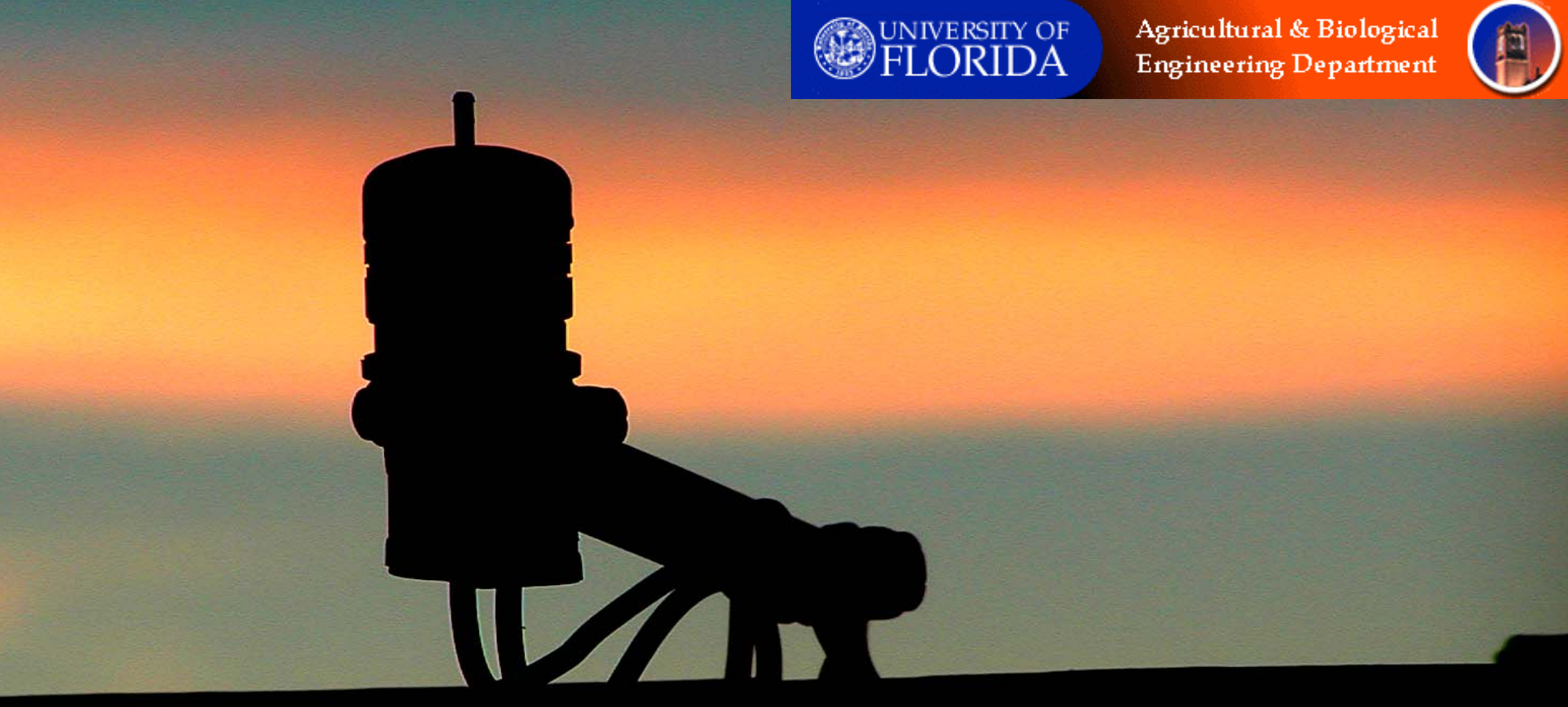


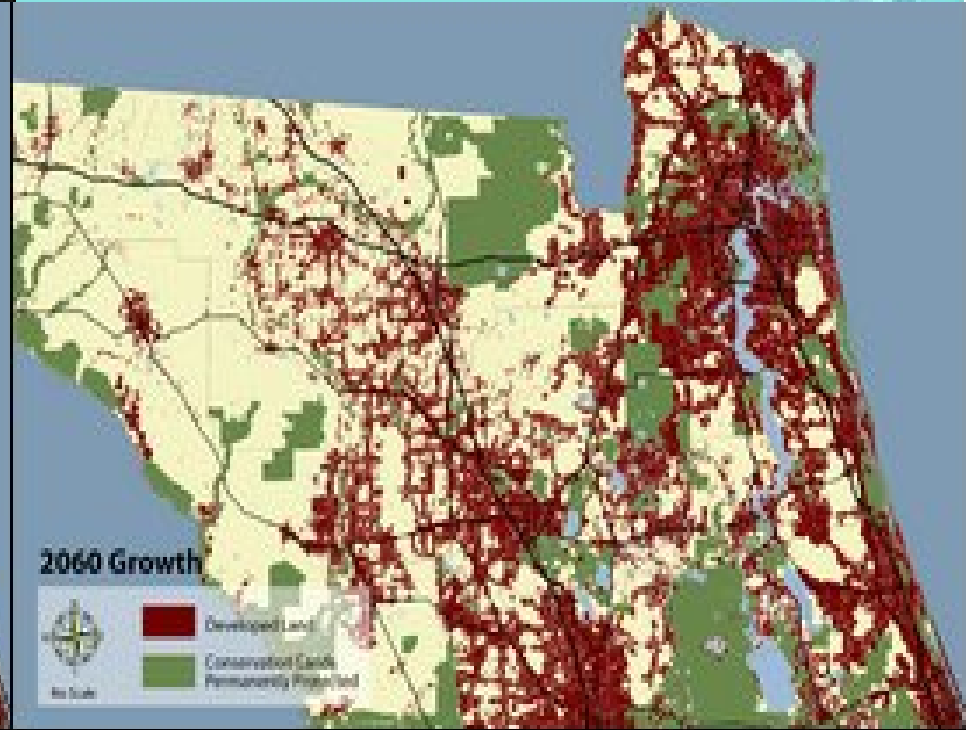
SENSOR-BASED AUTOMATION OF RESIDENTIAL IRRIGATION

Bernard Cardenas-Lailhacar and
Michael D. Dukes, Ph.D., P.E.

Soil Moisture Sensor Project; Phase 1
December 14, 2006


OVERPOPULATION
=SPRAWL


Existing Growth
Developed Land
Conservation Lands
Permanently Protected


2060 Growth
Developed Land
Conservation Lands
Permanently Protected

- **USA : 58% (Avg.)**
- **Central Florida : 64% (Avg.) - 71%**

Irrigation: a substantial opportunity for residential water savings

Ways to Decrease Irrigation Applied

- Reduce irrigation window
  - Water restrictions
- Reduce the irrigated area
  - Landscape ordinances
- Optimize irrigation application

OBJECTIVES

Quantify water use and turf quality on:

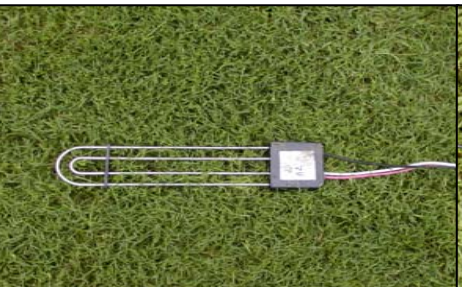
1) time-based tmts., with or without a rain sensor,

2) time-based tmts. compared to SMS-based tmts.

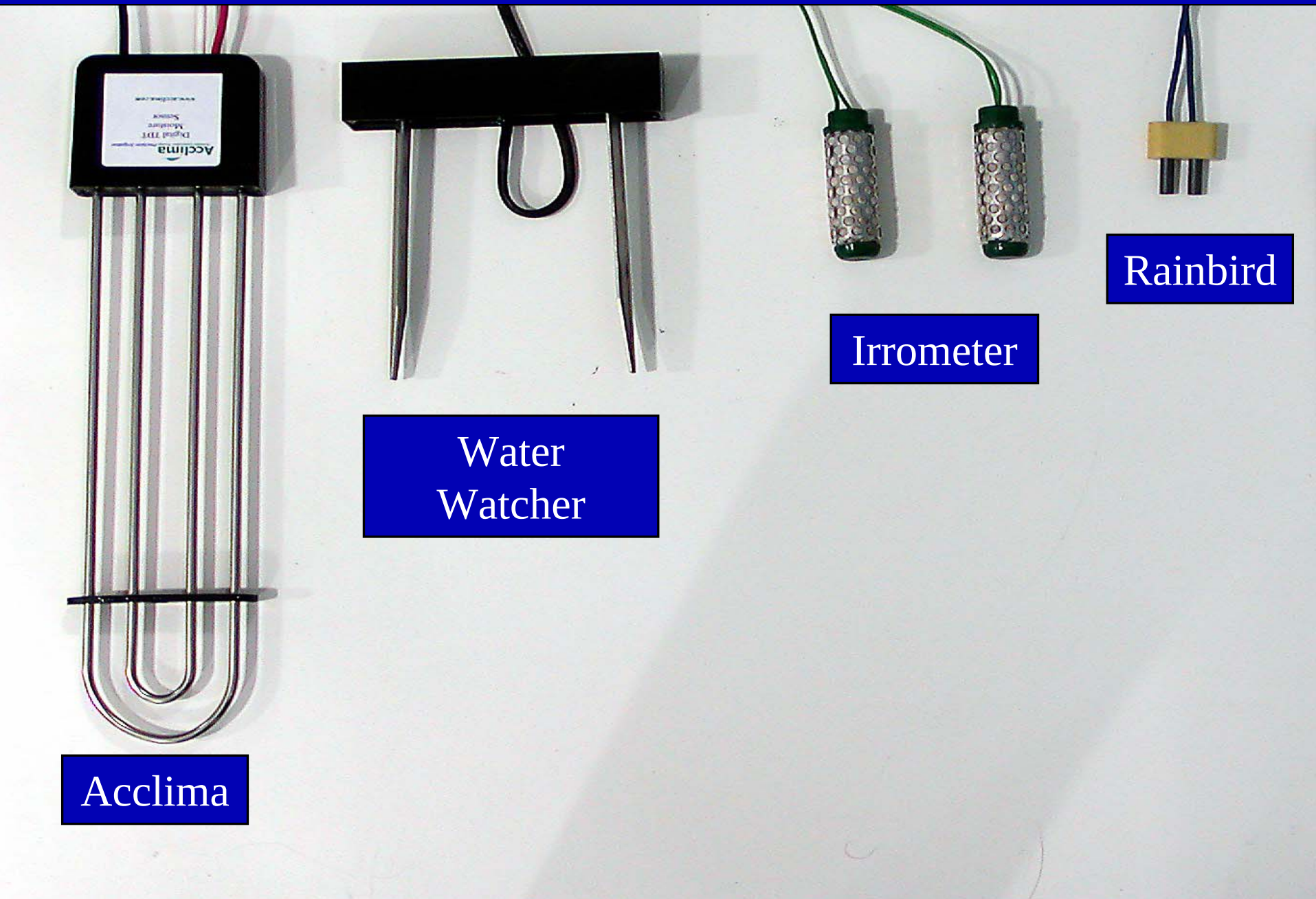
MATERIALS AND METHODS

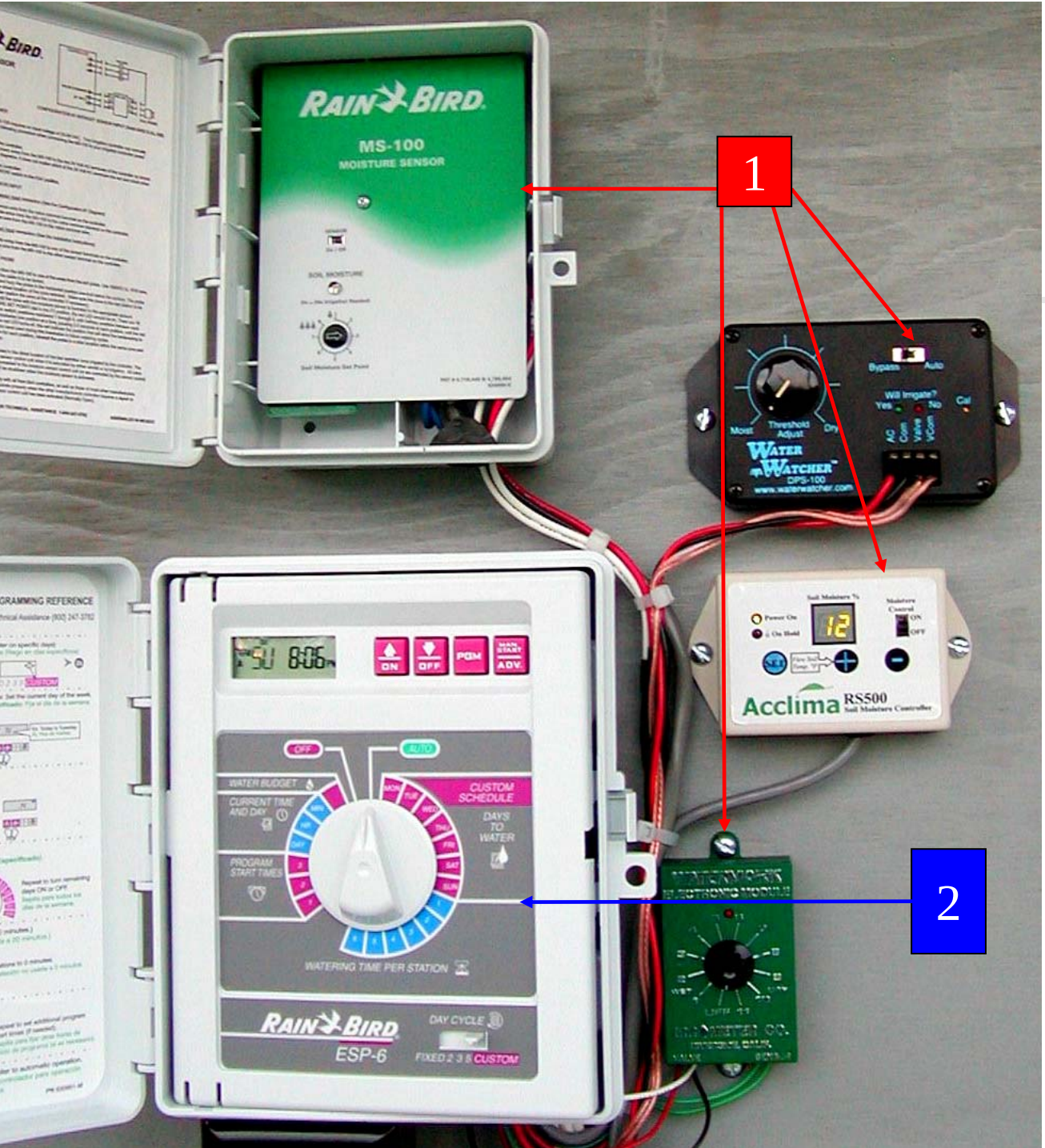
- **Location:**

On campus, UF, Gainesville, FL



Soil Moisture Sensors





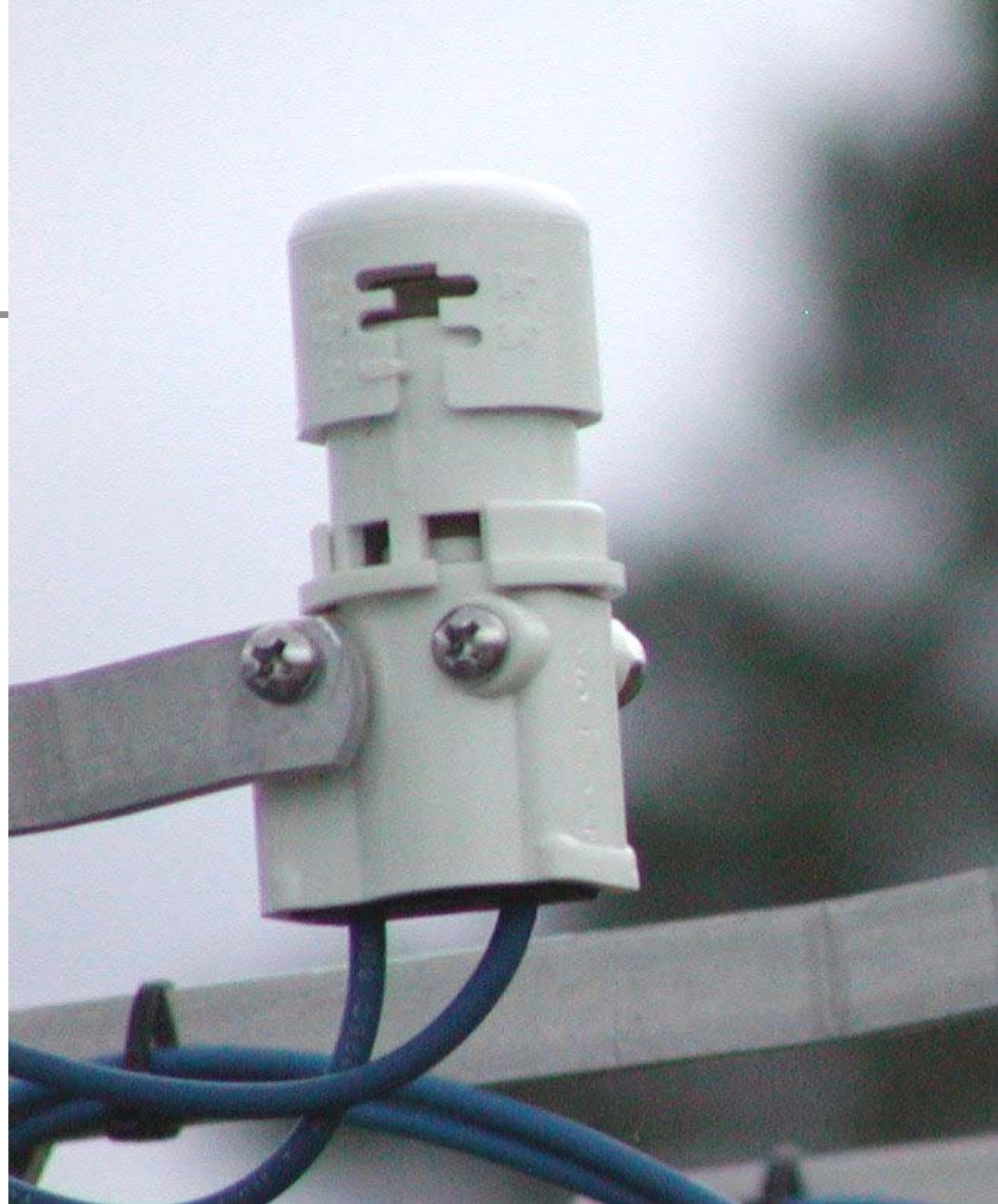
1: SMS Controllers

2:Timer

Rain Sensor

Mini-Click

Set: 6 mm

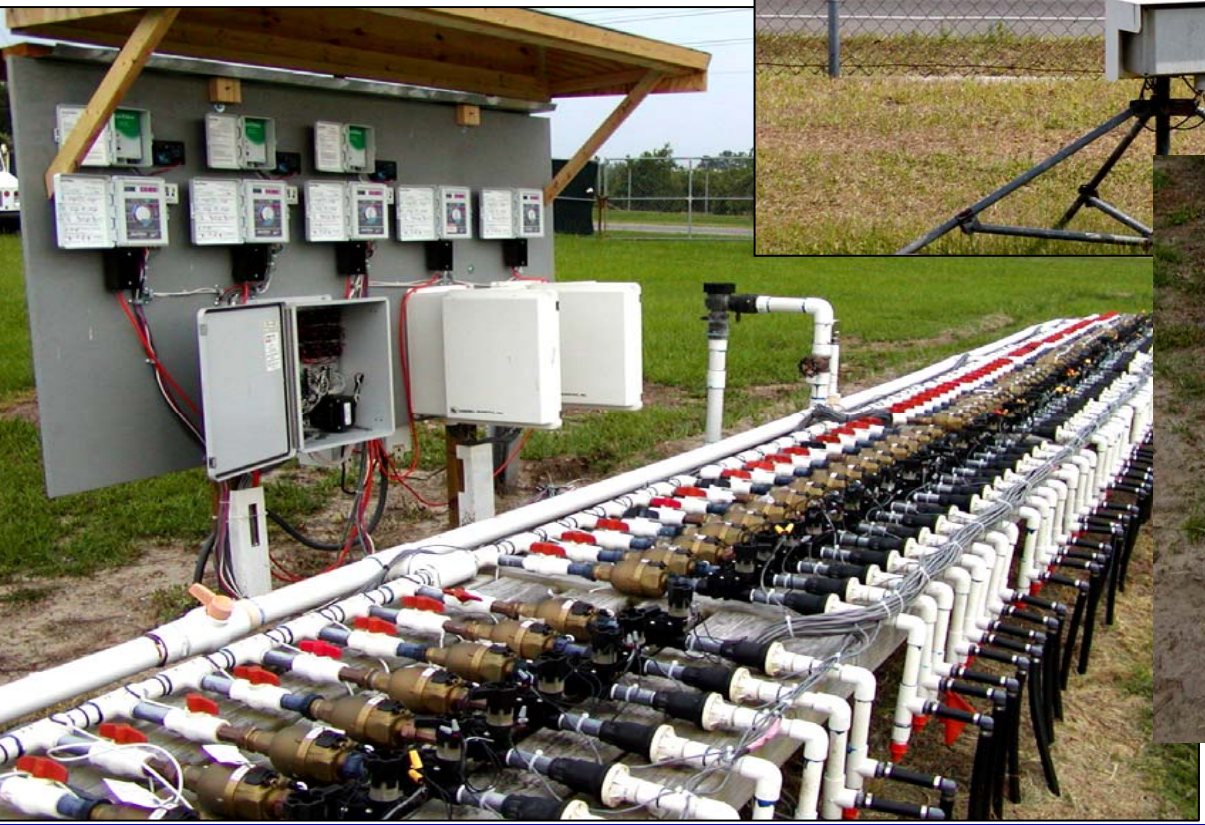


Treatments

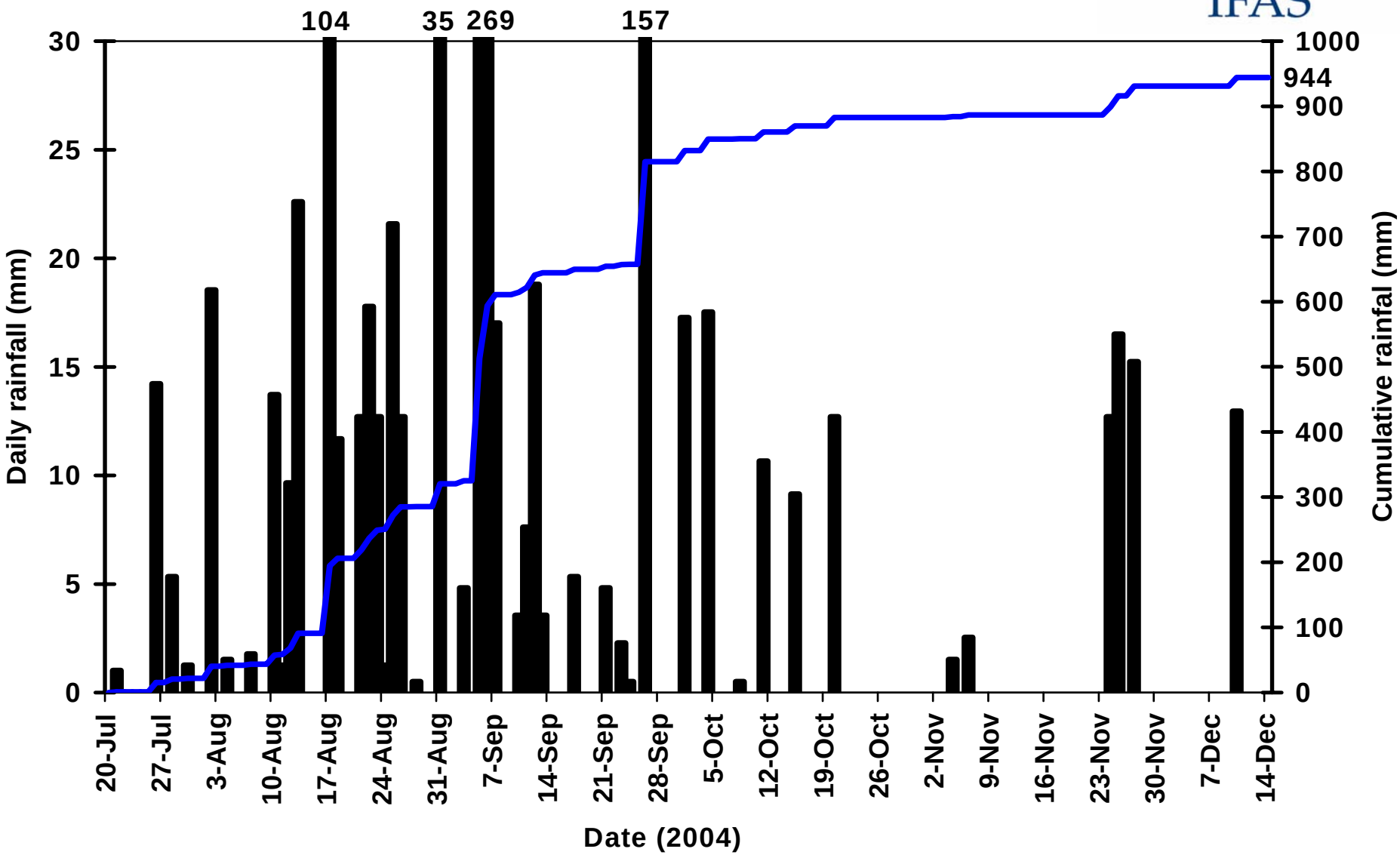
UNIVERSITY OF FLORIDA IFAS

Treatment	Irrigation Frequency (days/week)	Soil Moisture Sensor Brand or Treatment Description
SMS-Based		
1-AC	1	Acclima
1-RB	1	Rainbird
1-IM	1	Irrometer
1-WW	1	Water Watcher
2-AC	2	Acclima
2-RB	2	Rainbird
2-IM	2	Irrometer
2-WW	2	Water Watcher
7-AC	7	Acclima
7-RB	7	Rainbird
7-IM	7	Irrometer
7-WW	7	Water Watcher
Time-Based		
2-WRS	2	With rain sensor
2-WORS	2	Without rain sensor
2-DWRS	2	60% Deficit historical ET, with rain sensor
0-NI	0	No irrigation

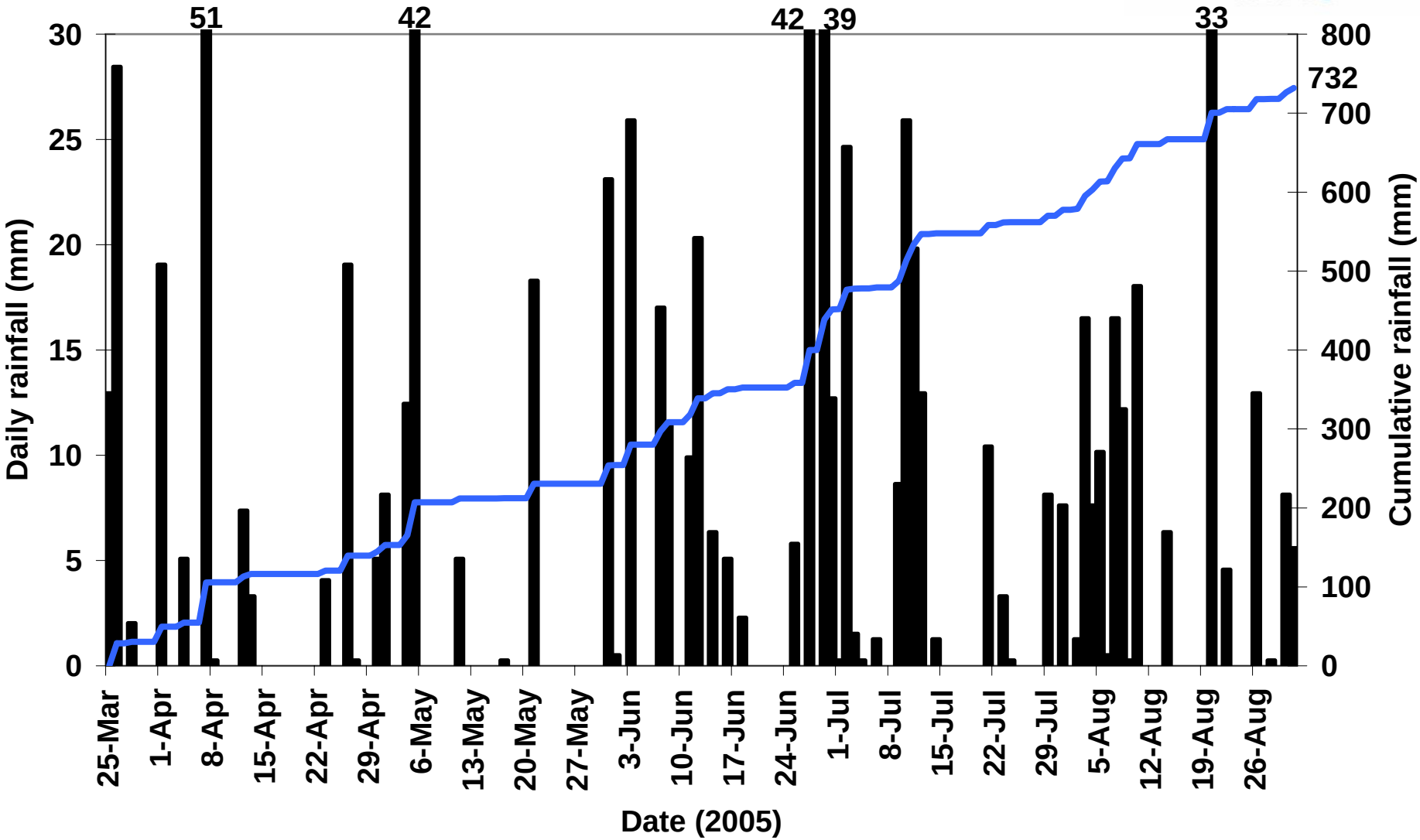
UNIVERSITY OF FLORIDA
IFAS



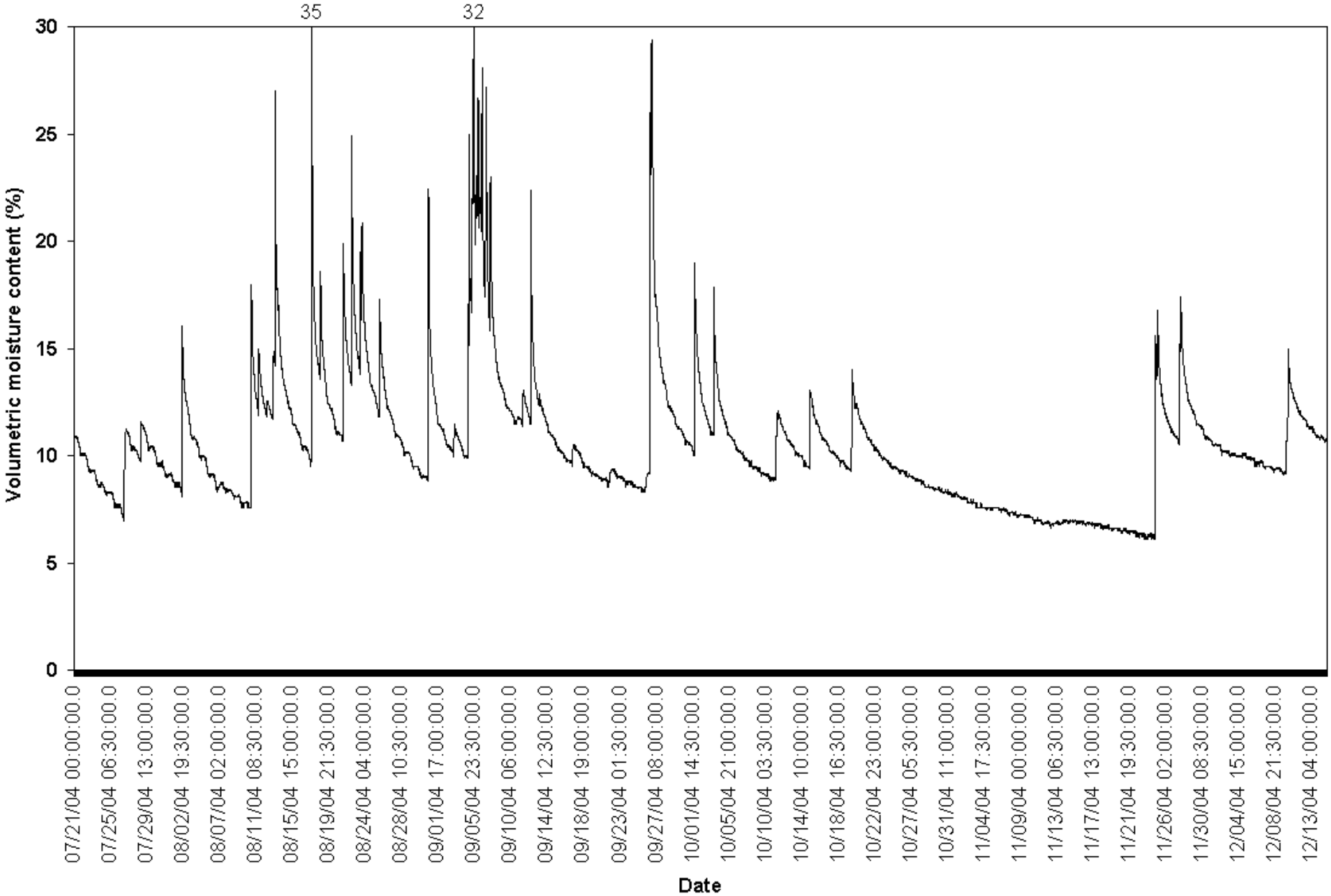
Irrigation Controls



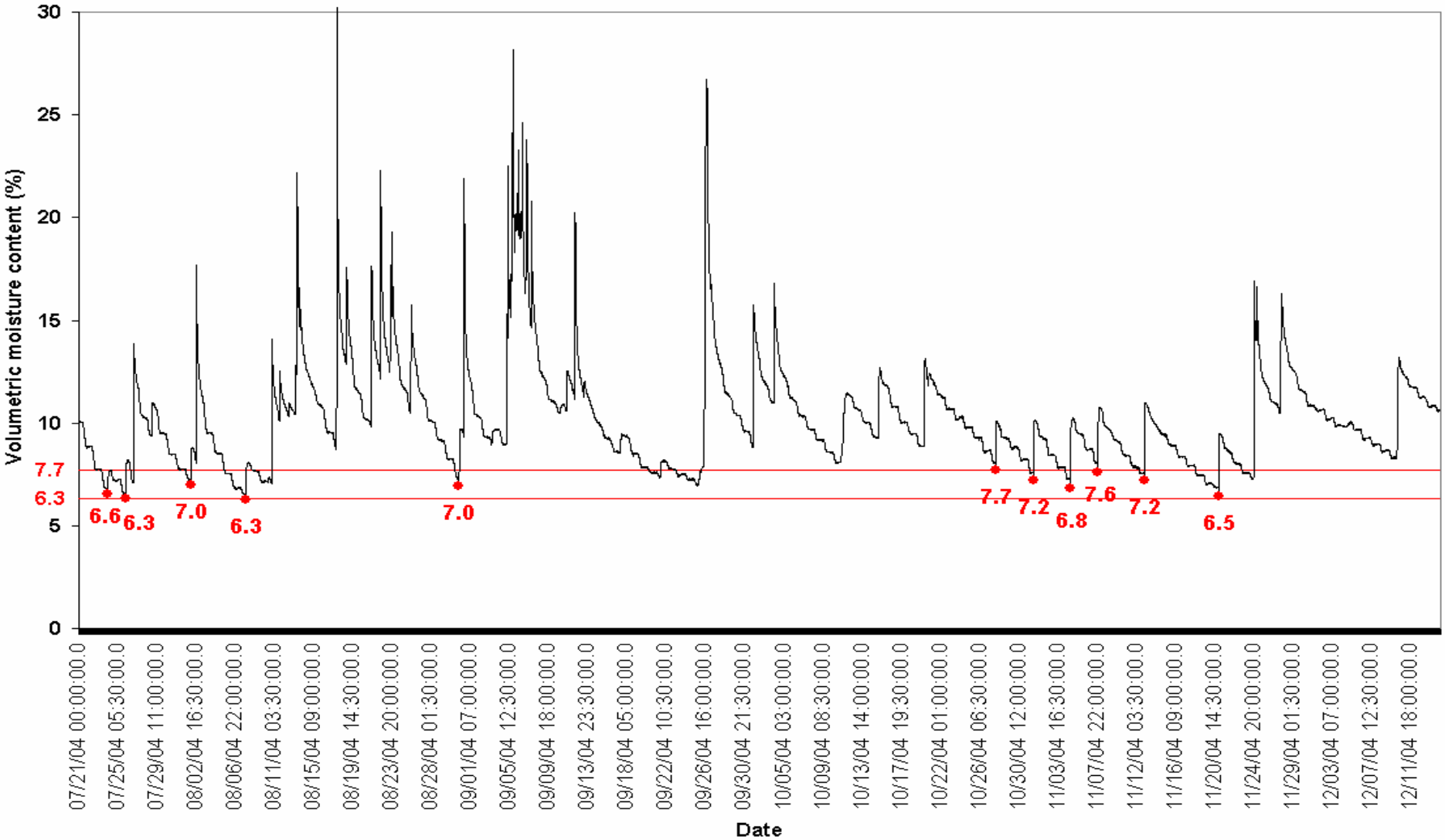
Daily and cumulative rainfall (2004).



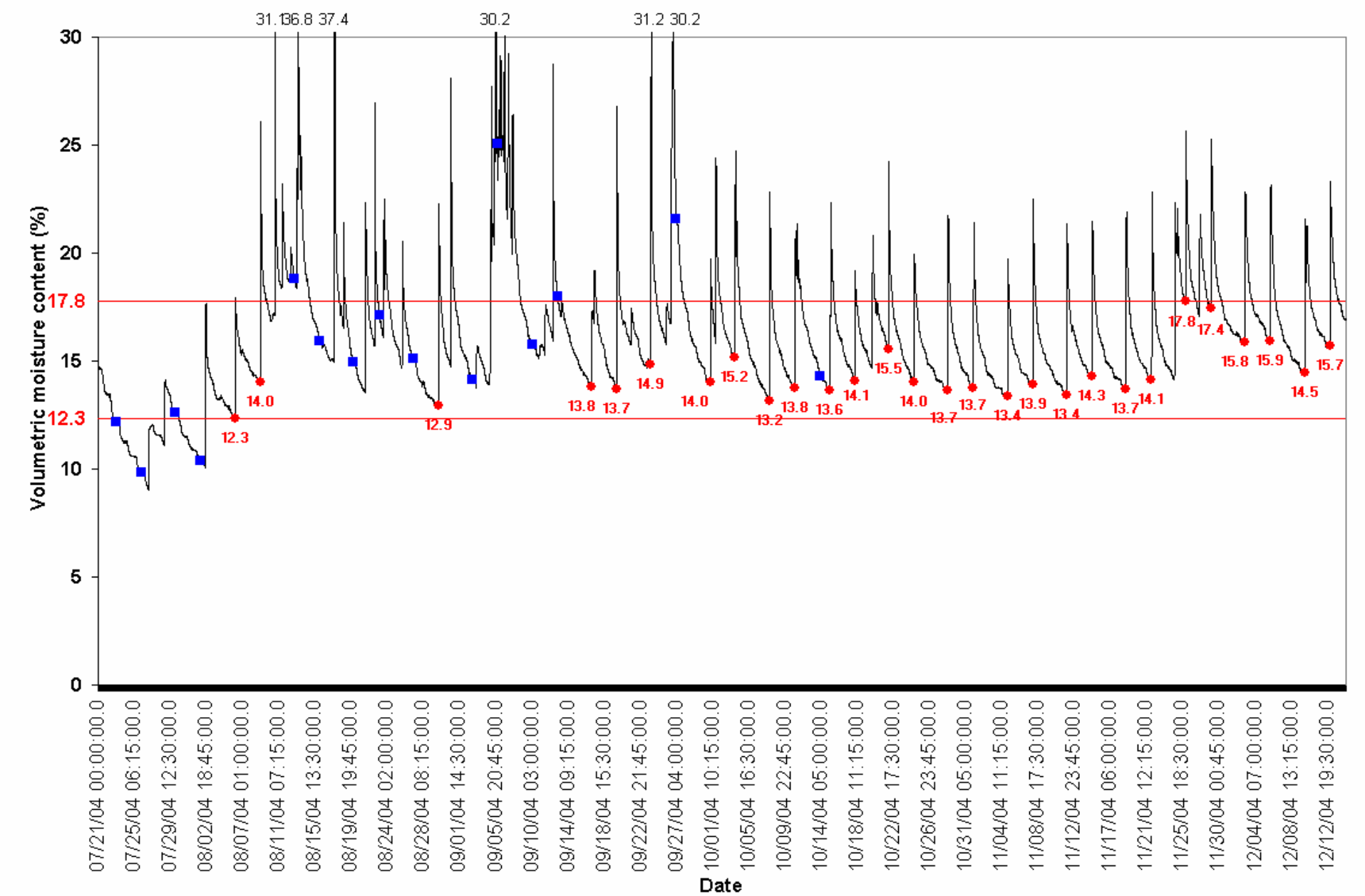
Daily and cumulative rainfall (2005).



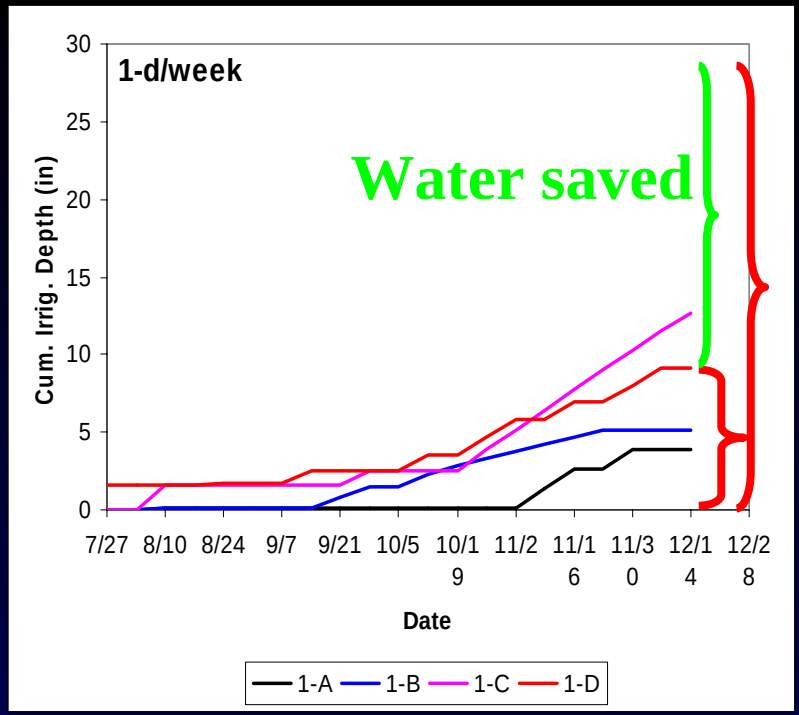
Volumetric moisture content; 0-NI, year 2004.

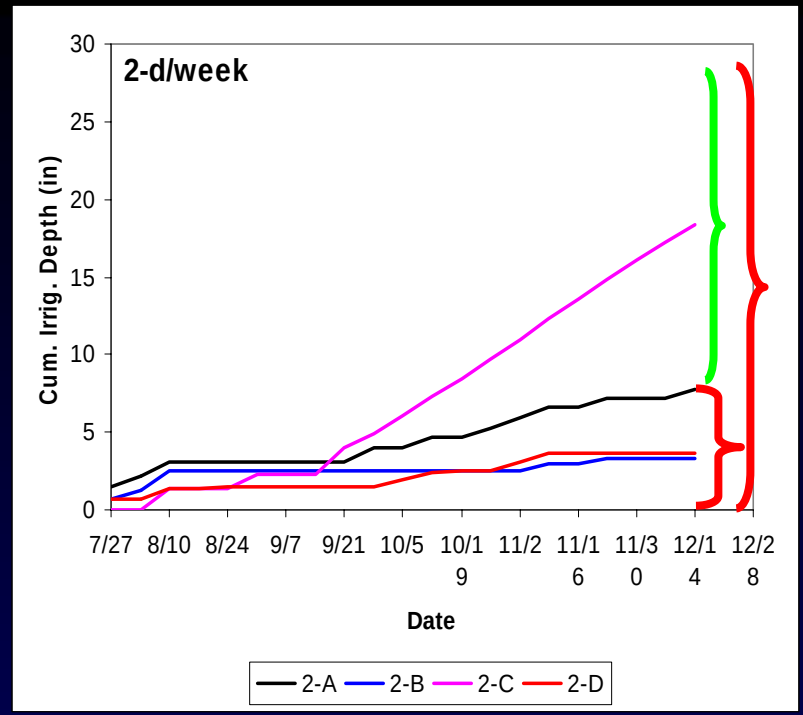


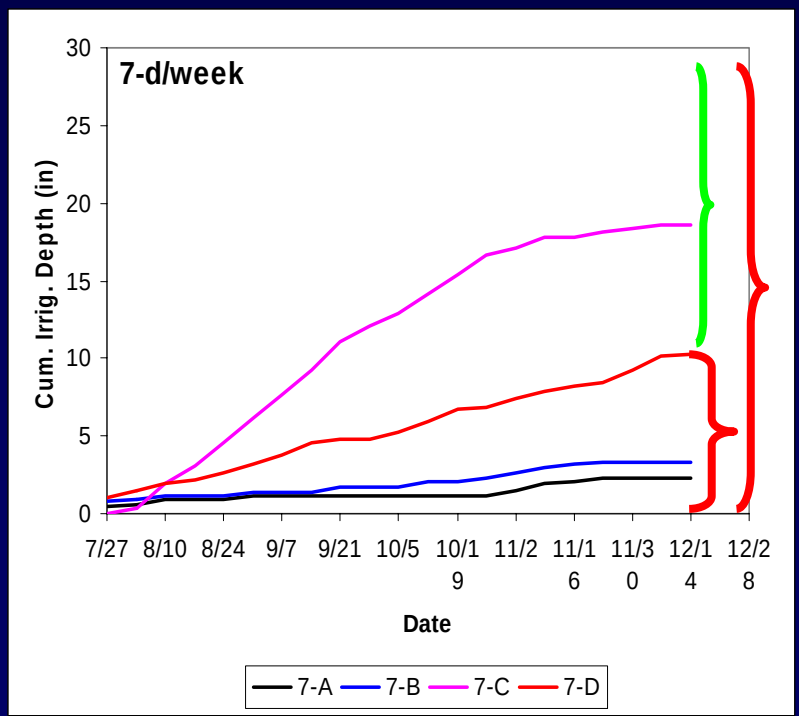
VMC through 2004, treatment 7-AC. Red dots represent allowed SIC (8% of the SIC), and the red lines represent the range of VMC when the SIC were allowed.

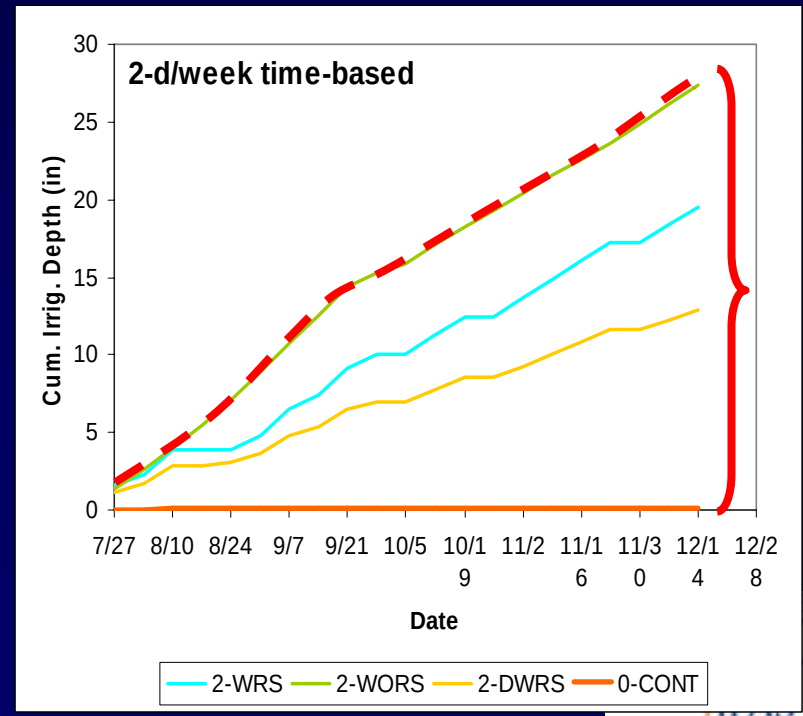


Volumetric moisture content through time; 2-IM, year 2004.


1-d/week
Water saved
Cum. Irrig. Depth (in)
30
25
20
15
10
5
0
7/27 8/10 8/24 9/7 9/21 10/5 10/19 11/2 11/16 11/30 12/14 12/28
Date
1-A 1-B 1-C 1-D


2-d/week
Cum. Irrig. Depth (in)
30
25
20
15
10
5
0
7/27 8/10 8/24 9/7 9/21 10/5 10/19 11/2 11/16 11/30 12/14 12/28
Date
2-A 2-B 2-C 2-D


7-d/week
Cum. Irrig. Depth (in)
30
25
20
15
10
5
0
7/27 8/10 8/24 9/7 9/21 10/5 10/19 11/2 11/16 11/30 12/14 12/28
Date
7-A 7-B 7-C 7-D


2-d/week time-based
Cum. Irrig. Depth (in)
30
25
20
15
10
5
0
7/27 8/10 8/24 9/7 9/21 10/5 10/19 11/2 11/16 11/30 12/14 12/28
Date
2-WRS 2-WORS 2-DWRS 0-CONT

Cumulative irrigation depth, statistical comparisons, and percent of water savings compared to 2-WORS.

Treatment	Cumulative depth (mm)	Comparisons[+]			Water savings vs.
		A	B	*C*	2-WORS (%)
SMS-Based					
1-AC	283				81
1-RB	281				81
1-IM	793				48
1-WW	323				79
1-Avg	420			*b*	
2-AC	348				77
2-RB	188				88
2-IM	1105				27
2-WW	270				82
2-Avg	478			*a*	
7-AC	122				92
7-RB	147				90
7-IM	715				53
7-WW	463				69
7-Avg	362			*c*	
SMS-Avg	420		*b*		
Time-Based					
2-WORS	1514	*a*			0
2-WRS	995	*b*			34
2-DWRS	623	*c*			59
Time-Avg	1044		*a*		

CONCLUSIONS

- No significant differences in turfgrass quality among treatments were detected → no irrigation was necessary.
- WRS 34%< WORS → importance & benefit of rain sensor.
- SMS savings: 69-92% (excluding brand IR).
- SMS-based technology could result in sound environmental and economic benefits to the state.

CONCLUSIONS

- 7d/w frequency used the least amount of water, and appears to be a better strategy regarding water conservation for turfgrass irrigation in Florida's sandy soils. c2 c1
- SMS-based technology could lead to a complete automation of residential irrigation systems.

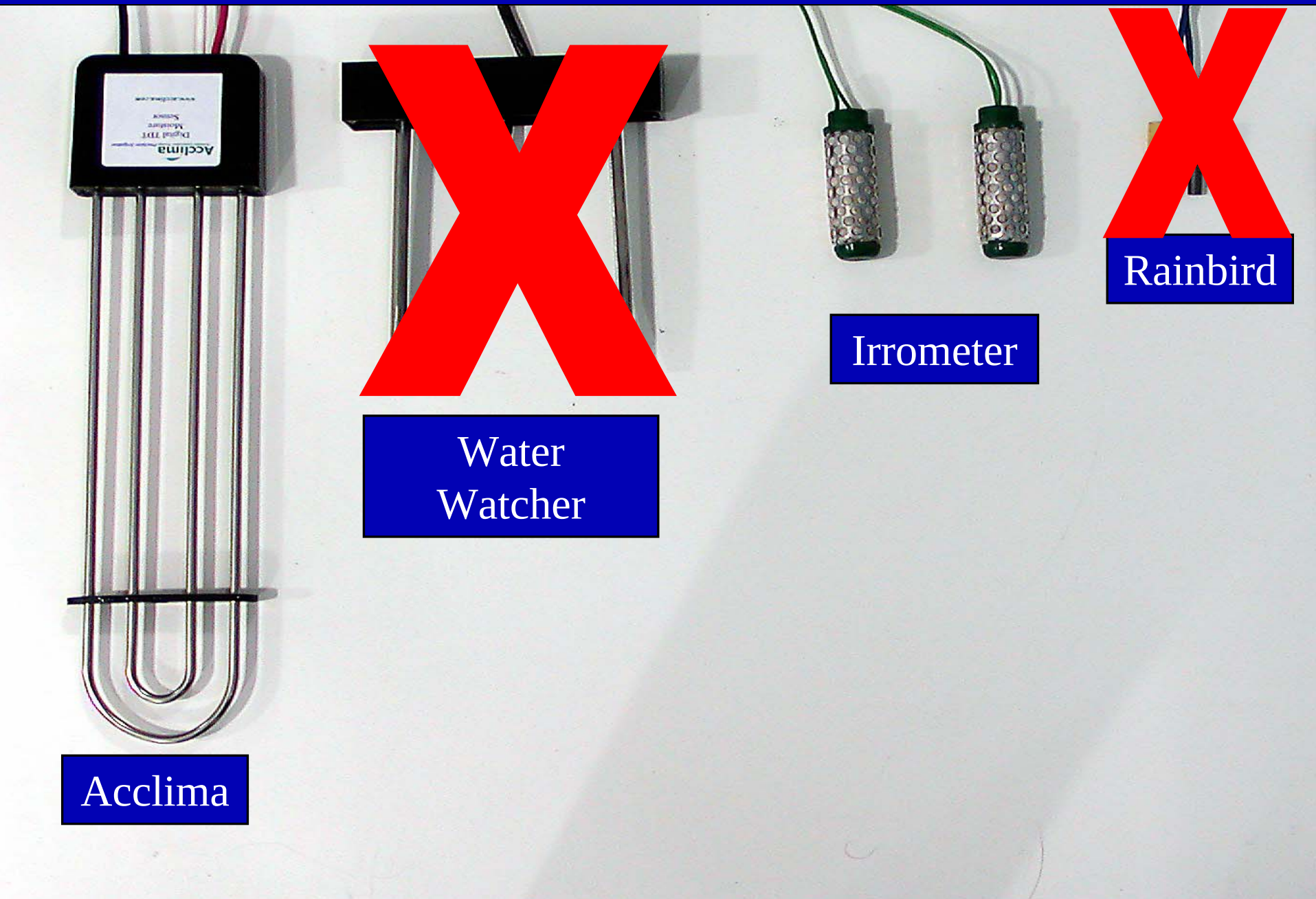
c1 schedule at 7 d/w for a whole cycle, and allow the system to decide the initiation of a SIC.
cardenas, 12/11/2006

c2 SMSs can act as RSs, detecting when sufficient rainfall has occurred, but with a better performance.
cardenas, 12/12/2006

POTENTIAL FUTURE WORK

- **Alternative scheduling: 7d/w with 2 or more events per day, to optimize irrigation efficiency and turf quality.**
- **Optimization of the controllers set point under varying soil/weather conditions.**
- **RSs and SMSs should be tested over a longer period of time, to test their performance through time and under different weather conditions (dry periods).**

Soil Moisture Sensors

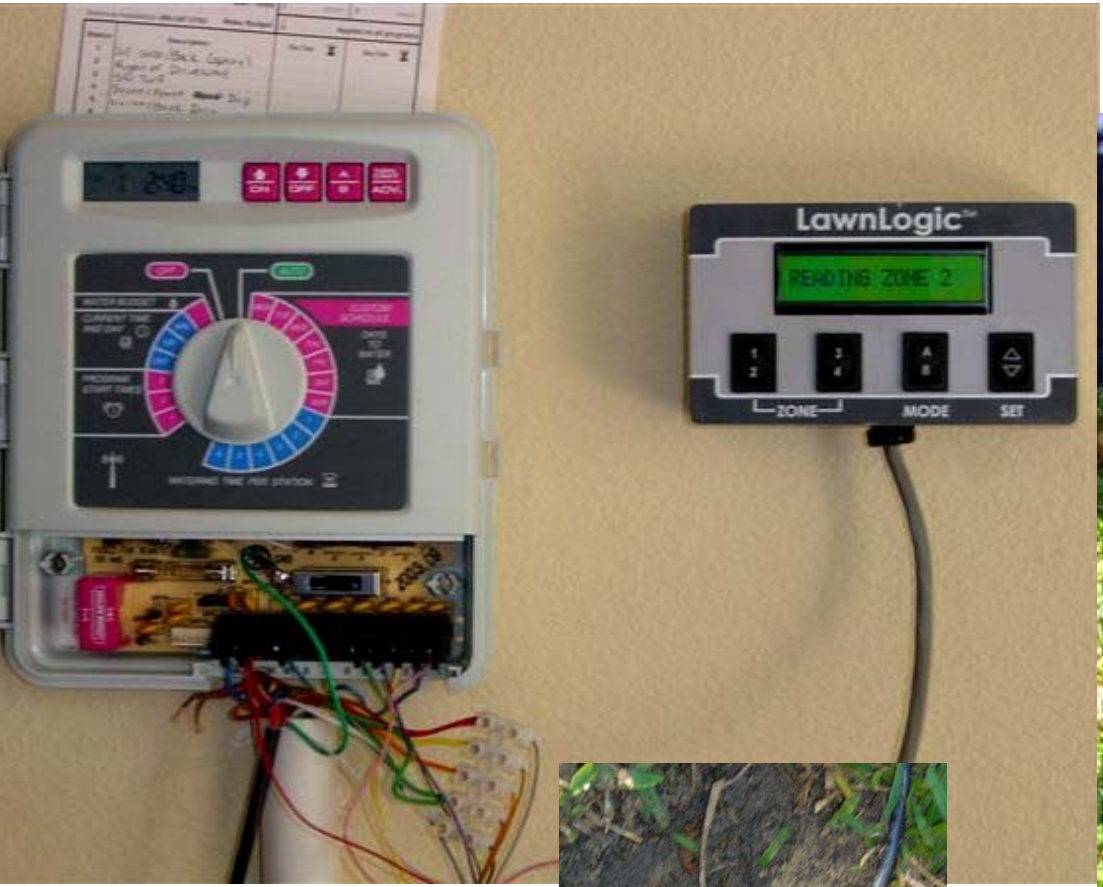


BL-5305 *biSensor* ™ *5'*

BL-5315 biSensor™ Stick

Agrilink AquaSense™ Turf

UNIVERSITY OF FLORIDA
IFAS




Questions?