
¹Normal ranges. Intake rates vary greatly with soil structure and structural stability.

Scheduling Requirements

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Base Schedule Worksheet					Irrigation Water Requirement					
Project name:		Date: 26-Jan-10			Precipitation Rate		Audit or calculation		1.67	inches per hour
Project Location: Stillwater, Oklahoma		Reference Month: July			Distribution Uniformity		Audit or Estimate		70.00%	efficiency adjustment
Controller No. One		Station No: 1			Irrigation Water Requirement		Plant H2O Requirement/DU		EIG	9.57 inches per period
Item		Source		Value	Total Runtime per Period		Irrig. H2O requirements/PR		(H/F) x 60	344 minutes
Plant water Requirement					Scheduling Requirements					
A.	Plant Material	Audit or Planting Plan		CS	Classification	J.	Root Zone Soil Type	Audit or Estimate	clay loam	classification
B.	Reference Period	Judgment		31	Days	K.	Avail. Water Hold. Capacity	Table	0.167	inches per inch of soil
C.	Reference ET (ET ₀)	Various sources		0.27	inches of water/day	L.	Active Root Zone Depth	Audit or Estimate	8	inches
D.	Total ET for period			8.37	inches of water/period	M.	Root Zone Available Water	AWHC x active root zone	K x L	1.336 inches
	Landscape Coefficient (K _L)	K _L x K _L x K _L		0.8	plant specific multiplier	N.	Working Storage	RZAW x MAD (50%)		0.668 budget multiplier
	(optional) Allowable Stress	K _L x K _L		1	site specific multiplier	O.	Number of Irrigation Days	Plant H2O requirement/WBS	EIN	10 days in a period
E.	Plant Water Requirement (ET ₀ x K _L)	C x D		6.70	inches	P.	Total Runtime per Day	Total run-period# irrig. Days	VO	34 minutes
						Q.	Runtime per Cycle	Audit or Estimate		18 minutes
						R.	Cycles per Day	Total run-day/runtime-cycle	P/Q	2 repeats to avoid runoff



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