IRRIGATION OF ST. AUGUSTINEGRASS WITH SOIL MOISTURE SENSOR AND EVAPOTRANSPIRATION CONTROLLERS

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ENGINEERING

UNIVERSITY OF FLORIDA

2008

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To my parents, Steve and Judy Shedd

ACKNOWLEDGMENTS

First off, I would like thank my parents who have always supported me in every endeavor I pursued. Their unconditional love has helped me through many obstacles and provided me with a firm foundation. I also want to thank my friends who have offered words of advice and encouragement, especially my best friend and husband, Steve.

I thank the following individuals for their help on this research: Bernard Cardenas, Stacia Davis, Kristen Femminella, Eban Bean, Lincoln Zotarelli, Melissa Haley, Larry Miller, Danny Burch, Brian Owens, Jan Weinbrecht, Mark Kann, Joel Berry, and Dave Carson. I would also like to thank the members of my graduate committee (Dr. Dorota Z. Haman and Dr. Grady L. Miller) for their guidance and assistance in my work. Finally, I would like to thank Dr. Michael D. Dukes for the chance to do this work and the encouragement to finish it. I have greatly enjoyed my time working with Dr. Dukes as an “irri-gator.”

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LIST OF ABBREVIATIONS

AC	Acclima soil moisture sensor
AW	Available water
DWRS	60% reduced irrigation schedule with a rain sensor (6 mm setting)
ET	Evapotranspiration
FC	Field capacity
LL	LawnLogic soil moisture sensor
NON	Non-irrigated
PWP	Permanent wilting point
RAW	Readily available water
RS	Rain sensor
RS1-3mm	Rain sensor treatment, 1 day/ week and 3 mm rainfall setting
SJRWMD	St. Johns River Water Management District
SMS	Soil moisture sensor
SWB	Soil water balance
TDR	Time domain reflectometry sensor
VWC	Volumetric water content
WOS	Without rain sensor
WRS	With rain sensor

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Engineering

IRRIGATION OF ST. AUGUSTINEGRASS WITH SOIL MOISTURE SENSOR AND EVPOTRANSPIRATION CONTROLLERS

By

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December 2008

Chair: Michael D. Dukes
Major: Agricultural and Biological Engineering

A variety of commercially available technologies for reducing residential irrigation water use are available to homeowners. These technologies include soil moisture sensors, rain sensors and evapotranspiration (ET) based controllers. The purpose of this research was to evaluate the effectiveness of these various technologies based on irrigation applied, turfgrass quality, accuracy of measurements made by the devices and the effect on root growth in St. Augustinegrass (*Stenotaphrum secundatum)*. Soil moisture sensor (SMS) testing was performed on two brands of sensors (LawnLogic and the Acclima Digital TDT RS500) at low, medium, and high soil moisture threshold settings. Mini-Clik rain sensors comprised seven time-based treatments, with three treatments pre-set for 3 mm of rainfall and the remaining 4 rain sensor (RS) treatments had sensors pre-set to bypass irrigation for 6 mm of rainfall. Each rainfall threshold was tested using three different irrigation frequencies; 1, 2 and 7 days-per-week. Each frequency was scheduled to apply the same total depth per week, but the depth was divided over the number of irrigation days-per-week. There was a reduced irrigation schedule treatment (DWRS) which had a rain sensor set for 6 mm and a depth of water applied per irrigation event equal to 60% of the depth of the other 2-day-per-week treatments. Two ET controllers were tested, the Toro Intelli-Sense controller (TORO) and the Rain Bird ET Manager (ETM). The

Toro controller scheduled the frequency of irrigation and the depth applied per event, while the RainBird controller was connected to an irrigation timer and only bypassed irrigation events scheduled by the timer. All SMS and ET controllers were limited to two days of irrigation per week.

A time-based treatment with two days of irrigation per week and no rain sensor (WOS) was established as a "homeowner" comparison; water savings reported are based on this treatment. The irrigation schedule for all treatments, with the exception of DWRS and TORO, was based on the net historical irrigation requirement in the area and was adjusted monthly for plant needs (Dukes and Haman, 2002b). While maintaining acceptable turf quality, SMS-based treatments resulted in 0 to 74% reductions in water applied compared to WOS, RS-based treatments (not including DWRS) resulted in 7 to 30% reductions in water applied and ET-based irrigation resulted in 25 to 63% reductions in water use compared to WOS. The SMS treatments, at low threshold settings, resulted in high water savings but poor turf quality. The medium threshold setting SMS-based produced good turfgrass quality while reducing irrigation water use compared to WOS. Savings for the medium SMS-based systems ranged from 11 to 53%.

Water savings were achieved with all control technologies, even under the dry conditions of 2006 and 2007. Compared to water use trends in some areas of Florida, the irrigation schedule used to develop these water savings was conservative. Most homeowners do not change their schedule monthly based on historical irrigation requirements. For this reason the water savings achievable in a homeowner setting may be even higher than the water savings found in this research, especially during years with normal rainfall patterns.

CHAPTER 1
INTRODUCTION

Turfgrass is a popular ground cover due to its aesthetic and recreational benefits. In Florida, turfgrass covered around 1.8 million hectares in 1991-1992, with residential use accounting for 75% of the area. St. Augustinegrass (*Stenotaphrum secundatum*) accounted for 0.6 million hectares, or 36% of the total turfgrass area, including residential and non-residential uses. St. Augustinegrass was followed by Bahiagrass (*Paspalum notatum*) which accounted for 19%, mixed grasses with 14% and Bermudagrass (*Cynodon dactylon*) with 10% (Hodges et al., 1994). The turfgrass industry is important to the economy of Florida, providing employment opportunities and sales inputs. Turfgrass industry sales and services accounted for approximately $7 billion value for the period of 1991-1992 (Hodges et al., 1994). Outdoor water use can account for a large amount of the total public supply, anywhere from 22% to 67% depending on climate (Mayer et al., 1999). In Florida, irrigation is necessary due to the sporadic nature of rainfall events and the low water holding capacity of the sandy soils. Demand for water in the residential sector of Florida is increasing rapidly in correlation with increasing populations. Water conservation is a growing issue and one of the areas with the largest potential for reducing water consumption is residential outdoor water use. Irrigation control technologies are available that offer the possibility of providing more efficient application of irrigation water.

Water Demand

Water withdrawal in Florida, along with California and Texas, accounted for one-fourth of all water withdrawals in the nation in 2000 (Hutson et al., 2004). Groundwater use in Florida is the highest among the states east of the Mississippi river and ranked sixth for the entire U.S. (Marella, 1992). The population of Florida is increasing, leading to increases in water demand. The population of Florida increased 11% from 2000 to 2005. In 1990, 2000 and 2005 Florida

ranked as the fourth most populated state (USCB, 2007). The population is expected to increase by 79.5% from a population of 16 million people in 2000 to 28.7 million people in 2030. This would make Florida the third most populated state in the nation, with the third highest growth rate in the nation (USCB, 2007).

Between the years of 1960 and 1987, public supply water use in Florida increased 242% (Marella, 1992). The increase in water use during this time period is due to several factors, increased population, number of people visiting the state and per capita consumption. The population grew from 4.95 million to 12 million during those 27 years, which is a 60% increase in population. There was also an 18% increase in the percentage of homes that relied on public water supply. From 1977 to 1987 there was a 45% increase in visitors to Florida from 18.8 million to 34.1 million (Marella, 1992). These increases account for 122% of the public supply water use between the years of 1960 and 1987. The other 120% of the increase in public supply water use must be due to changes in water use per person.

The St. Johns River Water Management District (SJRWMD) has estimated that total water demand will increase in their district 20% from the year 2000 to the year 2025 and that 90% of that increase will be due to public supply demand (SJRWMD, 2005a).

As Florida's population increases so does the development of previously undeveloped lands into homes and landscaped areas. Currently almost 13% of new homes being constructed in the U.S. are in Florida (USCB, 2007). Most of these new homes being built have automated irrigation systems. Turfgrass has many beneficial attributes making it highly desirable for homeowners. During the 1960's Cultural Revolution in China all of the turfgrass and many trees were removed from the public areas in Beijing and the results were major increases in air pollution from dust, health problems, and temperatures (Carrow, 2006). Functional benefits of

turfgrass include; soil erosion control, dust stabilization, groundwater recharge, organic chemical decomposition, soil improvement, temperature moderation, noise abatement, and glare reduction. Due to its high shoot density and dense root system, turfgrass can provide one of the most cost efficient methods for controlling water and wind erosion of soil surfaces. Turfgrass reduces runoff by trapping water, allowing it to infiltrate to the soil. Temperature in urban areas where there is little turfgrass can be up to 5 to 7°C warmer than nearby rural areas that have a higher percentage turf for groundcover. In addition to the environmental benefits turfgrass also provides aesthetic benefits (Beard and Green, 1994).

The Floridan aquifer is recharged by rainfall; however, aquifer recharge areas are decreasing as the development in Florida increases. Developed areas have more impervious surfaces such as roofs, sidewalks and streets that impede rainwater from infiltrating and recharging the aquifer (SJRWMD, 2001). There is reduced recharge of the aquifers occurring at the same time as increased withdrawal. Over-pumping of water from Florida's aquifer system can result in saltwater intrusion, the formation of sinkholes, decreased public water supply and can lead to drastic levels of drawdown in wetlands and lakes (SJRWMD, 2005b). Water management districts have already defined some areas where saltwater intrusion has occurred and designated them "water resource caution areas". These caution areas are locations where the water source for public supply is not currently adequate or within 20 years will not be adequate for meeting public supply demands (SJRWMD, 2005b). The rate of groundwater withdrawal in certain areas of the St. Johns River Water Management District is approaching the maximum rate that can be withdrawn before causing adverse effects to the water resources in the area (SJRWMD, 2005a).

In recent years, Florida has faced one of the worst drought periods on record in the state. During drought conditions water demands generally tend to increase from the demands seen during average conditions (FDEP, 2002). This period of drought along with population growth and limited water supply, led to the development of a statewide Water Conservation Initiative (WCI) by the Florida Department of Environmental Protection (FDEP). The WCI examined water use in Florida and made a list of 51 areas where water conservation could be achieved (FDEP, 2002). Included in the list was improved irrigation efficiency. In some areas of Florida, residents are already realizing the need to improve irrigation practices due to lack of water supply compared to demand for water. The WCI examined the possibility of increasing water prices because it is currently thought that water in Florida is undervalued causing it to be misused and wasted (FDEP, 2002).

Water Use

Water is required for the basic growth and maintenance of turfgrass along with sustaining the quality and health of a landscape desired by homeowners. All plants, including turfgrass, require water and nutrients to support growth and maintenance (Aldous and G.J. Connellan, 1999). Most cellular functions in plants require water as the medium in which they take place (Condon et al., 2002). Temperature, wind, relative humidity and solar radiation affect the amount of water used by the plant.

Florida receives an average of 1,300 mm of rainfall per year, but the amount and distribution throughout the state and during the year varies (Marella, 1992). Due to the sporadic nature of rainfall events in Florida and the low water holding capacity of the sandy soils present throughout the state irrigation is necessary to maintain plant health. Annual rainfall can vary greatly depending on the season of the year, the year itself or the area of the state receiving the rainfall. The trend in Florida is for rainfall to decrease from March to June resulting in an

increase in public water supply demand (Marella, 1992). Sandy soils have a low water holding capacity compared to other soils with high clay or organic matter content. The fine sandy soils in many areas of Florida have a low water holding capacity, usually less than 10% of their volume (Morgan et al., 1999). Due to the low water holding capacity small changes in soil water content can have large effects on water available for plant needs (Morgan et al., 1999).

Turfgrass areas require water to maintain acceptable quality, but could be irrigated more efficiently to enhance both turf quality and increase water savings. In Florida, landscape irrigation accounts for approximately 30 to 70% of the publicly supplied drinking water (FDEP, 2002). In one study by Mayer et al. (1999) outdoor water use attributed for a large percentage of total residential water use, with most of the outdoor water used for irrigation purposes. The study showed outdoor water use in humid climates to be around 22 to 38% and in arid climates around 59 to 67%. In a study by Haley et al. (2007), it was seen that in Central Florida 62% of household water use was for irrigation of the home lawn, which was an average monthly water use of 146 mm/month compared to a national average of 77 mm/month (Mayer et al. 1999). Haley et al. (2007) also noted that scheduling irrigation monthly based on historical net irrigation requirements reduced depth of irrigation water applied by 30% over a 30 month study period.

Residential irrigation systems that are automated have been shown to use 47% more water on average than sprinkler systems that are not automated (Mayer et al., 1999). High water use with automated irrigation systems can be attributed to several factors, including the tendency to set irrigation systems and then leave them regardless of weather conditions. Another factor may be that the irrigation system is not uniform and/or the system irrigates all zones similarly regardless of soil and slope conditions.

Studies have shown that the public supports finding more effective methods to conserve water. A recent survey conducted by Tampa Bay Water showed that 87% of those polled agreed that more should be done in order to conserve water, but 93% of those same people believed they were already doing all they could to conserve water (FDEP, 2002).

Current Irrigation Practices

In Florida, there are five water management districts responsible for establishing regulations on water use, including irrigation, within their district. Landscape irrigation is regulated in most, if not all, areas in Florida. In the St. Johns River Water Management District (SJRWMD) irrigation is restricted to a maximum of two days/week between 4 pm and 10 am (SJRWMD, 2008). A study conducted in Colorado looked at the effectiveness of day of the week watering restrictions at reducing water use during drought conditions. The study found that mandatory watering restrictions along with educational material reduced water use by 13 to 53% with the highest water savings seen in the cities where watering was limited to either one or two days/week (Kenney et al., 2004). However, anecdotal evidence suggests that even though day of the week water restrictions reduce water use, over-irrigation can still occur due to the encouragement of watering during limited windows.

Over-watering or inefficient irrigation of turfgrass can lead to the presence of weeds and diseases and can reduce the effectiveness of fertilizers and other management practices (Harivandi et al., 1984). Proper irrigation practice is generally thought to be infrequent, deep applications of water in order to encourage deeper rooting of the grass. Rooting characteristics influence the amount of soil moisture available to a plant for growth. The amount of soil moisture available then affects the frequency of irrigation that is necessary for optimum plant response. Understanding the rooting characteristics of plants can assist in developing more effective and efficient irrigation practices (Peacock and Dudeck, 1985). One study by Doss et al.

(1960) found that increased soil moisture decreased the effective rooting depth of a warm-season forage species of grass. However, a study conducted by Peacock and Dudeck (1985) looked at the impact of frequency and depth of irrigation on turfgrass rooting depth of 'Floratam' St. Augustinegrass (*Stenotaphrum secundatum)* in sandy soil. The volume of irrigation applied was the same, but the frequency of water application was varied (2, 3, 4 or 6 days-per-week). The study found no treatment effect from the depth and frequency of irrigation on rooting depth for the two years the study was conducted.

When determining the water needs of a landscape the plant type and microclimate have to be considered (IA, 2005). These microclimates can be influenced by structures or trees, which have an affect on wind speed, wind direction and solar radiation, and also by management practices such as the mowing height and fertilization practices (Feldhake et al. 1983).

Studies conducted by Doss et al. (1964) found that ET was highest when irrigation water was more frequent (Richie et al., 2002). The reduction in frequency of irrigation and the affect on the turfgrass can differ for different grasses. Peacock and Dudeck (1984) saw that varying irrigation intervals (2, 3, 4 and 6 days/per week) did not affect turfgrass quality or density (all treatments received the same total weekly volume of water). According to a study done by Doss et al. (1960) the rooting depth of five warm-season forage species decreased as soil moisture increased and 76% of the roots on average were in the upper 30 cm (12 inches) of soil. Peacock and Dudeck (1985) studied the rooting response of 'Floratam' St. Augustinegrass (*Stenotaphrum secundatum*) to varied irrigation intervals. The testing was performed under field conditions with loamy siliceous hyperthermic Grosarenic Paleudult soil, similar to soil conditions present in our study. Both root mass and length were examined in their study. Total irrigation volume was equal for all treatments; only frequency was varied with irrigation intervals of 2, 3, 4 or 6 days-

per-week. During two growing seasons no treatment effect was seen. Total root mass density decreased in the first season while in the second root mass density increased. In the first season over 40% of the root mass occurred below 30 cm (12 inches), while in the second only 9% of the root mass was found below 30 cm (12 inches). Overall the study found that the frequency of irrigation events had no effect on rooting depth or density.

Peacock and Dudeck (1984) also examined the effect of frequency of irrigation on turf quality. The testing used irrigation intervals of every 2, 3, 4 or 6 days each week to cause varying plant stress. All treatments received the same volume of irrigation. Turfgrass quality and density were not affected by the different irrigation intervals applied. An irrigation interval of every 6 days resulted in a decrease in carbon exchange rates (CER) and evapotranspiration (ET). After irrigation, both of these values increased. The season average values for CER, ET, leaf water potential components, and transpiration were all lowest for the treatment receiving irrigation every 6 days.

Results from a study performed using bermudagrass (*Cynodon dactylon*) on golf courses in Turkey showed that ground cover, root weights and color were all better for irrigation based on replacing 75% of ET as opposed to replacing 100% of ET (Bastug and Buyuktas, 2003). Feldhake et al. (1984) found that an irrigation schedule leading to a 27% ET deficit in an arid environment on Kentucky bluegrass (*Poa pratensis*) caused a 10% reduction in turfgrass quality. With larger deficits, the researchers observed larger decreases in turfgrass quality. Temperature of the turfgrass canopy increased 1.7^{o}C with every 10% reduction in water applied.

Irrigation Control

Irrigation Timers

Many homeowners in Florida have inground automated irrigation systems that are controlled by timers. Irrigation timers control the timing and depth of irrigation events through

the use of a clock unit. The user inputs the length of irrigation events, the days of the week to irrigate, and the start time of the irrigation event into the irrigation timer. The two general types of irrigation control systems are open control loop systems and closed control loop systems. Open control loop systems apply a specified amount or duration of water as directed by the user. Closed control loop systems receive feedback from a sensor and then use that feedback to make irrigation decisions (Zazueta et al., 1993).

In a closed control loop system, the user first inputs a general strategy for control and then the system uses the feedback from one or more sensors to make more detailed decisions concerning the irrigation. An example would be an irrigation timer connected to a soil moisture sensor. The sensor is wired to the solenoid valve using the connection between the timer and the valve which provides power to the valve. The sensor then provides feedback concerning the amount of moisture present in the soil and acts as a switch, keeping the circuit open when sufficient soil moisture is present and closing the circuit, which allows power to the valve, when irrigation is needed (Zazueta et al., 1993).

Florida law requires the installation of an automatic rain shut-off device for any irrigation system that is installed after May 1, 1991 (Florida Statutes, Chapter 373.62, n.d.). In more localized areas laws have been enacted that call for retrofitting of older irrigation systems with rain shut-off devices (SJRWMD, 2005b).

Rain Sensors

Rain sensors are devices designed to collect rainfall and after a certain depth of rainfall is collected the devices will interrupt scheduled irrigation events. These devices open the circuit between the irrigation timer and the irrigation valves (bypassing timed irrigation events) after a specific amount of rainfall has occurred. Rain sensors are attached to existing irrigation timers. An initial program is programmed into the timer and this program includes timing and depth of

irrigation. The rain sensor then either bypasses or allows the programmed irrigation events based on local rainfall (Dukes and Haman, 2002a).

There are two methods employed by rain sensors for measuring rainfall. Some rain sensors use hygroscopic porous disks to collect precipitation (Dukes and Haman, 2002a). As the disks absorb water they expand in size proportionally to the amount of water absorbed. When the disks expand to a user adjustable set point a switch is opened and stays open until the disks dry and shrink. These sensors are popular due to the low level of maintenance necessary and the low cost associated with them.

Other rain sensors either weigh or measure the amount of rainwater collected. The sensors which collect rainfall and weigh the volume collected have disadvantages. These sensors need to be emptied after rainfall is collected and other items aside from rainfall can end up in the weighing instrument such as insects, animals and debris which can trigger the irrigation system to turn off (Dukes and Haman, 2002a).

Advantages of rain sensors include water conservation by preventing unnecessary irrigation events, decreased monthly water bills, increased life expectancy of the irrigation system from operating less often, reductions in disease from not over watering, and reduced runoff leading to less pollution of surface and groundwater (Dukes and Haman, 2002a). These sensors need to be installed in a location where they can receive rainfall without obstruction and away from sprinklers to prevent irrigation water from wetting the sensor. Ideally these sensors are located along a roofline or fence line with no trees or overhangs blocking rainfall from the sensor (Dukes and Haman, 2002a).

Testing on rain sensors has shown that under rainy conditions they can produce up to 34% water savings without adversely affecting turfgrass quality (Cardenas-Lailhacar et al., 2008). In

a study conducted in Pinellas County, FL from June 2006 to March 2007, homes with rain sensors resulted in 19% less irrigation water than homes without a rain sensor (Haley and Dukes, 2007).

Soil Moisture Sensors

There are both direct and indirect methods for measuring soil moisture. Indirect methods include soil moisture sensing or using ET controllers. Direct methods, such as soil sampling, are not useful to irrigation scheduling because they are disruptive to the soil and they don't provide instant information (Muñoz-Carpena and Dukes, 2005). The use of soil moisture sensors in irrigation scheduling can make water application more efficient in both home lawns and agricultural crops. Feedback from a soil moisture sensor is used to bypass time-based irrigation events if the moisture content at the beginning of the irrigation event is higher than a pre-set value for moisture content. A single sensor can be used to set the irrigation for many zones or more than one sensor can be used to irrigate multiple zones. In the case of one sensor for several zones, the zone that is typically driest, or most in need of irrigation, should be selected for placement of the sensor in order to ensure the whole turf area is provided with adequate coverage of irrigation water.

Moisture sensors are becoming increasingly popular because they require little maintenance and provide measurements rapidly. Sensors measure water content in the soil using one of two methods, tensiometric or volumetric (Muñoz-Carpena and Dukes, 2005). Tensiometric sensors estimate soil water by measuring the adsorption and capillary effects in the soil. Typically volumetric sensors are designed to estimate soil volumetric water content (VWC) based on the dielectric constant of the soil. Water in the soil profile is the main factor that affects the value of the dielectric constant. Topp et al. in 1980 demonstrated the strength of the relationship between the dielectric constant and the VWC. In their study, factors such as soil

density, texture, and salt content had little effect on the dielectric constant. The dielectric constant of water is much larger than other soil constituents, such as air (Muñoz-Carpena et al., 2005). Dielectric methods are based on empirical relationships between the volumetric water content and sensor output signal factors such as time, frequency, impedance, and wave phase. TDR (time domain reflectometry), TDT (time domain transmission), ADR (amplitude domain reflectometry), and FDR (frequency domain reflectometry) are all examples of sensors that work using dielectric principles (Muñoz-Carpena and Dukes, 2005).

Time domain reflectometry (TDR) is one technique that uses the dielectric constant of the soil to find the volumetric water content. In this type of device an electromagnetic pulse is transmitted along a pair of parallel transmission lines into the soil. The propagation velocity of electromagnetic pulse along a transmission line through the soil is a measure of the apparent dielectric constant of the soil (Topp et al., 1980).

The dielectric constant determines how quickly an electromagnetic pulse can pass through the soil and along the length of the transmission line (Friel and Or, 1999). The dielectric constant is dependent on the type, composition and the moisture content of the soil. Soil is a composite material consisting of water, air and minerals and each of these components affect the dielectric constant of the soil. The dielectric constant increases as the water content in the soil increases, this is due to the fact that the dielectric constant of water is much larger (K_a = 81) then the other soil components (K_a = 2-5 for minerals and 1 for air) and so the presence of water in the soil profile has a much stronger impact on the dielectric constant compared to other properties of the soil (Muñoz-Carpena et al., 2005). This means that measuring the dielectric constant provides a measure of the soil moisture content.

Cardenas-Lailhacar et al. (2008) found that water savings for three commercially available soil moisture sensors ranged from 69% to 92% without adversely affecting turf quality in bermudagrass (*Cynodon dactylon*). One sensor tested in the study did not perform as well as the other three sensors tested saving between 27 and 53%. This study was performed in Gainesville, FL in a field setting during two five month periods, one in 2004 and the other in 2005, with wet weather conditions.

Allen (1997) performed a one-year study in Utah looking at soil moisture based control systems in a residential setting. A total of 27 homes had sensors installed and water applied was compared with 39 homes without sensors which were the control group. The homes with sensors installed used 10% less water than the homes in the control group while maintaining adequate turf quality. The homes with sensor also had a 10% reduction in water use compared to their water use the two years prior to the start of the study (1994 and 1995). Researchers in the project used a "hands off" approach to observe results when the homeowners were allowed to operate the system on their own. A study conducted in Pinellas County, FL from June 2006 to March 2007 found that homes with soil moisture sensors installed applied 51% less water compared to homes that used only a time-clock to control irrigation (Haley and Dukes, 2007).

Qualls et al. (2001) noted, during a 1997 study involving homeowners in Colorado, that homeowners and landscape contractors were reluctant to use soil moisture sensors due to concerns with the possible life expectancy and difficulty of use of the devices. The study was performed using granular matrix soil moisture sensors which were installed for three years in 23 sites. Of the 23 sensors installed only two failed during the three year project and researchers reported time required for the initial installations was minimal.

Evapotranspiration Controllers

Evapotranspiration (ET) based irrigation controllers are an example of indirect methods for measuring soil moisture. These systems ideally apply irrigation according to ET needs of the plant. ET is the water lost from the soil surface by the process of evaporation and lost from the plant by the process of transpiration. Since the two processes occur simultaneously and are very difficult to separate, they are combined into one process (Allen et al., 1998). ET-based irrigation systems may be scheduled based on total ET or based on a percentage of ET. These systems automatically bypass irrigation if ET is not above a pre-set ET value.

There are several types of ET-based irrigation controllers and they differ in how they obtain weather data and how they use that data to impact irrigation schedules. Some systems are based on historical data developed for the site where irrigation is being applied (Center for Irrigation Technology, 2006). Other systems use on-site sensors to measure weather information used to calculate ET, while other systems (signal-based) receive reference ET information from nearby weather stations (Center for Irrigation Technology, 2006). ET controllers can be purchased as an addition to an existing irrigation timer or as a single component to replace the standard timer. Values of ET found by an off-site weather station may not be closely representative of the area where the irrigation is being applied due to localized environmental changes such as shade cover. For ET to be used efficiently, adjustments should be made to the reference ET (ET_o) based on site specific conditions such as soil type, plant type, root depth, and sun exposure. These adjustments to ET_o are made using a crop coefficient which is a percentage of the potential evapotranspiration. Adjustments made for plant type are necessary because rates of transpiration for different plants vary greatly.

ET controllers have already been tested in the western U.S. but have undergone little research in humid climates like that of Florida. A study conducted in Florida by Davis et al.

(2007) during the summer (July 1 through August 31) and fall (September 1 through November 30) of 2006 found that three brands of ET controllers compared to a theoretical two-day-per-week irrigation schedule with no irrigation control devices were capable of reducing water applied. These reductions were between 20 and 60% with the exception of one controller which applied more water than the theoretical depth during the fall of 2006. These water savings were produced while maintaining acceptable turf quality.

A study conducted in Irvine, California in 40 single-family homes demonstrated the effectiveness of scheduling irrigation based on localized ET conditions for reducing residential water use. The study was conducted by the Irvine Ranch Water District (IRWD). The irrigation schedules in the homes were controlled through a remote signal and adjustments were made weekly based on the ET for the previous week. The value for ET was used to develop a "percentage change" factor which was sent to the individual homes controllers and applied to the existing irrigation schedule that was input during installation. The baseline irrigation schedule was site specific based on plant type, slope, etc. The controller was able to reduce outdoor water applied by 16%. The results show that the homes selected for the "ET" controller typically applied less water than homes in the control test group before the study began so the 16% water savings could be higher when installed in other homes. All participants in the study believed the automatic "ET" controller was convenient and 97% reported that they observed either no change or an improvement in the quality of their landscape (IRWD, 2001).

Based on the previous study further research was conducted by the Municipal Water District of Orange County (MWDOC) and IRWD to investigate the usefulness of this technology at reducing runoff from residential lawns. The number of homes in the study was expanded. The study included five neighborhoods, each having their own single point of

discharge for the runoff from the entire neighborhood. The ET based systems produced 10% water reductions in total household water use. During the dry season runoff was reduced by approximately 50% compared to the runoff prior to installing the ET based system (MWDOC and IRWD, 2004).

A study by the Los Angeles Department of Water and Power was conducted to look at the usefulness of ET controllers in settings with medium to large landscapes such as homeowners associations, schools and parks. Two commercially available ET controllers, both using signal based technology, were tested. The two controllers managed to reduce water applied by 17% and 28%. The researchers estimated that in dedicated turfgrass areas the ET controllers reduced water consumption by 432 mm/year (Bamezai, 2004).

Florida has growing water resource issues due to rapidly increasing populations and development. Various technologies are commercially available to help homeowners make their irrigation practices more efficient. These devices can possibly decrease water demand, save money for homeowners and result in healthier landscapes.

CHAPTER 2
RAIN SENSOR, EVAPOTRANSPIRATION CONTROLLER AND SOIL MOISTURE SENSOR BASED IRRIGATION CONTROL ON ST. AUGUSTINEGRASS

Introduction

Water conservation is a growing issue in the state of Florida due to increased water demands and limited resources. Water withdrawal in Florida, along with California and Texas, accounted for one-fourth of all water withdrawals in the nation for 2000 (Hutson et al., 2004). The population of Florida increased 11% from 2000 to 2005. In 1990, 2000 and 2005 Florida ranked as the fourth highest populated state (United States Census Bureau [USCB], 2007). The population is expected to increase by 79.5% from a population of 16 million people in 2000 to 28.7 million people in 2030. As Florida's population increases so does the development of previously undeveloped lands into homes and landscaped areas. Recently, nearly 13% of new homes being constructed in the U.S. are in Florida (USCB, 2007). Many if not most of these new homes being built have automated irrigation systems. Studies show that the public supports finding more effective methods to conserve water. A recent survey conducted by Tampa Bay Water showed that 87% of those polled agreed that more should be done in order to conserve water, but 93% of the people polled believed they were already doing all they could to conserve water (Florida Department of Environmental Protection [FDEP], 2002). Various irrigation control technologies are commercially available to optimize landscape irrigation. These technologies are soil moisture sensor controllers, ET controllers and rain sensors.

Soil Moisture Sensor Controllers

Sensors measure water content in the soil using one of two methods, tensiometric or volumetric. Typically volumetric sensors are designed to estimate soil volumetric water content (VWC) based on the dielectric constant of the soil. Topp et al. (1980) demonstrated the strength of the relationship between the dielectric constant and the VWC. In this study, factors such as

soil density, texture, and salt content had little effect on the dielectric constant. The dielectric constant of water is much larger than other soil constituents, such as air (Muñoz-Carpena et al., 2005). This means that the measurement of the dielectric constant gives a predictable estimation of water content. In a soil moisture based irrigation controller, data from the sensor is used to allow or bypass timed irrigation events. The sensor has an adjustable threshold setting and if the soil moisture content exceeds that setting the event is bypassed (Dukes, 2005). A single sensor can be used to control the irrigation for many zones or more than one sensor can be used to irrigate multiple zones. In the case of one sensor for several zones, the zone that is normally the driest, or most in need of irrigation, is selected for placement of the sensor in order to ensure adequate irrigation in all zones.

Cardenas-Lailhacar et al. (2008) found that water savings for three commercially available soil moisture sensor irrigation controllers ranged from 69% to 92% without adversely affecting turf quality in bermudagrass (*Cynodon dactylon*). One sensor tested in the study did not perform as well as the other three sensors tested saving between 27 and 53%. This study was performed in Gainesville, FL in a field setting during two five month periods, one in 2004 and the other in 2005, with normal to rainy weather conditions.

Evapotranspiration Controllers

Evapotranspiration (ET)-based irrigation controllers ideally allow irrigation according to ET needs of the plant. ET is the water lost from the soil and plant surfaces by evaporation and from the plant by transpiration. Since the two processes occur simultaneously and are very difficult to separate, they are combined into one process (Allen et al., 1998). There are various ways in which ET-based irrigation controllers are designed to work. Some systems are based on historical data developed for the site where irrigation is being applied. Other systems use on-site sensors to measure weather information then used to calculate ET while other systems receive

reference ET information from nearby weather stations and adjust irrigation accordingly (Center for Irrigation Technology, 2006). ET controllers can generally be programmed for various site specific conditions such as soil type, plant type, root depth, sun exposure, etc. ET controllers can be purchased as an addition to an existing irrigation timer or as a single component to replace the standard timer.

A study conducted in Irvine, California in 40 single-family homes demonstrated the effectiveness of scheduling irrigation based on localized ET conditions for reducing residential water use. The study was conducted by the Irvine Ranch Water District (IRWD). The results show that the homes selected for the "ET" controller typically applied less water than homes in the control test group before the study began so the 16% water savings could be higher when installed in other homes. All participants in the study believed the automatic "ET" controller was convenient and 97% reported that they observed either no change or an improvement in the quality of their landscape (IRWD, 2001).

A study conducted in Florida by Davis et al. (2007) during the summer (July 1 through August 31) and fall (September 1 through November 30) of 2006 found that three brands of ET controllers compared to a two-day-per-week irrigation schedule with no irrigation control devices were capable of reducing water applied by 20 to 60% with the exception of one controller which applied more water than the two-day-per-week comparison treatment during the fall of 2006. The water savings were produced while maintaining acceptable turf quality.

Rain Sensors

Rain sensors are devices designed to interrupt scheduled irrigation events after a certain depth of rainfall. An irrigation schedule is programmed into the timer and this program includes frequency and depth of irrigation events. The rain sensor then either bypasses or allows the programmed irrigation events based on local rainfall (Dukes and Haman, 2002a).

Some rain sensors use hygroscopic porous disks to trigger irrigation bypass (Dukes and Haman, 2002a). As the disks absorb water they expand in size proportionally to the amount of water absorbed. When the disks expand to a user adjustable set point a switch is opened and stays open until the disks dry and shrink.

Testing on rain sensors has shown that, under normal rainfall conditions in Central Florida, they can produce up to 34% water savings without adversely affecting turfgrass quality (Cardenas-Lailhacar et al., 2008). In a study conducted in Pinellas County, FL from June 2006 to March 2007, homes with rain sensors resulted in 19% less irrigation water than homes without a rain sensor (Haley and Dukes, 2007).

The objectives of this experiment were to evaluate the differences in irrigation water application and the resulting quality of St. Augustine (*Stenotaphrum secundatum*) turfgrass comparing irrigation control using: i.) two types of SMS-based controllers set at three soil moisture content thresholds; ii.) two types of ET controllers; iii.) one type of rain sensor set for two thresholds of precipitation and three frequencies of irrigation events; and iv.) a time-based irrigation system without a rain sensor.

Materials and Methods

Site Description

This study was performed at the Plant Science Research and Education Unit in Citra, Florida. There were four treatment periods during 22 April 2006 to 30 June 2006 (S06), 23 September 2006 to 15 December 2006 (F06) and 1 May 2007 to 31 August 2007 (S07) and 1 September 2007 to 30 November 2007 (F07). The experimental area is shown in Figure 2-1. The three mapped soil types present in the research area are Tavares sand, Candler sand, and Arredondo fine sand (Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults) (USDA, 2006).

Soil physical properties

Two evaluations were conducted to examine soil properties in the field. One of these tests was conducted with a TDR300 Soil Moisture Probe (Spectrum Technologies, Inc., Plainfield, IL.). Initial readings were taken on dry soil. Wet condition readings were taken 30 minutes after 25.4 mm of water was applied to the plots. Each plot had 25 measurements taken for both the dry and wet conditions. The locations of where readings were taken in each plot are shown in the Figure 2-2. The data compiled from TDR tests at the field site were plotted in order to view soil moisture differences (Figure 2-3). Due to the variation of inherent soil moisture content in the field the treatments were assembled in a randomized block design. The blocks were established from the east end of the field to the west end of the field to account for inherent soil moisture variation across the field.

Soil cores were collected on 11 August 2006 using a device with a diameter of 54 mm and a length of 60 mm for soil physical properties analysis. Samples were collected in a total of 16 locations with four locations in each block (Figure 2-4). At each location two samples were taken, one at a depth of 7.5 cm and the other at a depth of 15 cm. Soil samples were used to develop soil water retention curves according to methods described by Wraith and Or (1998) and to perform a particle size analysis according to methods described by Gee and Bauder (1986). Soil testing showed that the soil present at the field site consisted of 1.7% clay, 1.1% silt and 97.3% sand.

The curves can be used to determine soil properties such as field capacity and permanent wilting. Field capacity of the soil is the moisture content at a pressure of 100 cm H_2O (10 kPa) and permanent wilting point is moisture content at a pressure of 15,000 cm H_2O (1,500 kPa). The water retention curves for the soils in each block of the testing area are shown in Figure 2-5. Figure 2-6 shows the range of field capacities and permanent wilting points within the field and

in each block. Both field capacity and permanent wilting point values increase moving across the field from west to east (moving from block 1 to block 4) as seen in Figure 2-6.

Available water (AW) is the difference between FC and PWP, with FC as the upper limit and PWP as the lower limit. The depth of AW is calculated based on the root depth as follows (Cassel and Nielsen, 1986):

$$AW = \frac{(FC - PWP) \times RZ}{100} \tag{2-1}$$

where

FC = field capacity (% or cm^3 of water per cm^3 of soil)
PWP = permanent wilting point (% or cm^3 of water per cm^3 of soil)
RZ = root zone depth (mm)

For this testing, RZ was measured in millimeters and FC and PWP were each measured as a percentage of water content in the soil. Values of AW also increase across the field from block 1 to block 3, with block 3 having the largest depth of AW (Figure 2-7).

The experimental area consists of 72 plots of 'Floratam' St. Augustinegrass (*Stenotaphrum secundatum*). In August 2005, sod was laid in the center 1.8 m X 1.8 m of each 4.27 m X 4.27 m plot. The plots are irrigated using four Toro 570™ Series (The Toro Company, Bloomington, MN.) quarter circle pop-up spray heads with a measured application rate of 51 mm/hr. Rain Bird® ESP Modular Irrigation Controllers (Rain Bird International, Inc., Glendora, CA) were used for scheduling all of the treatments except where a time-based controller was not necessary. A border, 0.61 m wide, was established between all plots and was used for irrigation pipe and control wire burial. This border was kept clear of vegetation by mechanical and chemical means. Plots were mowed once weekly at a height of 10 cm. Chemicals were applied as necessary identically to all plots. Applications included fertilizer for healthy growth and pesticides for chinch bug removal. To promote establishment and minimize contamination potential, fertilizer

applications were based on Institute of Food and Agricultural Sciences (IFAS) recommendations (Trenholm, 2002). Soluble nitrogen (N) was applied approximately every 60 days beginning in May 2006 with a total N rate of 196 kg ha^{-1} yr^{-1}. Phosphorus and potassium was applied with N fertilizations at 22 and 45 kg ha^{-1} yr^{-1}, respectively.

Irrigation distribution uniformity testing

Prior to establishing treatments, uniformity tests were performed on the individual plots in the experimental area. Irrigation uniformity tests, using catch cans, measure the variability in the depth of water applied over the area of water application by an irrigation system. Merriam and Keller (1978) described an equation and parameters for calculating low quarter distribution uniformity DU_{lq}. Low quarter distribution uniformity emphasizes the areas which receive less irrigation compared to the total irrigated area. The DU_{lq} was calculated using the following formula:

$$DU_{lq} = \frac{\overline{D}_{lq}}{\overline{D}_{tot}} \tag{2-2}$$

where, $\overline{D}_{tot}$ is the average of the total depth of water applied and $\overline{D}_{lq}$ is the average depth of the lowest 25% of depths collected.

Christiansen's coefficient of uniformity (CU) is another measure of uniformity that was assessed for the experimental research plots. The equation for CU handles over-irrigation and under-irrigation equally compared to the mean. It is calculated as follows (Christiansen 1942):

$$CU = 1 - \frac{\sum_{i=1}^{n} \left| V_i - \overline{V} \right|}{\sum_{i=1}^{n} V_i} \tag{2-3}$$

where, *Vi* is the volume of water collected in one catch can and $\overline{V}$ is the mean volume of all catch cans. Another method to asses the uniformity is to measure the increase in water content

below the soil surface after water is applied. The same equations can be utilized for this method as a catch can test. Dukes et al. (2006) found that the irrigation uniformity calculated using the DU_{lq} when measured using soil moisture ranged from 0.7 to 0.8 when catch can uniformity was above 0.5.

A total of 25 catch can were placed in each plot in a grid pattern with 0.76 m X 0.76 m spacing. The outer catch cans were placed 0.3 m inside the plot boundaries. They were located in plots using the same design used for TDR testing (Figure 2-2 and Figure 2-8). The catch cans had a 15.9 cm diameter opening and were 20.3 cm deep. Volumetric soil moisture content readings were taken next to each bucket before and after irrigation using a Field Scout TDR300 Soil Moisture Probe (Spectrum Technologies, Inc., Plainfield, IL.) with 20 cm rods. Irrigation was then run for 30 min to apply an average depth of 25 mm. Wind speed during testing was measured using a handheld anemometer and then verified using data from a local weather station. Testing was aborted at wind speeds exceeding 5 m/s according to ASAE standards (ASAE, 2000).

Data Collection

Water use was monitored using pulse-type displacement flow meters, specifically AMCO PSMT 20 mm x 190 mm flow meters (Elster AMCO Water, Inc., Ocala, FL). These flow meters were wired to multiplexers connected to a CR-10X datalogger (Campbell Scientific, Logan, UT.) to monitor daily water use. The meters were also read manually at least every two weeks.

Volumetric soil moisture content was recorded hourly using time domain reflectometry (TDR) sensors (CS616 Water Content Reflectometer, Campbell Scientific, Logan, UT). Measurements made with the TDR probes are accurate up to +/-2.5% VWC (Campbell Scientific, Inc., 2006). These sensors were connected to a CR-10X datalogger. The TDR

sensors were buried in the center of every plot with the top of the sensor at a depth of 8 cm and the bottom of the sensor at a depth of 18 cm (Figure 2-9).

Weather data was collected using an automated weather station (Campbell Scientific, Logan, UT) within 900 m of the experimental site. Rainfall data at the weather station was collected with both a tipping bucket rain gauge and with a manual rain gauge located at the research plots. Manual rain gauge data was used to verify depths measured by the tipping bucket rain gauge. Reference ET (ET_o) is the rate at which ET occurs from a uniform surface of actively growing vegetation with a specified growing height and that is well-watered. ET_o was calculated using solar radiation, relative humidity, air temperature, and wind speed collected by the weather station on-site. ET_o was calculated using the ASCE standardized method (Allen et al. 2005) as follows:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T + 273}(e_{e-}e_a)u_2}{\Delta + \gamma(1 + C_d u_2)} \tag{2-4}$$

$$\Delta = \frac{4098\left[0.6108\exp\left(\frac{17.27T}{T + 237.3}\right)\right]}{(T + 237.3)^2} \tag{2-5}$$

$$R_n = R_{ns} - R_{nl} \tag{2-6}$$

$$R_{nl} = \sigma\left[\frac{T_{\max,K}^4 + T_{\min,K}^4}{2}\right]\left(0.34 - 0.14\sqrt{e_a}\right)\left(1.35\frac{R_s}{R_{so}} - 0.35\right) \tag{2-7}$$

$$R_{ns} = (1 - \alpha)R_s \tag{2-8}$$

$$R_{so} = \left(0.75 + z\left(2 \times 10^{-5}\right)\right)R_a \tag{2-9}$$

$$R_a = \frac{24(60)}{\pi}G_{sc}d_r\left[\omega_s \sin(\varphi)\sin(\delta) + \sin(\omega_s)\cos(\varphi)\cos(\delta)\right] \tag{2-10}$$

$$d_r = 1 + 0.033\cos\left(\frac{2\pi}{365}J\right) \quad (2\text{-}11)$$

$$\delta = 0.409\sin\left(\frac{2\pi}{365}J - 1.39\right) \quad (2\text{-}12)$$

$$\omega_s = ar\cos\left[-\tan(\varphi)\tan(\delta)\right] \quad (2\text{-}13)$$

$$e_s = \frac{e^o(T_{max}) + e^o(T_{min})}{2} \quad (2\text{-}14)$$

$$e_a = \frac{e^o(T_{min})\frac{RH_{max}}{100} + e^o(T_{max})\frac{RH_{min}}{100}}{2} \quad (2\text{-}15)$$

$$e^o(T) = 0.6108\exp\left(\frac{17.27 \times T}{T + 273.3}\right) \quad (2\text{-}16)$$

where

ET_o = standardized reference crop evapotranspiration, (mm day^{-1})
R_n = net radiation at the crop surface, (MJ m^{-2} day^{-1})
G = soil heat flux density at soil surface, (MJ m^{-2} day^{-1})
T = mean daily temperature at 1.5 m to 2.5 m height, (^oC)
u_2 = mean daily wind speed at 2 m height, (m s^{-1})
e_s = mean saturation vapor pressure, (kPa)
e_a = mean actual vapor pressure, (kPa)
Δ = slope of the vapor pressure – temperature curve, (kPa $^oC^{-1}$)
γ = psychometric constant, (kPa $^oC^{-1}$)
C_n = numerator constant based on reference type and time step, (900)
C_d = denominator constant based on reference type and time step, (0.34)
R_{ns} = net solar radiation, (MJ m^{-2} day^{-1})
R_{nl} = net longwave radiation, (MJ m^{-2} day^{-1})
σ = Stefan-Boltzman constant, (4.903 x 10^{-9} MJ K^{-4} m^{-2} day^{-1})
$T_{max,K}$ = maximum absolute temperature, (K)
$T_{min,K}$ = minimum absolute temperature, (K)
R_s = solar radiation, (MJ m^{-2} day^{-1})
R_{so} = clear sky radiation, (MJ m^{-2} day^{-1})
α = canopy reflection coefficient, (0.23 for turfgrass)
z = station elevation above sea level, (m)
R_a = extraterrestrial radiation, (MJ m^{-2} day^{-1})
G_{sc} = solar constant, (0.0820 MJ m^{-2} min^{-1})
d_r = inverse relative distance Earth-Sun,
δ = solar declination, (rad)

φ = latitude, (rad)
ω_1 = solar time angle at beginning of period, (rad)
ω_2 = solar time angle at end of period, (rad)
J = Julian day
ω_s = sunset hour angle, (rad)
$e^o(T_{min})$ = saturation vapor pressure at daily minimum temperature, (kPa)
$e^o(T_{max})$ = saturation vapor pressure at daily maximum temperature, (kPa)
RH_{min} = minimum relative humidity, (%)
RH_{max} = maximum relative humidity, (%)

Adjustments to ET_o for particular plant types are made using crop coefficients (K_c). A crop coefficient is a percentage of the potential evapotranspiration the product is a value called the crop evapotranspiration (ET_c). Adjustments made for plant type are necessary because rates of transpiration vary greatly from plant to plant. The equation for crop evapotranspiration according to Allen et al. (2005) is:

$$ET_c = K_c \times ET_o \tag{2-17}$$

Monthly values of K_c used in this study are listed in table 2-1 and were calculated using bahiagrass (*Paspalum notatum*) turfgrass at a research site also within 900 m of the research area (Jia et al., 2007).

Turfgrass quality was rated at least once every two weeks during S06 and F06 and at least once a month during S07 and F07. Quality evaluations were made using the National Turfgrass Evaluation Program (NTEP) procedures (Shearman and Morris, 1998). The ratings were on a 1 to 9 scale, with 1 representing dead or dormant grass and 9 representing grass with good color and density, and without weeds (Morris and Shearman, 2006). A quality rating of 5 was considered minimally acceptable for a homeowner lawn. Figure 2-10 shows an example of the appearance of the turfgrass for quality ratings of 2 (almost dead), 5 (minimally acceptable) and 8 (nearly perfect quality).

Statistical analyses for irrigation and turf quality data using Statistical Analysis System software (SAS Institute, Inc., Cary, NC) using the General Linear Model (proc GLM) and the mixed procedure (proc MIXED). Means separation was conducted with Duncans Multiple Range Test.

Experimental Design

There were 18 treatments with four replications arranged in a completely randomized block design (blocks east to west) due to inherent soil moisture differences in the research area. Treatment descriptions and codes are summarized in Table 2-2.

Soil moisture sensors were connected to an irrigation time clock to function in bypass mode operation so that a scheduled irrigation event would be bypassed if soil moisture exceeded the soil moisture sensor threshold (Dukes, 2005). The monthly irrigation schedule was based on recommendations for two-day-per-week operation by Dukes and Haman (2002b) and is presented in Table 2-3. The two-day-per-week operation was used to emulate typical day of the week water restrictions in Florida.

Two commercially available soil moisture sensors were tested: Acclima Digital TDT® RS500 (Acclima Inc., Meridian, ID.) and the LawnLogic® LL1004 (Alpine Automation, Inc., Aurora, CO.) (Figure 2-11 and 2-12). Both of the soil moisture sensor (SMS) based system was tested at three different volumetric moisture content thresholds. The three VWC threshold settings were considered low (dry), medium, and high (wet) VWC conditions. The settings for the Acclima Digital TDT sensors were 7%, 10%, and 13%. The LawnLogic, which uses site specific calibration methods, was set for relative low, medium and high levels of moisture content in the soil. The manufacturer suggests calibration 24 hours after a significant rainfall or irrigation event that fills the soil profile to field capacity. Once the calibration is performed, the controller has relative set points from 1 (dry) to 9 (wet). The settings used as experimental

treatments were 2, 5 and 8 for S06 and 4, 5 and 6 for F06 and for all of 2007. Six of the SMS treatments utilized one sensor buried in the driest block (block 2) to control the irrigation for all plots in the treatment. All of these sensors were placed in the same block, which was selected during intensive soil moisture characterization of the site during the uniformity testing. One treatment, AC IR (threshold of 7%), used four sensors, one sensor buried in a plot in each block controlling the irrigation for that individual plot. Acclima sensors were installed horizontally at a depth of 8 cm and the LawnLogic sensors were buried with rods placed vertically with the top of the sensor buried at a depth of 6 cm. All control sensors (except three of the sensors from AC IR) were buried in block 2.

After the S06 experiment, ET controllers were installed at the test site (Figure 2-12). Two commercially available controllers were selected for the study: the Toro Intelli-sense (The Toro Company, Bloomington, MN) and the RainBird ET Manager (RainBird Corporation, Glendora, CA). Both ET controllers utilize paging technology to gather reference ET information. The systems perform a daily water balance based on daily ET, depth or presence of rainfall, and other inputs and then use the calculated soil moisture level for making irrigation decisions. The Toro Intelli-sense controller (TORO) calculates irrigation runtime and has the ability to determine irrigation day if not restricted based on application rate and other inputs from the homeowner. The ET Manager (ETM) is connected to an irrigation time clock in bypass mode. The ET manager does not calculate irrigation run time; it either bypasses or allows irrigation as needed based on the soil moisture balance calculated using daily ET, rainfall, application depth and other inputs. The ETM treatment was set for irrigation depths based on the same methods used for the soil moisture sensor and rain sensor treatments according to Table 2-3. A summary of inputs for

both ET controllers is provided in Table 2-4. Both the ET-based treatments were restricted to irrigating twice per week.

Rain sensor (RS) treatments were also connected to a time clock in bypass mode similar to the description presented for soil moisture sensors. A Mini-Clik® (Hunter Industries Inc., San Marcos, CA.) rain sensor was used to establish seven treatments. The rain sensors were set for two depths of rainfall, 6 mm and 3 mm and three different frequencies of irrigation events, 1, 2 and 7 days of irrigation per week.

There was one control treatment in the experimental design and two time-based comparisons (Table 2-2). The control was a non-irrigated (NON) treatment. The comparison treatments consisted of time-based without a rain sensor (WOS) and time based with a rain sensor at 6 mm and a deficit replacement schedule that was scheduled to apply 60% of the possible depth scheduled for WOS and the other RS treatments (DWRS).

The same total application depth per week was divided over the possible number of days of irrigation per week. Every treatment except for the TORO, DWRS and the NON treatments had the same possible total depth of irrigation application. Differences in irrigation application were due to bypassed irrigation events. Reductions in water applied by TORO and DWRS could be from bypassed irrigation events or from shorter irrigation run times.

Results and Discussion

Distribution Uniformity Testing

Results from uniformity testing varied across the field and are summarized in Table 2-5 and Figure 2-13. The DU_{lq} values ranged from 0.29 to 0.72 but the average DU_{lq} for the entire field was 0.55, which is considered “fair” by the Irrigation Association (2005). When using soil moisture uniformity as described by Dukes et al. (2006) the values of DU_{lq} at the research site were between 0.52 and 0.91. The CU of the field ranged from 0.58 to 0.84 with an average value

of 0.75. A uniformity study performed on homes irrigated with spray heads in Central Florida showed that the systems had an average DU_{lq} of 0.41 with a range from 0.12 to 0.67 and an average CU of 0.59 with a range from 0.50 to 0.72 (Baum et al., 2005). Thus, the uniformity of irrigation in this experiment was better than typical homes in Central Florida. In addition, Dukes et al. (2006) showed that catch can DU_{lq} values above 0.50 resulted in soil moisture DU_{lq} of 0.70 to 0.80.

The low values for calculation of DU_{lq} came from catch cans placed just inside the edge of the plot. The average DU_{lq} of the center catch cans was 0.86 with a range from 0.74 to 0.99. The CU of the center catch cans was 0.90 with a range of 0.84 to 0.86. The area evaluated for turf quality is the center of the plots, which is the area with the best and most uniform coverage from the irrigation system.

Rainfall

Three of the four treatment periods were relatively dry compared to historical rainfall for the research area (Figure 2-14). The total rainfall was 138 mm from 16 rainfall events during S06. Historical average rainfall data for the same time period as the spring treatments is 298 mm (NOAA, 2006). During the F06 experiment, 92 mm from 15 events occurred. For the same duration of time historical average rainfall is 188 mm (NOAA, 2006). Both treatment periods had total rainfall depths less than half that of the historical depths for the area. Figure 2-15 shows the cumulative rainfall depth for the spring and fall along with cumulative calculated ET_c. Infrequent rainfall events and below average rainfall amounts led to dry conditions for the research site. In the beginning of the S06 the volumetric moisture content of the soil in non-irrigated plots was as low as 3% to 4% (Figure 2-16), which is lower than or equal to the permanent wilting points at the field site (Figure 2-6).

Rainfall during S07 experiment was 287 mm compared to 636 mm, which is the historical rainfall for the same time period. F07 received 347 mm compared to historical averages of 258 mm. The number of days per month where there was a rainfall event with a depth greater than 2.5 mm was fewer than the monthly historical averages for every time period except in F07 (Figure 2-14). During October 2007 there were 60 percent more rainy days than the historical average. The total depth received in October was 178 mm compared to historical values of 61 mm. The F07 time period was also the only one where cumulative rainfall was greater than calculated ET_c, with almost all of the rain occurring in September and October and only one rainfall event in November (Figure 2-15). Overall the treatment periods S06, F06 and S07 can be considered drier than normal for the testing area both in frequency of rainfall events and total depth received by the area.

Water Savings and Turf Quality in S06

Water savings for this testing period ranged from 0% to 63% for all treatments; the treatments with acceptable turf quality had water savings ranging from 0% to 36% (Tables 2-6 and 2-7). Rain sensors reduced water applied by between 21% and 36% while soil moisture sensors reduced water by 0% to 63% (Table 2-6). Cardenas-Lailhacar et al. (2008) achieved water savings of 34% during normal Florida rainfall conditions using a rain sensor set at a 6mm rainfall threshold. That treatment was comparable to RS 2-6mm in this experiment which during S06 (dry conditions) reduced water applied by 20%. The highest water savings achieved without adversely affecting turf quality was in the DWRS treatment (36%). Treatment RS1-3mm had lower water savings (33%) than DWRS but poor turf quality (treatment period average of 4.6 for RS1-3mm and 6.5 or DWRS, Table 2-7). In S06, the total depth was not as important to turf quality as frequency of the depth applied. The RS1-3mm treatment reduced water applied by bypassing irrigation while DWRS reduced irrigation by both bypassing irrigation events and due

to the reduced depth applied with each irrigation event, although DWRS bypassed fewer events than RS1-3mm due to a higher RS threshold setting of 6 mm (Table 2-8). Both SMS-based treatments with medium and high thresholds resulted in better than minimally acceptable turf quality. Some deterioration in turf quality across all treatments at the end of the testing period was due to chinch bug damage at the site. The biggest impact from the chinch bugs occurred in the plots with low water application (LL Low and NON). The experiment was concluded June 30, 2006 before most of the damage from chinch bugs occurred.

Soil moisture sensors

Both SMS-based treatments with medium and high thresholds resulted in better than minimally acceptable turf quality (between 6.2 and 6.5 averaged during S06). Generally, higher threshold settings for the SMS resulted in higher water use and increased turf quality in S06. Among the medium and high threshold treatments the water savings were between 0% and 21% (Table 2-6). Figure 2-17 shows the cumulative water use for the SMS-based treatments during the spring. Neither of the high threshold SMS treatments (LL High and AC 13) showed reductions in irrigation water applied. The AC 13 treatment did not save any water since it did not bypass any irrigation events. The LL High treatment bypassed two irrigation events but did not result in water savings due to problems with the irrigation control system that caused the irrigation to run longer than programmed when irrigation was allowed. Average turf quality during S06 for the AC 13 treatment was 6.2 (Table 2-7).

The AC 7 treatment reduced irrigation application by 40% and the LL Low had higher water savings of 63%. Weekly water applied was higher for AC 7 (17.9 mm/wk) than for LL Low (11.2 mm/wk) ($P<0.001$; Table 2-6). These treatments did not maintain acceptable turf quality throughout the entire treatment period. The average turf quality rating during the testing period was slightly higher for AC 7, with a rating of 5.1, compared to LL Low with a rating of

4.2 (P=0.024) (Table 2-7). The average turf quality over the entire testing period was acceptable for AC 7; however, turf quality at the end of the treatment period was only a 4.3. Treatment AC IR (which has a threshold setting of 7%) resulted in an average 32% reduction of water applied while maintaining an average treatment turf quality of 5.7 (Figure 2-18). The range of weekly water applied by these treatments was from16.3 mm/wk to 23.4 mm/wk (water savings of 22 to 45%). The range in average turf quality during S06 was from 3.8 to 6.6. There was no significant difference between the four plots in the AC IR treatment for weekly water applied (P=0.120), but for turf quality there was a significant difference between the plot in the second block (average turf quality of 3.8) and the other plots in the treatment (P=0.001). Similarly turf quality was lower for the AC 7 treatment (sensor buried in the same block as AC 7.2) than the other SMS-based treatments, with the exception of LL Low. The plot in block 4 had the highest turf quality rating (6.6) which was significantly higher than for block 2 (3.8; P<0.001). Comparing average turf quality ratings for the AC IR (5.7) and AC 7 (5.1) treatments showed a significant difference between the two (P=0.017). Average weekly water applied between the two treatments was similar during the S06 season, with AC IR applying only 2.5 mm/wk more water (P=0.151).

The medium threshold settings for both sensors resulted in water savings of 11% and 21% for the AC 10 and the LL Med treatments respectively (Figure 2-17). The weekly water application of these two treatments was similar with 26.5 mm/wk for AC 10 and 23.9 mm/wk for LL Med (P=0.151) (Table 2-6). The LL Med average turf quality rating over the entire testing period (6.5) was similar to the AC 10 rating (6.2; P=0.349), and both were above minimally acceptable (Table 2-7). Compared to the medium and high threshold treatments the low threshold settings for both the LL and AC treatments resulted in poor turf quality ratings. LL

Low turf quality was 4.2 which was well below other treatments such as AC 13 ($P<0.001$), AC 10 ($P<0.001$), and LL Med ($P<0.001$). Over the entire testing period, AC 7 treatment had an average turf quality rating of 5.1 which was higher than LL Low but still lower than the high threshold treatments such as AC 13 ($P=0.002$), AC 10 ($P=0.004$), and LL Med ($P=0.001$). Ultimately, the LL Low treatment had almost complete death of the turfgrass in the treatment plots and had to later be re-sodded.

Rain sensors

Water savings for the rain sensor treatments ranged from 20% to 36% (Table 2-6). The highest water savings occurred in the DWRS treatment, reducing water application by 36% (Figure 2-19). This treatment was set to apply 60% of the water compared to the other time-based treatments. The DWRS treatment had a lower percentage of irrigation events bypassed than the other two-day-per-week rain sensor treatments by 5%, as seen in Table 2-8, but saved water due to the decreased depth of application per irrigation event. Average turfgrass quality for this treatment was 6.5. The next highest water savings were with the RS1-3mm treatment, applying 33% less water than WOS; however, the turf quality at the end of the testing period was less than acceptable (4.6; Table 2-7). The RS1-6mm treatment only reduced water application by 21%. Both of the 1 day/week treatments had similar low turf quality ratings at the end of the treatment period ($P=0.104$) but only RS1-3mm was below acceptable. The average weekly depth applied was higher for RS1-6mm (23.6 mm/wk) than for RS1-3mm (19.9 mm/wk) ($P=0.017$), but RS1-3mm only bypassed one irrigation event more than RS1-6mm. The time-based treatments set for two and seven days of irrigation per week had similar water savings compared to each other between 20 and 22% and weekly water applied depths between 23.3 mm/wk and 23.9 mm/wk (P values greater than 0.5). Treatments RS2-3mm and RS2-6mm bypassed the same number of irrigation events during S06 (Table 2-8).

Frequency of irrigation seemed to have a more direct impact on quality than the rain sensor threshold setting in S06. The poorest turf quality ratings were seen in the one-day-per-week irrigation schedules. With little rainfall in S06, turfgrass depended on irrigation water to maintain quality. As seen in Figure 2-14, there were weeks during S06 where no rainfall occurred to supplement irrigation. Both of the one day/week treatments had similar low turf quality ratings at the end of S06, but only RS1-3mm was below acceptable. Treatment RS1-3 mm bypassed one more irrigation event than the 6 mm setting resulting in a decrease in turf quality. Treatments DWRS and RS7-3mm applied irrigation water similarly with average weekly depths applied of 19.2 mm/wk and 22.8 mm/wk respectively (P=0.018).

Water Savings and Turf Quality in F06

During the F06 period three treatments were added; RS7-6mm, ETM and TORO. The LL Low and the NON treatments were ended in the third week of the experiment due to very low turf quality ratings of 2. Three treatments were excluded (RS1-3mm, RS1-6mm, and RS7-3mm) due to a loss of power to the irrigation timer for these treatments. The LL High had an error in the setting of the irrigation schedule and so the treatment was also excluded. Data collected for treatment AC 7 was not included in this treatment period due to improper installation of the sensor after re-sodding following S06. The sensor was reinstalled before the S07 and F07 treatment periods. All of the remaining treatments had an average turf quality rating during F06 of 6 or 7, which is above minimally acceptable. Water savings during the treatment period ranged from 7% to 63% for all treatments (Table 2-6). TORO produced the highest water savings overall (63%). The lowest water savings (10% or less) were with RS2-3mm, RS2-6mm, RS7-6mm and AC 13. Rain sensors reduced water applied by between 7% and 42% while soil moisture sensors reduced water by 10% to 54% and ET controllers reduced water applied by

40% and 63% (Table 2-6). Overall, turf quality was better in F06 than S06 due to lower temperatures and more rainfall than the spring ($P<0.001$; Table 2-7).

Davis et al. (2007) found water savings compared to a theoretical two-day-per-week irrigation schedule with no irrigation control devices of 20 to 60%. Specifically the Toro Intelli-sense controller produced water savings of 40%. The water savings were produced while maintaining acceptable turf quality. The research was conducted under dry conditions, where rainfall received was less than the depth of historical rainfall for all months of testing except July. In this experiment the ET controllers had water savings of 40% (ET Manager) and 63% (Toro Intelli-sense).

Soil moisture sensors

During the F06 treatment period two SMS treatments were modified based on results from S06. The LL Low and LL High settings were modified to less extreme threshold values. In S06 the settings (based on the 1 to 9 scale) were 2 for LL Low and 8 for LL High. These settings were changed to 4 for LL Low and 6 for LL High and were maintained at these thresholds for the remaining testing periods. Treatment AC 10 resulted in a 30% savings of water applied and AC 13 had a 10% savings (Figure 2-20). The LL Med treatment reduced irrigation applied by 18%, which is lower than the water savings seen for the AC 10 treatment (30%) (Table 2-6). The average amount of water applied weekly was less for AC 10 (16.4 mm/wk) than for LL Med (19.5 mm/wk) ($P=0.002$) (Table 2-6).

AC IR had water savings ranging from 24% to 74% and a range in turf quality from 4.8 to 7.3 (Figure 2-21). The lowest turf quality rating was seen in the plot with the highest water applied (AC 7.2; Table 2-9). The water applied and the turf quality for AC 7.2 was the only significantly different plot in the treatment during S06. This plot was located in block 2 of the research area which was considered to be the driest block based on TDR testing (Figure 2-3). If

the soil in the second block has lower water holding capacity irrigation would need to be applied more often to maintain the VWC programmed into the SMS controller. During TDR analysis of the experimental field, block 2 was the driest block with VWC values as low as 5% after irrigation occurred (Figure 2-3). The turf quality ratings for the other three plots (AC 7.1, AC 7.3 and AC 7.4) were all similar (P=0.261) also weekly water applied was similar between the remaining three treatment plots (P=0.067).

Rain sensors

Reductions in water applied for the rain sensor based treatments in F06 ranged from 7% to 42% (Figure 2-22). All of the treatments had an average turf quality of 5.8 or better over the entire testing period. The highest water savings were in the DWRS treatment (42%). The DWRS treatment applied 35% less water than RS2-6mm but it bypassed the same percentage of irrigation events (Table 2-7). During the treatment period DWRS and RS2-6mm only bypassed two irrigation events. The average weekly water applied by the DWRS treatment (14.0 mm/wk) was lower than the RS2-6mm treatment (22.1 mm/wk) (P<0.001) while the average turf quality for the DWRS plots (7.1) was higher than the RS2-6mm plots (5.8) (P<0.001). The remaining time based treatments (RS2-3mm and RS7-6mm) had water savings of 8% and 9%. Weekly water applied by these two treatments were 21.8 mm/wk for RS2-3mm and 21.9 mm/wk for RS7-6mm which were similar to RS2-6mm (P=0.764 and P=0.915). Treatments RS2-3mm and RS7-6mm had similar turf quality ratings of 6.6 and 6.5 respectively (P=0.722). These ratings were lower than DWRS (P=0.125 and P=0.059), but higher than RS2-6mm (P=0.019 and P=0.045).

Evapotranspiration controllers

The ET Manager had a water savings of 36%, bypassing 50% of the possible irrigation events, while the Toro Intelli-Sense controller had a water savings of 59%, bypassing 29% of the

possible irrigation days (Figure 2-23). Rain sensor treatments with same number of possible irrigation days only bypassed 9% of irrigation events during F06. Events bypassed by the TORO controller, which did not have a rain sensor attached, were due to the rain pause feature. The ETM treatment reduced water applied by irrigating less frequently. The TORO treatment bypassed fewer irrigation events than ETM but had smaller depths applied with each event. Average weekly water applied for TORO and ETM were treatments were 8.6 mm and 14.4 mm respectively ($P<0.001$). Both treatments had better than acceptable average turf quality ratings. TORO plots had an average turf quality rating of 6.5 compared to the ETM plots, which had a rating of 7.1 ($P=0.082$). ETM resulted in water savings higher than the SMS based systems with the exception of the AC IR treatment (water savings of 54%) and the time based systems with the exception of DWRS treatment (water savings of 42%) (Table 2-6).

Water Savings and Turf Quality in S07

During the S07 treatment period the LL Low, RS1-3mm and NON treatments were ended early due to poor turf quality. Treatment LL Low was ended in the third week of testing, RS1-3mm was ended in the fourth week and the NON treatment was ended at the beginning of the second week of the study. Water savings for the remaining treatments ranged from 0 to 59% (Table 2-6). Treatments with acceptable turf quality had water savings ranging from 0% to 49%. The highest water savings with acceptable turf quality averaged over the whole treatment period were from AC 7 (49%) followed closely by DWRS which reduced water applied by 45%. Turf quality was higher for DWRS (6.9) than for AC 7 (5.8) ($P<0.001$). Rain sensors reduced water applied by between 7% and 45% while soil moisture sensors reduced water by 0% to 49% and ET controllers reduced water applied by 25% to 59% (Table 2-6).

Soil moisture sensors

The highest water savings for SMS treatments were from AC 7 and AC IR, which reduced water applied by 49% and 44% respectively (Figures 2-23 and 2-24). The two treatments had similar weekly water applied depths of 19.8 mm/wk and 21.5 mm/wk respectively (P=0.193) (Table 2-6). Within the AC IR treatment water savings ranged from 32% to 50% (Figure 2-25). The largest difference in water applied was between AC 7.2 (17.8 mm/wk) and AC 7.4 (6.3 mm/wk; P=0.046). Similar to the F06 treatment period, the controller for AC 7.2 applied most water of the AC IR treatment (Table 2-9). During both the previous treatment periods the AC 7.2 had significantly lower turf quality ratings than the other three plots in the treatment (P<0.001). The turf quality ratings for the other three plots (AC 7.1, AC 7.3 and AC 7.4) were all similar (P=0.667) also weekly water applied was similar between the remaining three treatment plots (P=0.848).

Treatment AC 10 reduced water applied by 18% compared to a 19% reduction in water applied by LL Med (Figure 2-24). The average weekly water applied was 31.9 mm/wk for AC 10 and 33.8 mm/wk for LL Med (P=0.140) (Table 2-6). These treatments actually bypassed the same number of events and any difference in water applied is due to minor differences in water delivery in the field and timing of bypassed irrigation events since depth applied per irrigation event changes monthly (Table 2-8).

LL High did not bypass any irrigation events in S07 and so produced no water savings. AC 13 produced an 11% reduction in water applied by bypassing four irrigation events. The weekly water applied for AC 13 was 34.4 mm/wk which was lower than LL High at 39.3 mm/wk (P<0.001) (Table 2-6). Average turf quality ratings for the two treatments during S07 were very similar (P=0.860) (Table 2-7). All of the irrigation events bypassed by the AC 13 sensor occurred after receiving large amounts of rainfall (greater than 11 mm).

Rain sensors

Treatment RS1-3mm was ended on May 31 (4 weeks after study began) due to poor turf quality. The VWC of this plot before supplemental irrigation was added is shown in Figure 2-26. The treatment only bypassed one irrigation event, which lead to VWC levels in the plots around 4%. Average turf quality for the treatment was a 3 with one plot having a rating of 2 before supplemental irrigation was applied. Water savings for the remaining rain sensor based treatments ranged from 7% to 45% with DWRS producing the highest and RS1-6mm producing the lowest water savings (Table 2-6).

Treatments RS2-3mm and RS2-6mm produced water savings of 14 and 10% respectively (Figure 2-27). These treatments had similar average weekly depths of water applied with 33.2 mm/wk for RS2-3mm and 34.9 mm/wk for RS2-6mm ($P=0.054$). Treatments RS7-3mm and RS7-6mm had slightly different weekly water depths applied of 31.3 mm/wk and 33.1 mm/wk respectively ($P=0.046$). The water savings for these treatments was 21% (RS7-3mm) and 16% (RS7-6mm) (Figure 2-22). Treatment RS1-6mm had the lowest turf quality rating of the rain sensor treatments with an average rating of 5.8 over the entire testing period. This value was above minimally acceptable but lower than ratings for other treatments such as RS2-3mm with a rating of 6.7 ($P<0.001$), RS7-6mm with a rating of 6.8 ($P<0.001$), RS 7-3mm with a rating of 6.5 ($P=0.005$) and RS2-6mm with a rating of 6.0 ($P=0.422$).

Treatment DWRS produced the highest water savings applying an average weekly depth of 21.3 mm/wk of water and had the highest average turf quality rating (6.9) of all treatments. This treatment applied less weekly than RS1-6mm (34.5 mm/wk) ($P<0.001$) and had higher turf quality ($P<0.001$). DWRS also had lower water applied weekly than the RS2-6mm treatment (34.9 mm/wk) ($P<0.001$) and higher turf quality ($P<0.001$). These two treatments bypassed the

same percentage of irrigation events, treatment DWRS simply applied less water per irrigation event (Table 2-8).

Evapotranspiration controllers

TORO and ETM reduced water applied by 25% and 59% respectively (Figure 2-28). The average weekly water applied was higher for the TORO plots with 29.1 mm/wk compared to the ETM plots with 15.0 mm/wk ($P<0.001$). While water savings were high for the ETM treatment turf quality for the treatment period was less than acceptable (4.5). The average turf quality rating for the TORO treatment (6.1) was higher than ETM ($P<0.001$). Loss of turf quality in the ETM treatment could be due to the number of irrigation events bypassed. The ETM manager bypassed 57% of the possible irrigation events (Table 2-8).

The ET Manager uses effective rainfall settings to determine how much rainfall can be stored in the root zone of the plant. One effective rain setting is the Saturation Allowance (Table 2-4). According to the manufacturer, this value is the amount of rain required to saturate the soil after irrigation has been applied without causing runoff to occur. It is the maximum amount of water that the ET controller believes can be held in the root zone of the plant in addition to the irrigation water. The value used for the Saturation Allowance during S07 was too high and caused too many irrigation events to be bypassed during a period of time where little rainfall occurred. The same value was used during the F06 treatment period, but the treatment only produced water savings of 40% and no damage to turf quality was seen. This may have been due to the cooler temperatures and lower values of ET_o during the month of November preventing loss of turf quality. During the month of November 2006 the ETM controller only allowed irrigation once. The Toro Intelli-Sense controller had a water savings of 25% and only bypassed irrigation once.

Water Savings and Turf Quality in F07

The F07 treatment period received a substantial depth of rainfall both in comparison to three previous testing periods and compared to historical average rainfall depths. Average turf quality for the NON treatment was a 5, which is minimally acceptable but lower than most other treatments (Table 2-7). The ETM treatment had a similar average turf quality rating compared to NON of 5.7 (P=0.097). Water savings with SMS treatments ranged from 11% to 75% with every treatment receiving at least acceptable turf quality ratings (Table 2-7). Water savings for rain sensors ranged from 22% to 53% and water savings for ET controllers was 59% and 62% (Table 2-6).

There was more rainfall in F07 than the previous testing periods. It was the only treatment with a cumulative depth of rainfall exceeding historical averages and it was the only testing period where the number of days per month where there was a rainfall event with a depth greater than 2.5 mm was greater than the monthly historical averages (Figure 2-14). Due to the wetter conditions during F07, the results were more comparable to the savings seen by Cardenas-Lailhacar et al. (2008). Even though this period had more rainfall than previous testing periods, it was drier than normal for this time of year. Cardenas-Lailhacar et al. (2008) found that soil moisture sensors (set to irrigate 2 days/week) reduced water applied in that experiment by 27 to 88%. Specifically, the Acclima controller had water savings of 77%. Using a rain sensor set to replace 100% of the historical net irrigation requirement resulted in a water savings of 34% (2 days/week and a 6 mm rainfall threshold) and for a rain sensor treatment scheduled to replace 60% of the historical net irrigation requirement they saw water savings of 59%. The AC 7 controller (2 days/week) in this study reduced water applied by 74% and the AC 10 controller reduced water applied by 53%. During F07 the treatment RS 2-6mm reduced water applied 22%

and the DWRS treatment (scheduled to apply 60% of the historical net irrigation requirement) produced water savings of 53%.

Soil moisture sensors

The highest water savings were seen in the AC 7 and the AC IR treatments with a 75% reduction of water applied by both (Figures 2-28 and 2-29). The average weekly depth of water applied for the two treatments was also similar with 9.1 mm/wk (AC 7) and 8.4 mm/wk (AC IR) (Table 2-6; P=0.665). Water savings for the AC IR treatment ranged from 64 to 81% with the lowest water savings seen in the second block of the research area. As seen in the previous testing periods AC 7.2 (located in block 2) had the highest water applied and the lowest turf quality of the four plots in the AC IR treatment (Table 2-9). During F07, the difference between AC 7.2 and the other plots was not as significant as in other testing periods for both turf quality and water applied. AC 7.2 and AC 7.4 had similar weekly depths of water applied with 12.1 mm/wk and 8.8 mm/wk respectively (P=0.153). The plots for AC 7.2 and AC 7.1 had similar turf quality ratings with 5.3 and 5.7 respectively (P=0.574). The only significant difference in turf quality was between AC 7.2 (5.3) and AC 7.4 (7.0) (P=0.025), however the water applied by these two controllers was not significantly different (P=0.153). Treatment LL Low produced a 44% reduction in water applied (Figure 2-29). Weekly water applied for the LL Low treatment (16.3 mm/wk) was significantly higher than that applied by AC 7 and AC IR (P<0.001) (Table 2-6).

Treatment AC 10 produced water savings of 53%, which was higher than the water savings by both the LL Low treatment (44%) and the LL Med treatment (31%) (Figure 2-29). Weekly water applied by the AC 10 treatment was lower than the LL Med treatment by 5.5 mm/wk (P=0.001). AC 13 and LL High had water savings of 14 and 11% respectively. The weekly water applied by these treatments was similar with depths of 25.6 mm/wk for AC 13 and 26.3

mm/wk for LL High (P=0.656). The AC 13 treatment bypassed two more irrigation events than the LL High sensor did, however due to a leak in the irrigation for one plot in the AC 13 treatment water savings look more similar between the two treatments than they should. Without the leaking spray head, AC 13 would have had a water savings of 19%. During this treatment period all of the AC sensors produced higher water savings than the comparable LL treatments (Table 2-6).

Rain sensors

Water savings for the DWRS treatment was 53% and for all the other rain sensor treatments water savings were between 22 and 30% (Figure 2-31). The weekly water applied by the two-day-per-week treatments, RS2-3mm and RS2-6mm, was similar at 21.7 mm and 23.4 mm respectively (P=0.192) (Table 2-6). The turf quality was also similar for these two treatments with a rating of 6.8 for RS2-3mm and a rating of 6.3 for RS2-6mm (P=0.248). Treatment RS1-3mm had a lower weekly water application depth of 18.8 mm/wk compared to RS1-6mm with a depth of 21.8 mm/wk (P=0.017). Average turf quality for RS1-3mm was 6.3 and the rating for RS1-6mm was 6.2 (P=0.847). Treatment RS7-3mm had a weekly application depth of 20.2 mm/wk which was slightly lower than treatment RS7-6mm with a depth of 22.9 mm/wk (P=0.032). The water savings for these two treatments were 30% and 23%. The turf quality for RS7-3mm was 6.8 and the turf quality for RS7-6mm was 6.9 (P=0.699). Treatment DWRS applied substantially less water weekly than the other rain sensor treatments. DWRS applied 14.2 mm/wk compared to the next lowest rain sensor treatment RS1-3mm which had a weekly depth of 18.8 mm/wk (P<0.001). DWRS had the highest turf quality rating (7.0) for all treatments in F07.

Evapotranspiration controllers

In F07 the saturation allowance parameter for the ET Manager was changed from 9.1 mm to 2.5 mm due to loss of turf quality during S07. The new value was selected to ensure adequate irrigation was applied. Treatments ETM and TORO had water savings of 59% and 62% respectively (Figure 2-32). The weekly depths of water applied were similar with 12.8 mm/wk for ETM and 11.7 mm/wk for TORO (P=0.261). The turf quality rating for ETM was 5.7 and for TORO a 6.4 (P=0.088). Much of the damage to turf quality for the ETM plots occurred during S07, turf quality from S07 to F07 increased from 4.7 to 5.7. The TORO controller bypassed 35% of the possible irrigation days and ETM bypassed 58%. A rain sensor treatment with same number of possible irrigation days (RS2-6mm) only bypassed 23% of irrigation events during F07.

Summary and Conclusions

Even though three of the four testing periods were relatively dry, all of the technologies tested managed to reduce water application compared to the WOS treatment, with most treatments also producing acceptable turf quality.

The medium threshold SMS-based treatments produced water savings and good quality turf during all treatment periods with water savings up to 30% (AC) and 21% (LL) during dry conditions and 53% (AC) and 31% (LL) during three months with normal rainfall conditions. Low threshold sensor treatments during the S06 produced minimally acceptable turf quality (AC 7) and less than acceptable turf quality (LL Low). In F07, under wetter conditions, the treatments AC 7 and LL Low (which had a higher threshold after S06) reduced water applied by 74% and 44% respectively. High threshold treatments produced little or no savings (between 0 and 14%) during any of the treatment periods. The establishment of a proper threshold for the

sensor is extremely important in producing good turf quality and water savings at the same time, especially in sandy soil.

During three seasons, treatments AC 7 and AC IR had similar weekly water applied. These two treatments had the same threshold setting; the AC 7 treatment only has one sensor controlling the irrigation for all four plots in the treatment, while AC IR has a separate sensor in each plot. There were differences in turf quality between AC IR and AC 7 during S06 and S07. The average turf quality ratings for the AC 7 treatment were a 5.1 (S06) and a 5.8 (S07) while the AC IR plots had an average turf quality rating of 6.2 (S06) and 6.5 (S07). The range in turf quality for the four plots in the AC 7 treatment were from 4 to 6 (S06) and from 5 to 7 (S07). To ensure adequate water application the sensor must have the proper threshold setting for the worst conditions or the driest plot. During F07 the two treatments had similar turf quality ratings, but all other treatments during the testing period had acceptable turf quality. Utilizing one sensor to control the irrigation for multiple areas can be effective as long as the correct location and set point is selected for sensor installation. In this example the driest plot was selected to ensure that adequate irrigation was applied to all of the plots.

The plot for AC 7.2 (located in block 2) had significantly lower turf quality ratings than the other plots during three of the four testing periods (S06, F06, and S07) while applying more water weekly than the other AC IR plots during three out of the four testing periods (F06, S07, and F07). In F07, AC 7.2 had the lowest turf quality rating but it was not significantly lower than AC 7.1 or AC 7.3. Location attributed to the lower turf quality in the AC 7.2 plot, it was located on the edge of the treatment area, with a non-irrigated area next to it. Turf quality decline in this The turf quality ratings for the other three plots (AC 7.1, AC 7.3 and AC 7.4) were all similar during, S06 ($P=0.279$), F06 ($P=0.261$), S07 ($P=0.667$), and F07 ($P=0.055$). Also

weekly water applied was similar among the remaining three treatment plots for F06 (P=0.067), S07 (P=0.848), and F07 (P=0.163).

Rain sensor treatments, excluding DWRS, reduced water by 7% to 24% during the dry treatment periods and by 22% to 30% during F07. The RS1-3mm treatment, which had a low threshold on the rain sensor and only one day of the week irrigation scheduling, had less than acceptable turf quality for S06 and in S07 had to be ended early due to loss of turf quality. The RS1-6mm treatment, which only had a 3 mm higher threshold setting, had acceptable turf quality for all of the treatment periods. Thus, a 6 mm rain sensor threshold should be considered the minimum for one-day-per-week irrigation frequencies. Treatment DWRS consistently had high water savings compared to the other rain sensor treatments, and compared to the medium threshold sensor treatments during every treatment period. Reductions in water applied for this treatment ranged from 36% to 45% for the relatively dry conditions and 53% during F07.

ET controllers had water saving ranging from 25% to 63% during F06 and S07. However in S07 treatment ETM produced less than acceptable turf quality due to an inappropriate input parameter setting related to effective rainfall. This input affected the water holding capacity of the soil calculated by the controller. This shows the importance of controller set up in enabling the systems to work correctly, both reducing water applied and producing quality turfgrass. During F07, ET controllers had water savings of 59% (ETM) and 62% (TORO) and acceptable turf quality.

The water savings for treatments that maintained turf quality above a rating of 6 (better than minimally acceptable) during the treatment periods when all the technologies were installed are as follows in order from greatest to least water savings produced; TORO (25% to 63%), DWRS (42% to 53%), AC 10 (18% to 53%), LL Med (18% to 31%), RS7-3mm (21% to 30%),

RS2-3mm (8% to 28%), RS7-6mm (9% to 23%), AC 13 (10% to 14%) and LL High (0% to 11%).

Treatment ETM produced high water savings in S07 (59%) but had poor turf quality (4.5). The low threshold SMS treatments also produced high water savings, but during the S06 period LL Low resulted in an average turf quality rating of 4.2 (63% water savings) and AC 7 had an average turf quality rating of 5.1 (water savings of 40%). The AC 7 treatment had deteriorating turf quality later in the S06 treatment period. During S07 and F07 the AC 7 treatment had turf quality ratings of 5.8 and 5.9 respectively along with water savings of 49 and 74%.

Overall, the proper installation and set-up of each of the technologies tested here was an important factor in determining the effectiveness to which each system could reduce water applied and maintain turfgrass quality at a level sufficient for homeowners. Volumetric moisture content threshold was an important factor in correctly establishing an irrigation schedule using an SMS system along with ensuring adequate contact with soil. For ET controller systems the input parameters affect the amount of water applied and the frequency with which it is applied. The input parameters determine things such as water holding capacity of the soil. Rain sensors produced water savings and only one treatment had less than acceptable quality. The threshold setting should be set appropriately based on local watering restrictions. With limited allowable days for irrigation the threshold needs to be set adequately so that irrigation is only bypassed when a sufficient amount of water has been applied for plant needs.

Table 2-1. Summary of crop coefficients (K_c) used for calculating ET_c, developed by Jia et al. (2007).

Warm-season turfgrass crop coefficients	
January	0.35
February	0.37
March	0.57
April	0.83
May	0.90
June	0.77
July	0.73
August	0.72
September	0.69
October	0.65
November	0.60
December	0.46

Table 2-2. Summary of treatment codes and descriptions.

Treatment code	Irrigation window frequency (day/week)	Treatment description
SMS-Based		
AC 7	2	Acclima set at 7% VWC[a]
AC 10	2	Acclima set at 10% VWC
AC 13	2	Acclima set at 13% VWC
AC IR	2	Acclima (7%) individually controlled plots
LL Low	2	LawnLogic set at low setting[b]
LL Med	2	LawnLogic set at medium setting (#5)
LL High	2	LawnLogic set at high setting[c]
ET-Based		
ETM	2	RainBird ET Manager
TORO	2	Toro Intelli-Sense
Time-Based		
RS1-3mm	1	Rain Sensor set at 3mm rainfall threshold
RS2-3mm	2	Rain Sensor set at 3mm rainfall threshold
RS7-3mm	7	Rain Sensor set at 3mm rainfall threshold
RS1-6mm	1	Rain Sensor set at 6mm rainfall threshold
RS2-6mm	2	Rain Sensor set at 6mm rainfall threshold
RS7-6mm	7	Rain Sensor set at 6mm rainfall threshold
DWRS	2	Reduced irrigation schedule (60% of RS2-6mm)
WOS	2	Without sensor
NON	0	Non-irrigated

[a] VWC stands for volumetric water content. [b]LL Low setting was a #2 for S06 and then changed to #4 for F06, S07 and F07. [c]LL High had a setting of #8 for S06 and then it was changed to #6 for F06, S07 and F07.

Table 2-3. Monthly total irrigation depth scheduled in order to replace historical ET values based on information by Dukes and Haman (2002b). Run times are based on an irrigation application rate of 5 cm/hr.

Month	Irrigation depth (mm)	Total run time (min/month)	2 d/wk cycle run time (min/event)
January	0	0	0
February	0	0	0
March	0	0	0
April	115	136	17
May	183	216	27
June	142	168	21
July	135	160	20
August	176	208	26
September	135	160	20
October	122	144	18
November	88	104	13
December	88	104	13
Total	1184		

Table 2-4. Summary of input parameters for the two ET controllers tested (Toro Intelli-Sense and RainBird ET Manager)

Input parameter	Input
TORO	
Soil type	Sand
Sprinkler type	Spray head
Root depth	15.2 cm
Plant type	Warm-season turfgrass
Sun exposure	Sunny all day
Slope	None
Usable rainfall	100%
Kc	1
Efficiency	95%
ETM	
Landscape adjustment	70%
Max hourly rain	2.1 cm
Saturation allowance (F06 and S07)	0.91 cm
Saturation allowance (F07)	0.25 cm
Irrigation amount[a]	depth changed monthly

[a]The Irrigation Amount used for ETM is the same depth used for RS and SMS treatments based on Dukes and Haman (2002b). This is the irrigation depth scheduled in the irrigation timer that the ET Manager is connected to.

Table 2-5. Average DU_{lq} and CU values for each treatment

Code	Description	DU_{lq}	CU
AC 7	Acclima 7% VWC	0.53	0.72
AC 10	Acclima 10% VWC	0.58	0.77
AC 13	Acclima 13% VWC	0.55	0.76
AC IR	Acclima 7% VWC ind rep control	0.56	0.75
LL Low	Lawn Logic #2 setting	0.61	0.77
LL Med	Lawn Logic #5 setting	0.56	0.75
LL High	Lawn Logic #8 setting	0.57	0.76
ETM	ET Manager controller	0.63	0.79
TORO	Toro Intelli-sense controller	0.63	0.79
RS1-3mm	Rain sensor 1 d/wk 3 mm setting	0.50	0.72
RS2-3mm	Rain sensor 2 d/wk 3 mm setting	0.54	0.76
RS7-3mm	Rain sensor 7 d/wk 3 mm setting	0.60	0.77
RS1-6mm	Rain sensor 1 d/wk 6 mm setting	0.46	0.70
RS7-6mm	Rain sensor 7 d/wk 6 mm setting	0.49	0.72
WRS	Rain sensor 2 d/wk 6 mm setting	0.58	0.74
DWRS	60% of WRS time setting	0.46	0.69
WOS	2 d/wk no RS	0.52	0.73
NON	Non-irrigated	0.51	0.73

Table 2-6. Summary of average weekly water applied and water savings for each treatment during the four testing periods.

	Average water applied (mm/week)				Water savings (%) compared to WOS			
Treatment	S06	F06	S07	F07	S06	F06	S07	F07
SMS-based								
AC IR	20 ***de***	11 ***d***	22 ***c***	8 ***e***	32	54	44	75
AC 7	18 ***e***	--*	20 ***c***	9 ***e***	40	--*	49	74
AC 10	27 ***bc***	16 ***c***	32 ***b***	14 ***d***	11	30	18	53
AC 13	31 ***a***	21 ***b***	34 ***b***	26 ***b***	0	10	11	14
LL Low	11 ***f***	~	~	16 ***d***	63*	~	~	44
LL Med	24 ***cd***	20 ***b***	34 ***b***	20 ***c***	21	18	19	31
LL High	--	--	39 ***a***	26 ***b***	--	--	0	11
WOS	30 ***ab***	24 ***a***	39 ***a***	30 ***a***	0	0	0	0
CV %	34.9	25.9	23.7	42.5				
ET-based								
ETM	*NA*	14 ***b***	15 ***c***	13 ***b***	*NA*	40	59*	59
TORO	*NA*	9 ***c***	29 ***b***	12 ***b***	*NA*	63	25	62
WOS	-	24 ***a***	39 ***a***	30 ***a***	-	0	0	0
CV %	-	37.7	25.5	26.8				
RS-based								
RS1-3mm	20 ***cd***	--	~	19 ***d***	33*	--	~	29
RS2-3mm	23 ***b***	22 ***a***	33 ***b***	22 ***bc***	22	8	14	28
RS7-3mm	23 ***bc***	--	31 ***c***	20 ***cd***	24	--	21	30
RS1-6mm	24 ***b***	--	35 ***b***	22 ***bc***	21	--	7	30
RS2-6mm	24 ***b***	22 ***a***	35 ***b***	23 ***b***	20	7	10	22
RS7-6mm	*NA*	22 ***a***	33 ***b***	23 ***b***	*NA*	9	16	23
DWRS	19 ***d***	14 ***b***	21 ***d***	14 ***e***	36	42	45	53
WOS	30 ***a***	24 ***a***	39 ***a***	30 ***a***	0	0	0	0
CV %	29.2	23.0	16.2	30.3				
Treatment period comparison								
	23 ***b***	18 ***c***	30 ***a***	19 ***c***				
CV %	51.4							

Different letters (in columns for comparison of water applied by treatments and within the row for the treatment period comparison) indicate differences by Duncan's multiple range test at the 95% confidence level. * Treatments that produced less than acceptable turf quality. ~ Treatments that were ended before the treatment period was over. -- Treatments where the irrigation system was malfunctioning. --* In F06 the AC 7 sensor was installed incorrectly and so did not function properly. *NA* Treatments that were not installed during S06

Table 2-7. Average turf quality ratings during the four treatment periods. Turf quality is on a scale of 1 to 9, with a 1 representing dead turfgrass and a 9 representing perfect turfgrass quality. A rating of 5 was considered minimally acceptable for homeowners.

	Average turf quality			
Treatment	S06	F06	S07	F07
SMS-based				
AC 7	5.1 ***c***	--*	5.8 ***b***	5.9 ***b***
AC 10	6.2 ***ab***	7.0 ***a***	6.5 ***a***	6.6 ***ab***
AC 13	6.3 ***ab***	6.8 ***a***	6.8 ***a***	6.6 ***ab***
AC IR	5.7 ***abc***	6.6 ***ab***	5.7 ***b***	6.2 ***ab***
LL Low	4.2 ***d***	*NA*	*NA*	6.2 ***ab***
LL Med	6.5 ***a***	7.2 ***a***	6.5 ***a***	6.3 ***ab***
LL High	--	--	6.8 ***a***	6.8 ***a***
WOS	5.6 ***bc***	6.1 ***b***	6.5 ***a***	6.3 ***ab***
NON	1.4 ***e***	~	~	5.0 ***c***
CV %	23.0	14.3	11.3	11.9
ET-based				
ETM	*NA*	7.1 ***a***	4.5 ***b***	5.7 ***ab***
TORO	*NA*	6.5 ***ab***	6.1 ***a***	6.4 ***a***
WOS	-	6.1 ***b***	6.5 ***a***	6.3 ***a***
NON	-	~	~	5.0 ***b***
CV %	-	16.4	20.6	17.9
RS-based				
RS1-3mm	4.6 ***c***	--	~	6.3 ***a***
RS2-3mm	6.0 ***ab***	6.6 ***ab***	6.7 ***a***	6.8 ***a***
RS7-3mm	6.2 ***ab***	--	6.5 ***a***	6.8 ***a***
RS1-6mm	5.3 ***bc***	--	5.8 ***b***	6.2 ***a***
RS2-6mm	6.1 ***ab***	5.8 ***c***	6.0 ***b***	6.3 ***a***
RS7-6mm	*NA*	6.5 ***abc***	6.8 ***a***	6.9 ***a***
DWRS	6.5 ***a***	7.1 ***a***	6.9 ***a***	7.0 ***a***
NON	1.4 ***d***	~	~	5.0 ***b***
WOS	5.6 ***ab***	6.1 ***bc***	6.5 ***a***	6.3 ***a***
CV %	28.0	18.9	14.4	16.5
Treatment period comparison[+]				
	5.4 ***c***	6.7 ***a***	6.3 ***b***	6.3 ***b***
CV %			22.3	

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level. ~ Treatments were ended before the treatment period was over. -- Treatments where the irrigation system was malfunctioning. --* Indicates the sensor was installed incorrectly. *NA* Treatments that were not installed during S06. [+]Treatment period mean comparison was performed within the row.

Table 2-8. Summary of the percentage of irrigation events bypassed by the different irrigation control devices.

	Irrigation events bypassed (%)			
Treatment	S06	F06	S07	F07
SMS-based				
AC 7	40	--*	49	77
AC 10	15	35	20	54
AC 13	0	13	11	19
AC IR	33	58	45	75
LL Low	60*	~	~	42
LL Med	30	17	20	31
LL High	--	--	0	12
ET-based				
ETM	*NA*	52	57*	58
TORO	*NA*	26	9	35
RS-based				
RS1-3mm	30*	--	~	31
RS2-3mm	20	9	14	27
RS7-3mm	27	--	21	33
RS1-6mm	20	--	0	31
RS2-6mm	20	9	11	23
RS7-6mm	*NA*	21	17	24
DWRS	15	9	11	23

* Treatments that produced less than acceptable turf quality. ~ Treatments that were ended before the treatment period was over. -- Treatments where the irrigation system was malfunctioning. --* Sensor was installed incorrectly. *NA* Treatments that were not installed during S06.

Table 2-9. Summary of water applied and turf quality for the four plots in the AC IR treatment.

	Average water applied (mm/week)				Turf quality (1 to 9 scale)			
Plot	S06	F06	S07	F07	S06	F06	S07	F07
AC 7.1	23.4 ***a***	10.3 ***b***	20.0 ***a***	7.0 ***b***	6.0 ***a***	7.0 ***a***	6.1 ***a***	5.7 ***ab***
AC 7.2	22.3 ***ab***	17.8 ***a***	25.9 ***a***	12.1 ***a***	3.8 ***b***	4.8 ***b***	4.6 ***b***	5.3 ***b***
AC 7.3	19.7 ***ab***	9.1 ***b***	20.3 ***a***	5.7 ***b***	6.4 ***a***	7.2 ***a***	6.0 ***a***	6.7 ***ab***
AC 7.4	16.3 ***b***	6.3 ***b***	19.7 ***a***	8.8 ***ab***	6.6 ***a***	7.3 ***a***	6.1 ***a***	7.0 ***a***
CV %	33.5	47.4	41.3	67.2	14.8	7.5	10.0	11.1

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level.

Figure 2-1. View of experimental plots located in Citra, FL at the Plant Science Research and Education Unit on July 7, 2007. Control boards and irrigation valves are located behind the turfgrass plots on the west side of the test area.

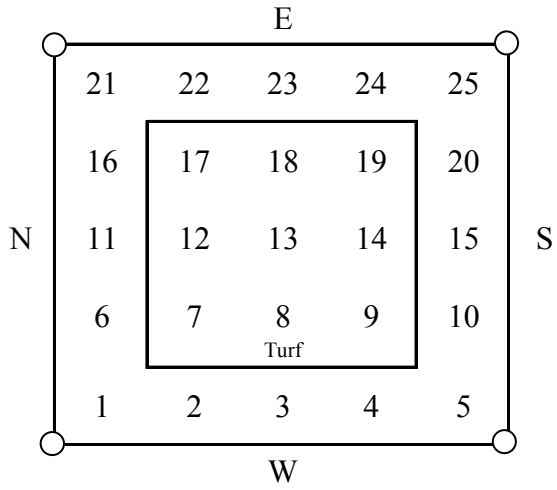


Figure 2-2. Locations within the turf plots where volumetric water contents (VWC; %) measurements were taken for soil TDR testing. Small circles at the corner of the plots represent spray heads. This pattern was repeated throughout all 72 plots in the field. The same placement was used for catch cans during DU testing

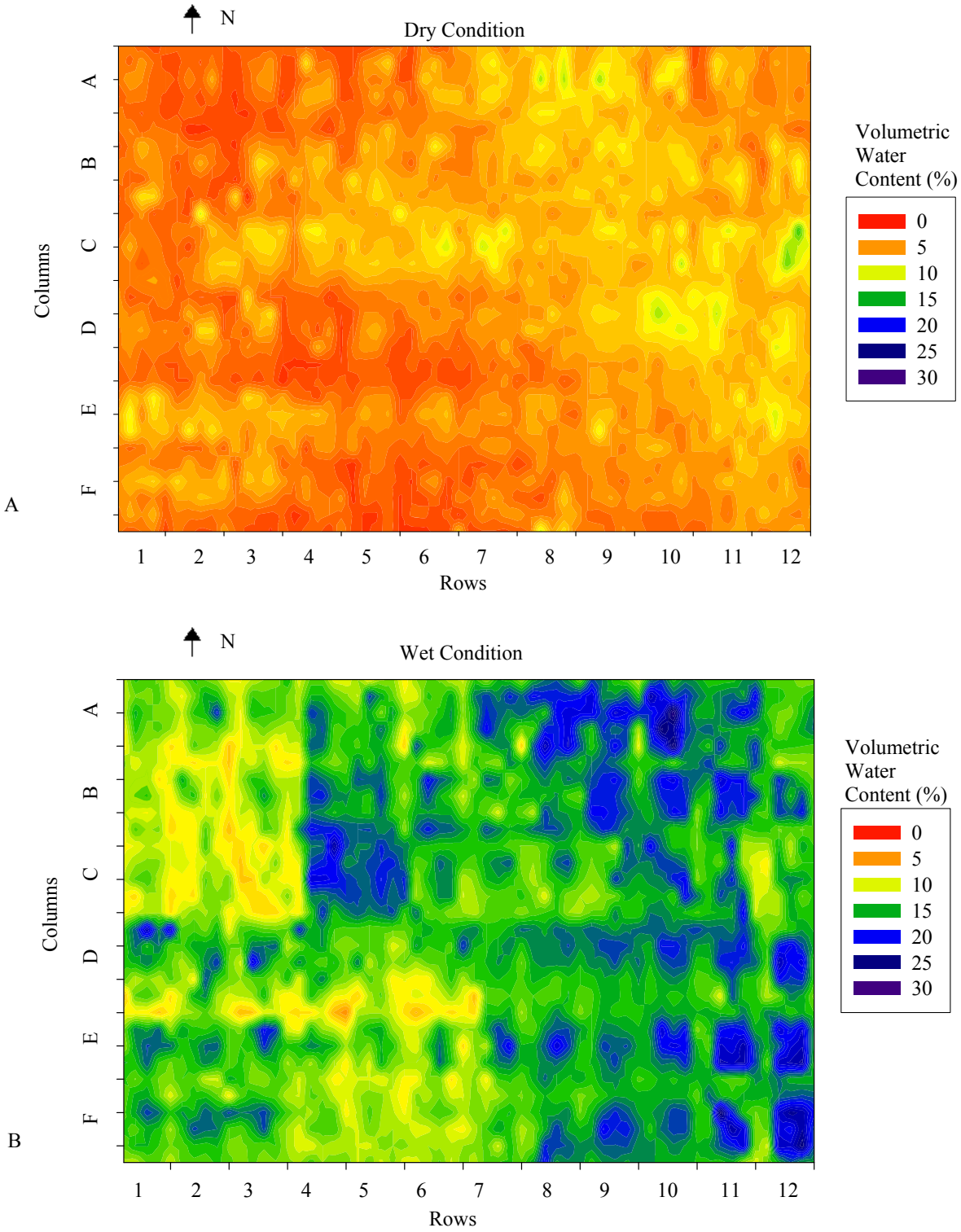


Figure 2-3. Volumetric water content (VWC; %) measurements throughout the field A) before irrigation and B) after irrigation. The color scale moves from red (dry locations) to dark blue (wet locations).

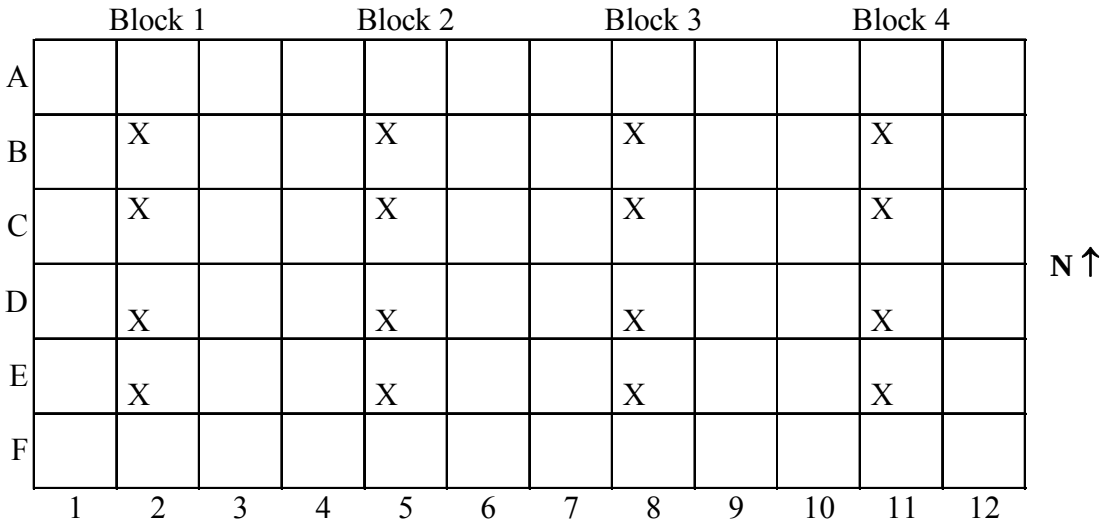


Figure 2-4. Locations for soil sampling marked with an "X" throughout the experimental area. There were four locations in each block.

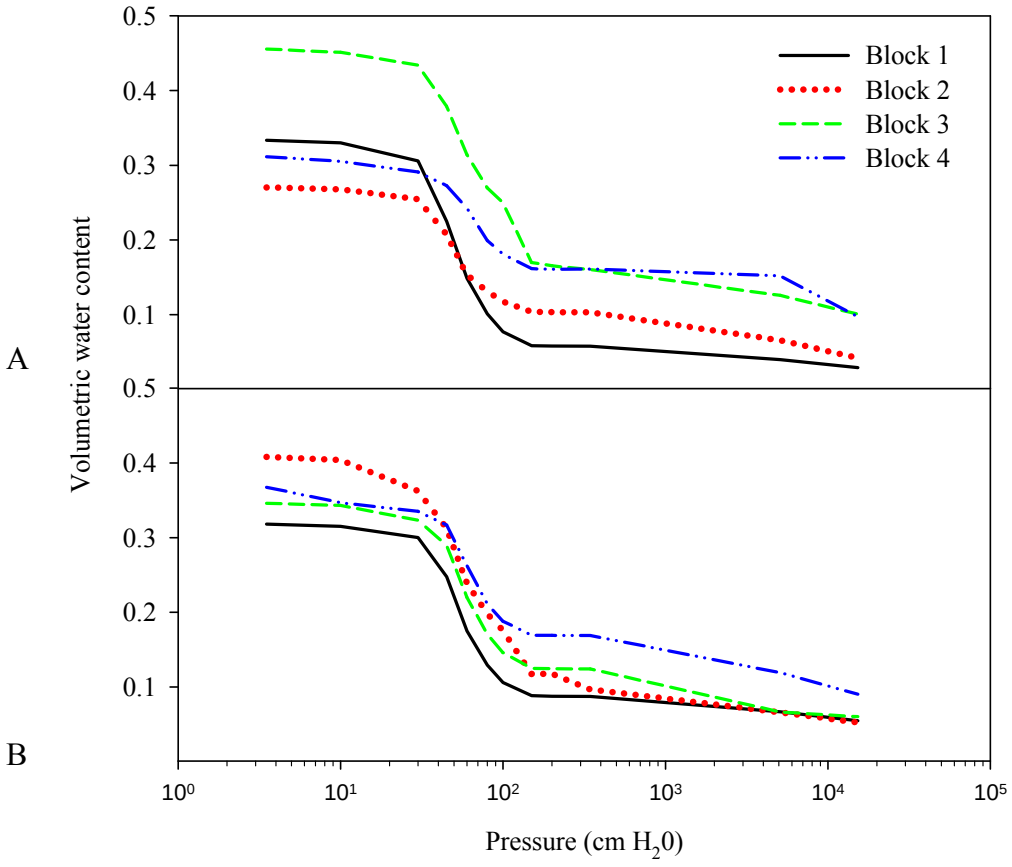


Figure 2-5. Water retention curves of soils throughout research area at two depths in the soil profile A) 7.5 cm and B) 15 cm.

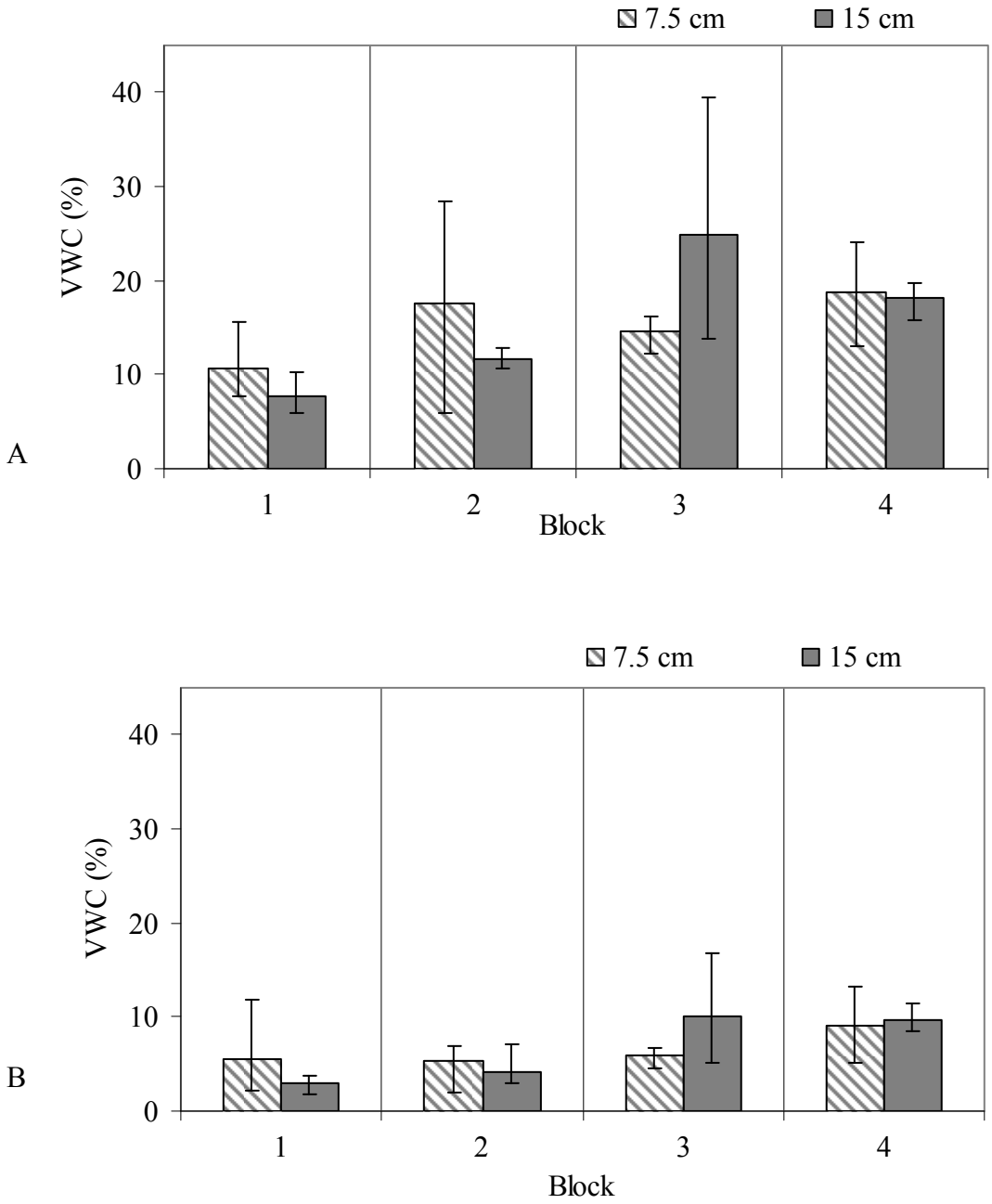


Figure 2-6. Range of A) field capacity (FC) and B) permanent wilting point (PWP) values found throughout the field site and within blocks. Columns represent the average value for the parameters at depths of 7.5 cm (diagonal fill) and 15 cm (gray fill) respectively and bars represent the extreme values in a block and.

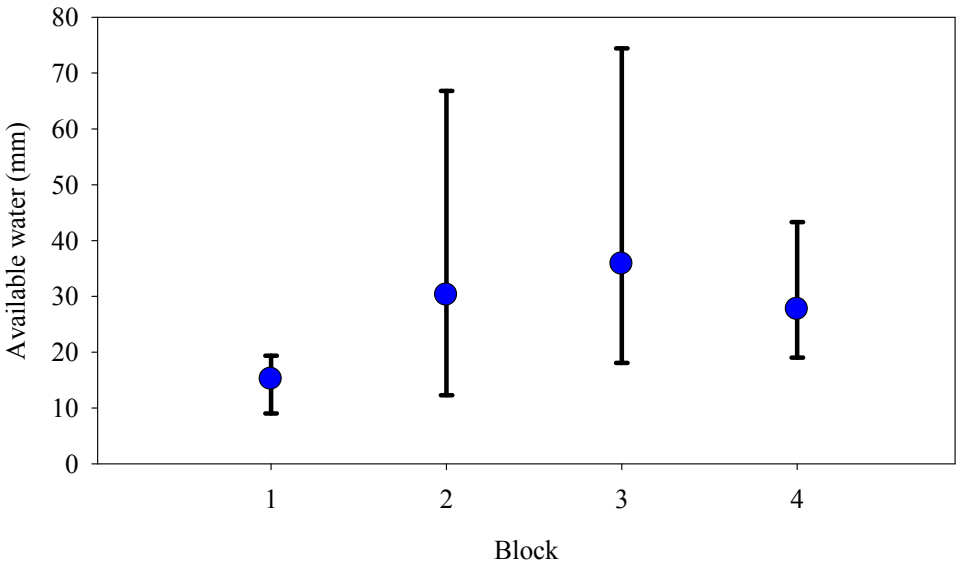


Figure 2-7. Mean values for available water are shown for each block in the field based on a 30 cm root depth. Bars show the maximum and minimum range of the values within in each block.

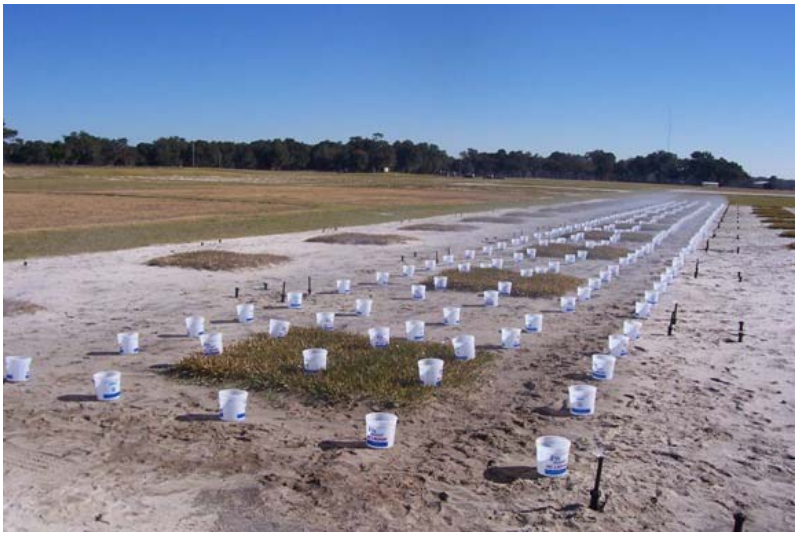


Figure 2-8. Placement of catch cans for uniformity testing on 12 plots.

Figure 2-9. Installation of the CS616 Water Content Reflectometer (left) and the Acclima Digital TDT sensor (right).

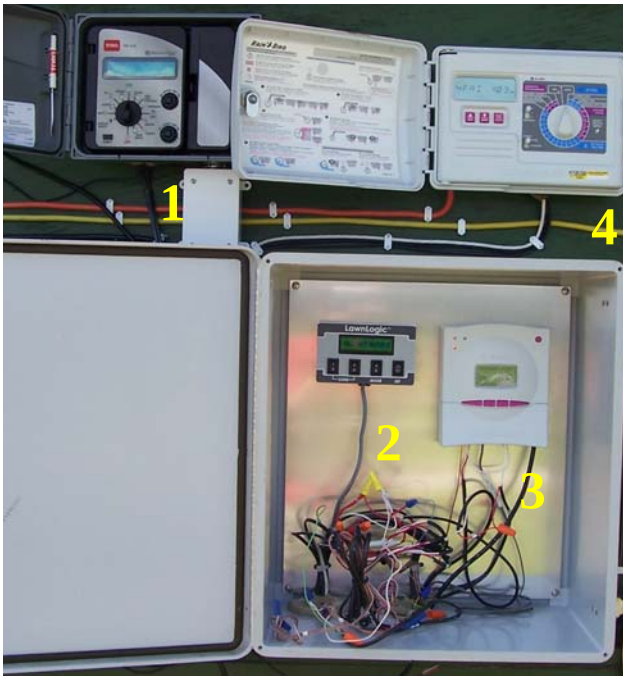
A

B

C

Figure 2-10. Pictures of turfgrass plots at the research site on 10/5/2006. These three plots represent typical turf quality ratings of (A) 2 (B) 5 and (C) 8.

Figure 2-11. Image of 2 control boards with irrigation timers, SMS and ET controllers, and rain sensors.

A 

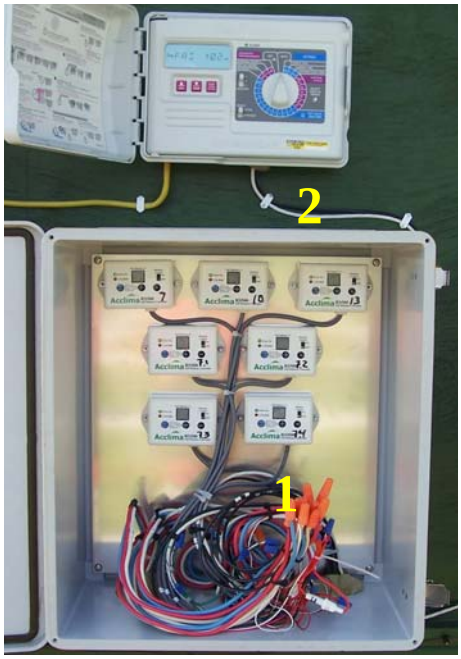
B 

Figure 2-12. Pictures showing the SMS and ET controllers along with the irrigation timers. Shown in picture A are 1) the Toro Intelli-Sense ET controller, 2) the LawnLogic SMS controller, 3) the RainBird ET Manager ET controller and 4) an irrigation timer. Shown in picture B are 1) the Acclima SMS controllers and 2) an irrigation timer.

	Block 1			Block 2			Block 3			Block 4			
A	0.58	0.54	0.56	0.57	0.58	0.55	0.52	0.61	0.59	0.62	0.63	0.5	
B	0.48	0.59	0.55	0.55	0.55	0.56	0.54	0.55	0.57	0.53	0.47	0.49	
C	0.56	0.52	0.58	0.63	0.39	0.48	0.43	0.47	0.45	0.31	0.29	0.29	
D	0.5	0.55	0.43	0.53	0.54	0.43	0.45	0.56	0.57	0.56	0.5	0.3	**N** ↑
E	0.57	0.56	0.63	0.56	0.56	0.56	0.56	0.63	0.58	0.61	0.5	0.62	
F	0.54	0.63	0.65	0.68	0.69	0.66	0.68	0.71	0.67	0.69	0.67	0.72	
	1	2	3	4	5	6	7	8	9	10	11	12	

Figure 2-13. Plot Plan with DU_{lq} values for each plot shown

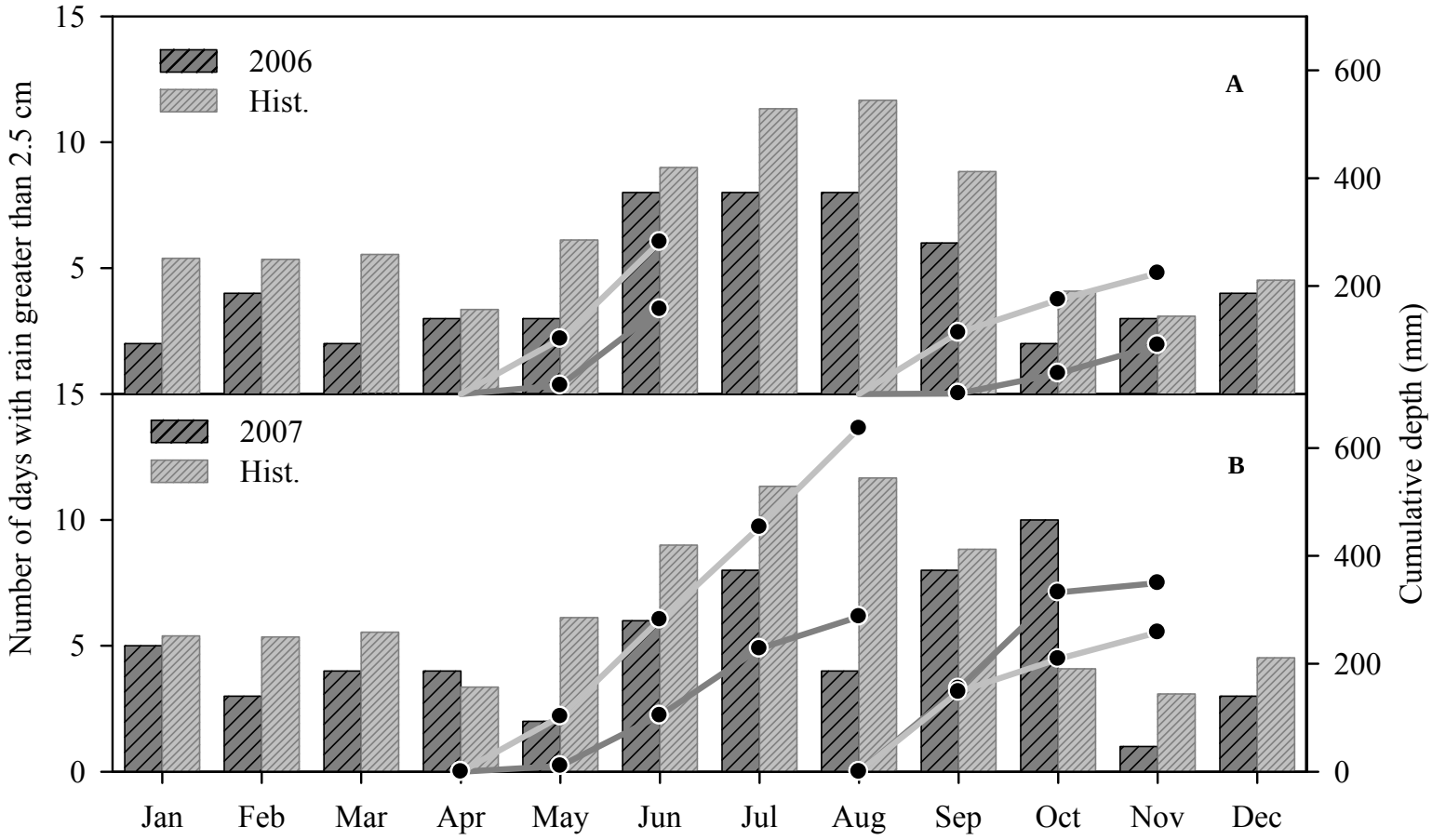


Figure 2-14. Number of days receiving rain events with a depth greater than 2.5 mm and total cumulative rainfall for 2006 and 2007 compared to historical values. The S06 treatment includes the months of May and June of 2006, F06 includes September through December 2006, S07 includes May through August 2007 and F07 includes September through November 2007.

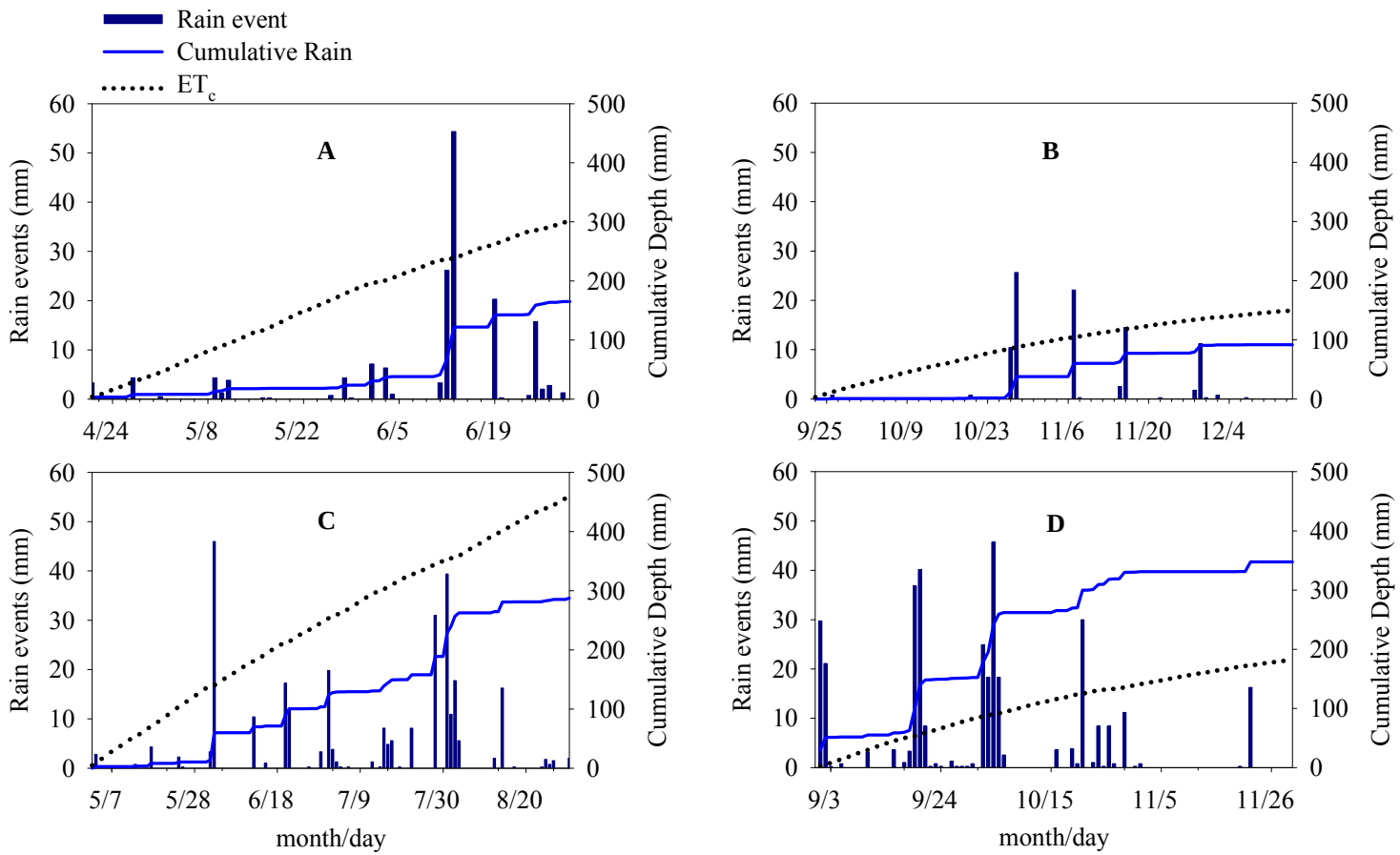


Figure 2-15. Comparison of rain and calculated ETc during the four experimental treatment periods A) S06, B) F06, C) S07 and D) F07. Dotted lines show the cumulative ETc while the solid line indicates cumulative rainfall. Bars represent individual rainfall event

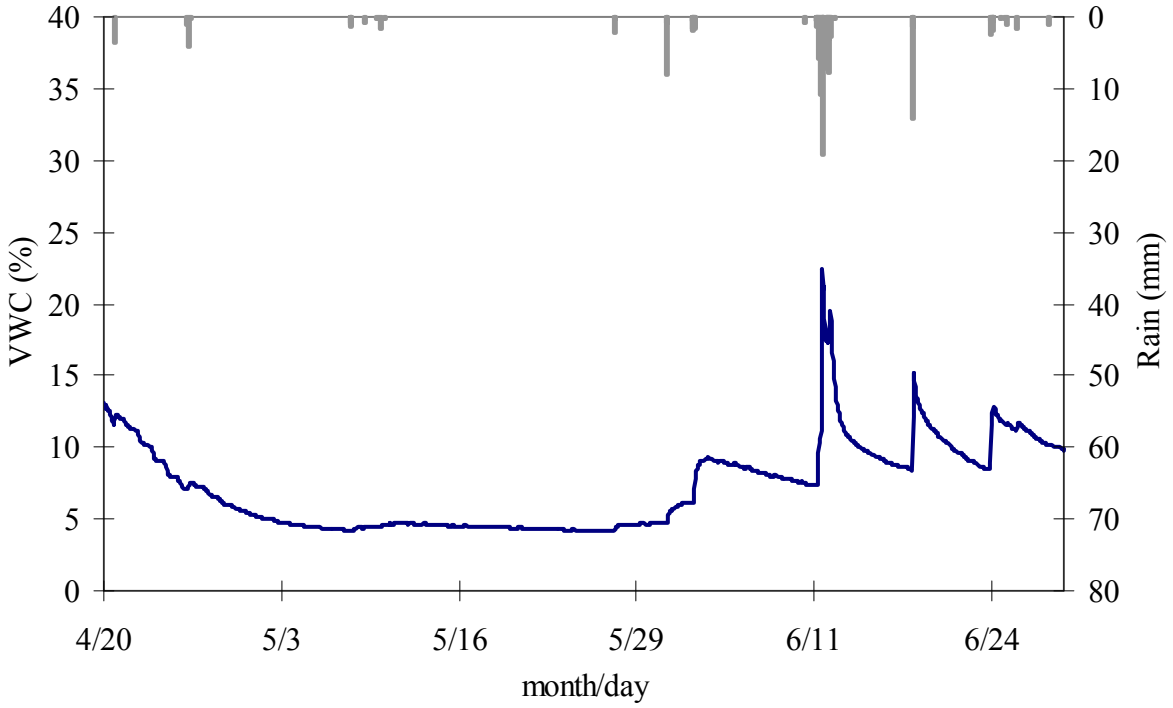


Figure 2-16. Volumetric water content (VWC; %) and rainfall (top of the graph) in a non-irrigated plot located in block 2 of the research field during S06.

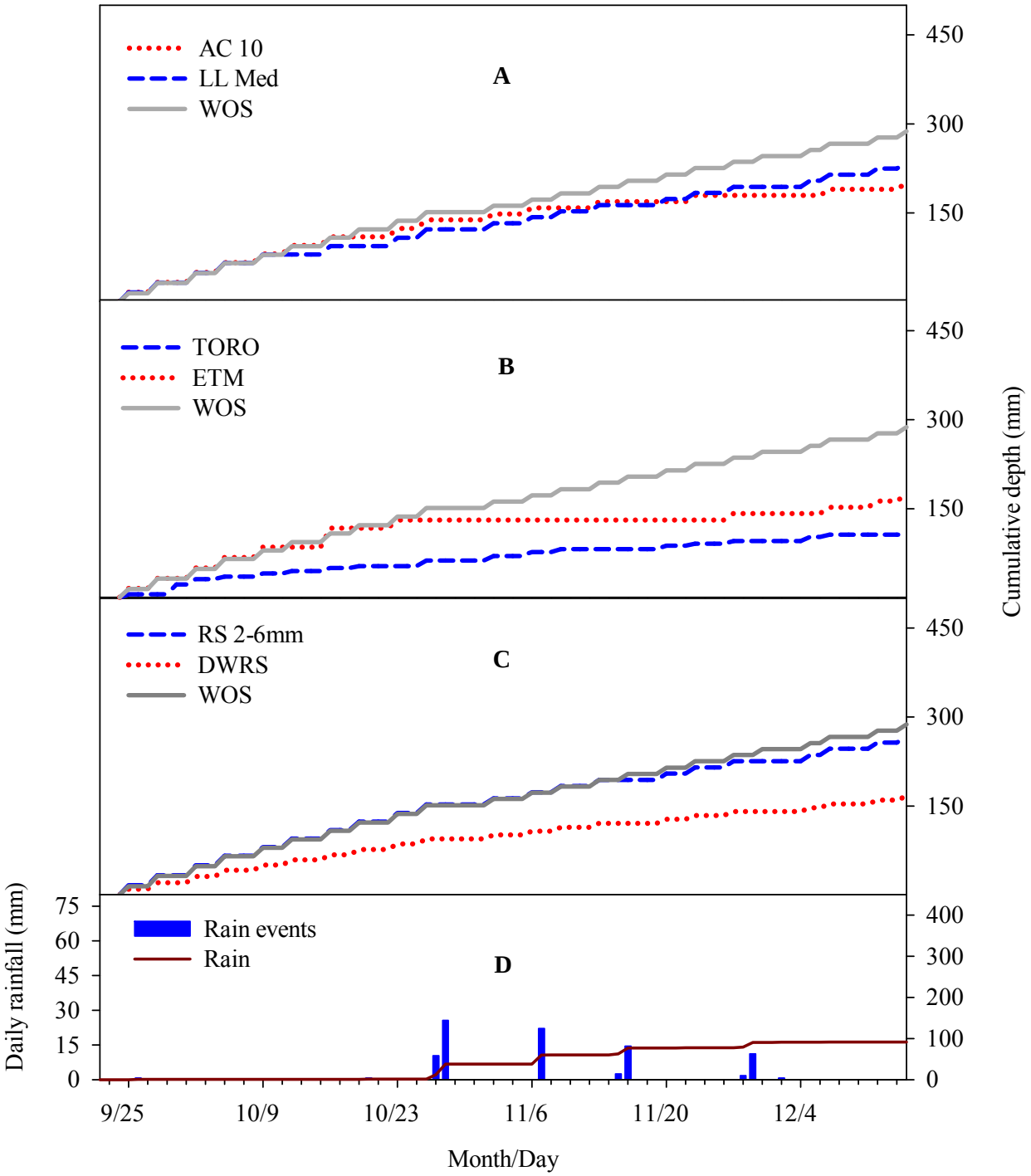


Figure 2-17. Cumulative irrigation applied during F06 by treatments A) AC 10 and LL Med, B) TORO and ETM, and C) RS2-6mm and DWRS compared to WOS. Total cumulative rainfall and daily rainfall are also shown (D).

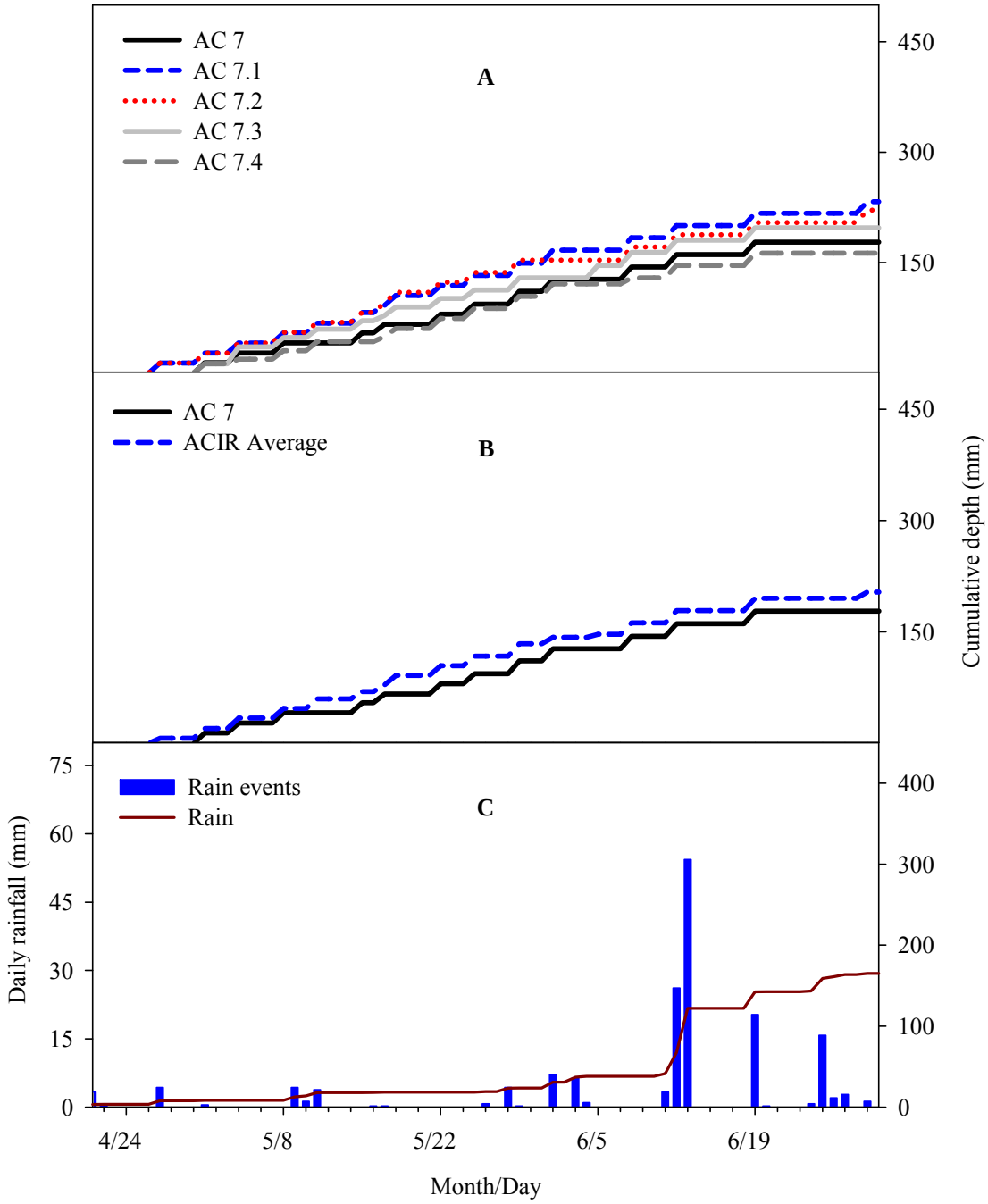


Figure 2-18. Cumulative irrigation water applied during S06 by treatments A) AC 7 (sensor in block 2), AC 7.1, AC 7.2, AC 7.3 and AC7.4 and, B) AC 7 and AC IR average. Total cumulative rainfall and daily rainfall are also shown (C). Treatments AC 7.1 through AC 7.4 are the four plots that constitute the AC IR treatment.

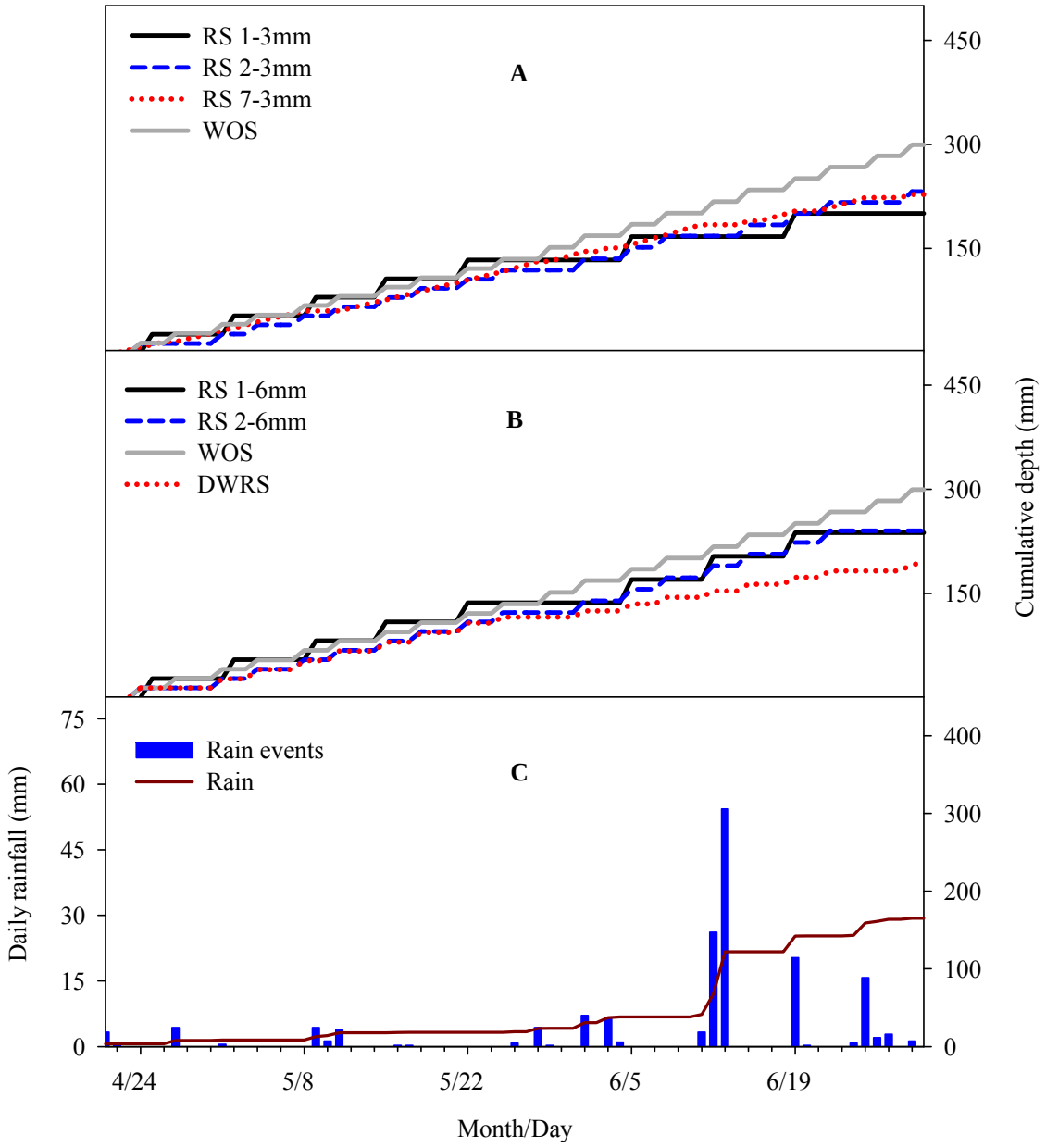


Figure 2-19. Cumulative irrigation applied during S06 by treatments A) RS1-3mm, RS2-3mm, RS7-3mm and, B) RS1-6mm, RS2-6mm and DWRS. Total cumulative rainfall and daily rainfall are also shown (C).

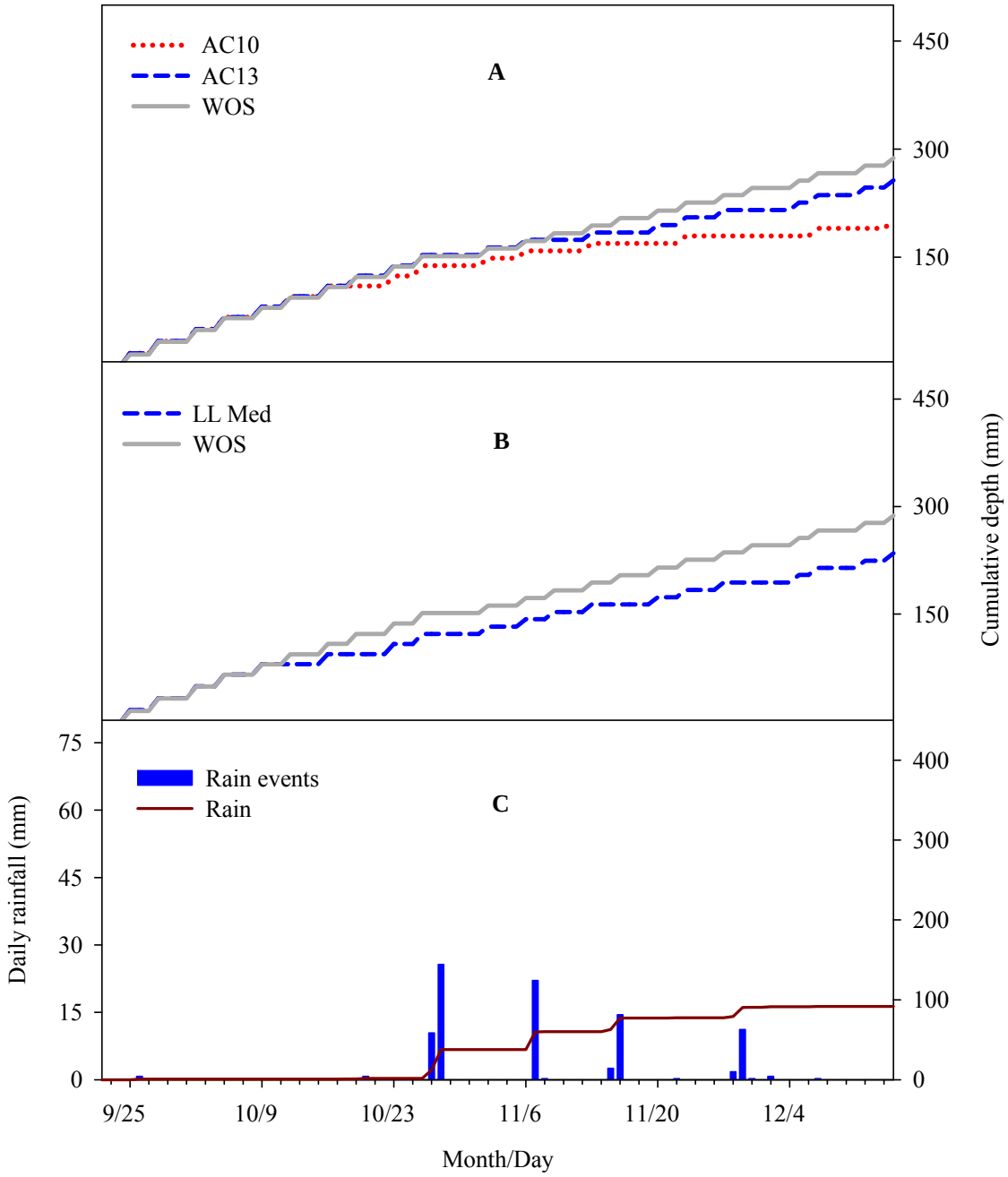


Figure 2-20. Cumulative irrigation applied during F06 by treatments A) AC 10 and AC 13 and B) LL Med. Total cumulative rainfall and daily rainfall are also shown (C). Treatment AC 7 was not included due to improper installation of the sensor at the beginning of the treatment period. Treatment LL Low was excluded because the treatment was ended early sue to poor turf quality. The LL High treatment had an error in the setting of the irrigation schedule and so the treatment was also excluded.

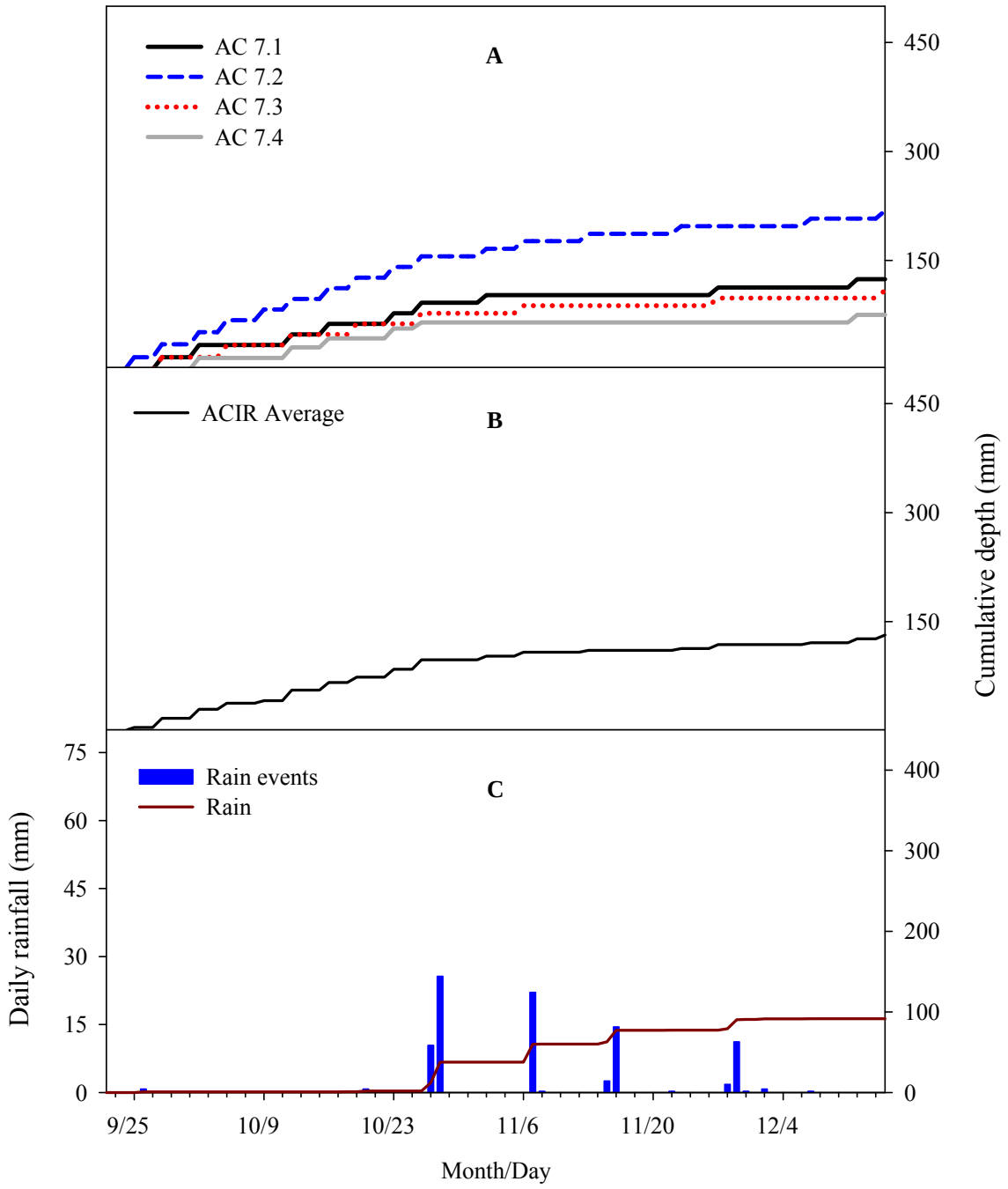


Figure 2-21. Cumulative irrigation applied during F06 by treatments A) AC 7.1, AC 7.2, AC 7.3 and AC7.4, and B) AC IR average. Total cumulative rainfall and daily rainfall are also shown (C). AC 7.1, AC 7.2, AC 7.3 and AC 7.4 are the four plots that constitute the AC IR treatment. Treatment AC 7 was not included due to improper installation of the sensor at the beginning of the treatment period.

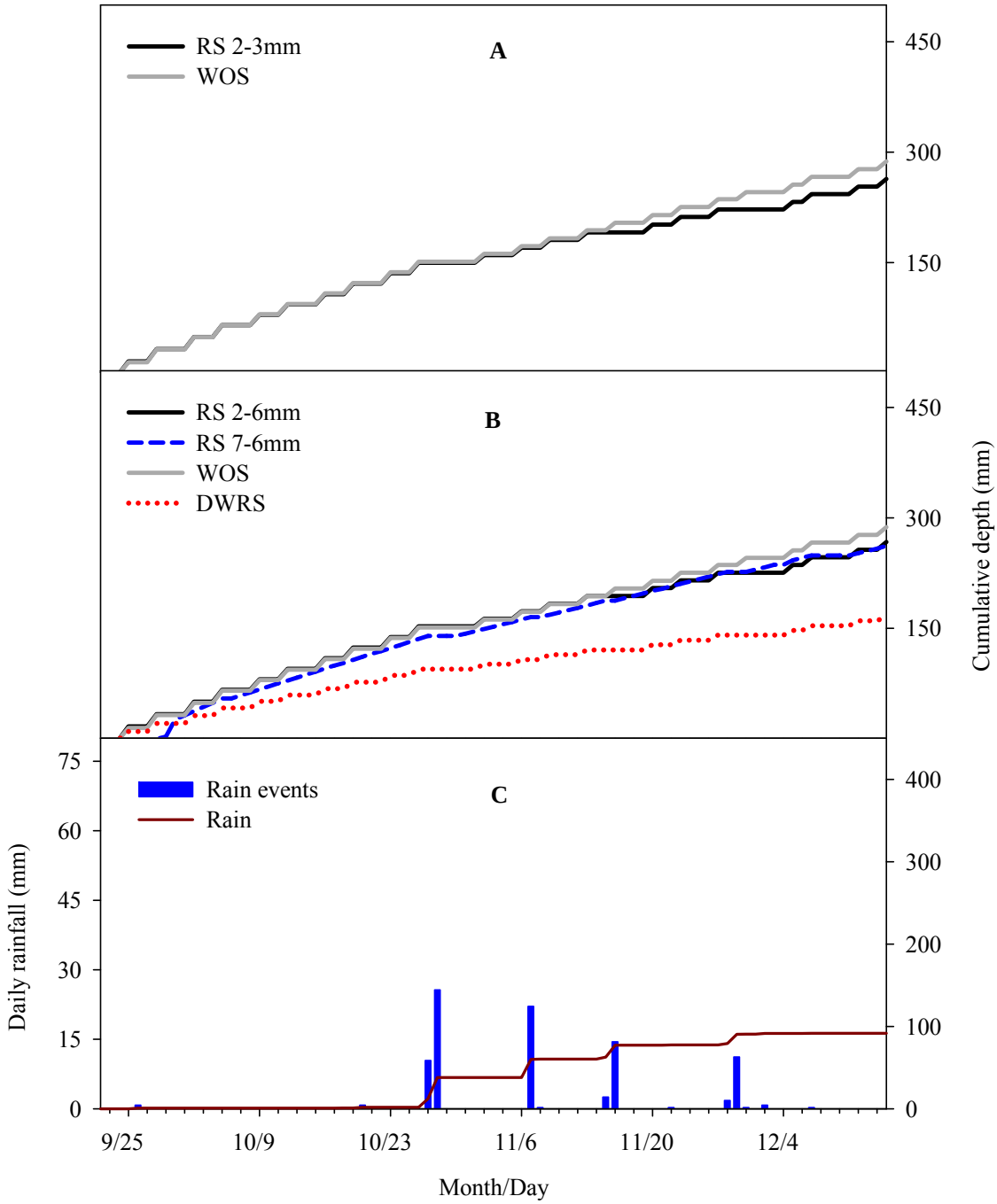


Figure 2-22. Cumulative irrigation applied during F06 by treatments A) RS2-3mm, B) RS2-6mm, RS7-6mm and DWRS. Total cumulative rainfall and daily rainfall are also shown (C). Three rain sensor treatments were excluded (RS1-3mm, RS1-6mm, and RS7-3mm) due to a loss of power to the irrigation timer for these treatments

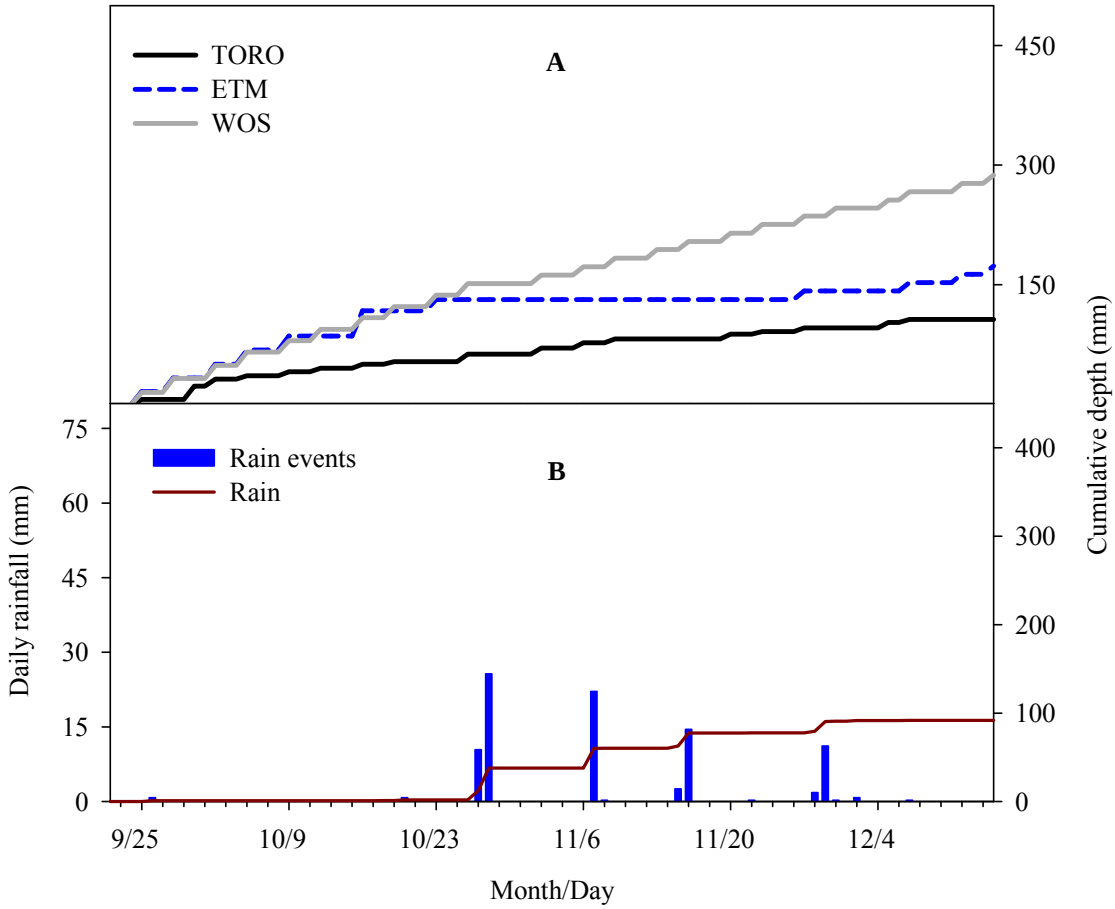


Figure 2-23. Cumulative irrigation applied during F06 by treatments A) TORO and ETM. Total cumulative rainfall and daily rainfall are also shown (B).

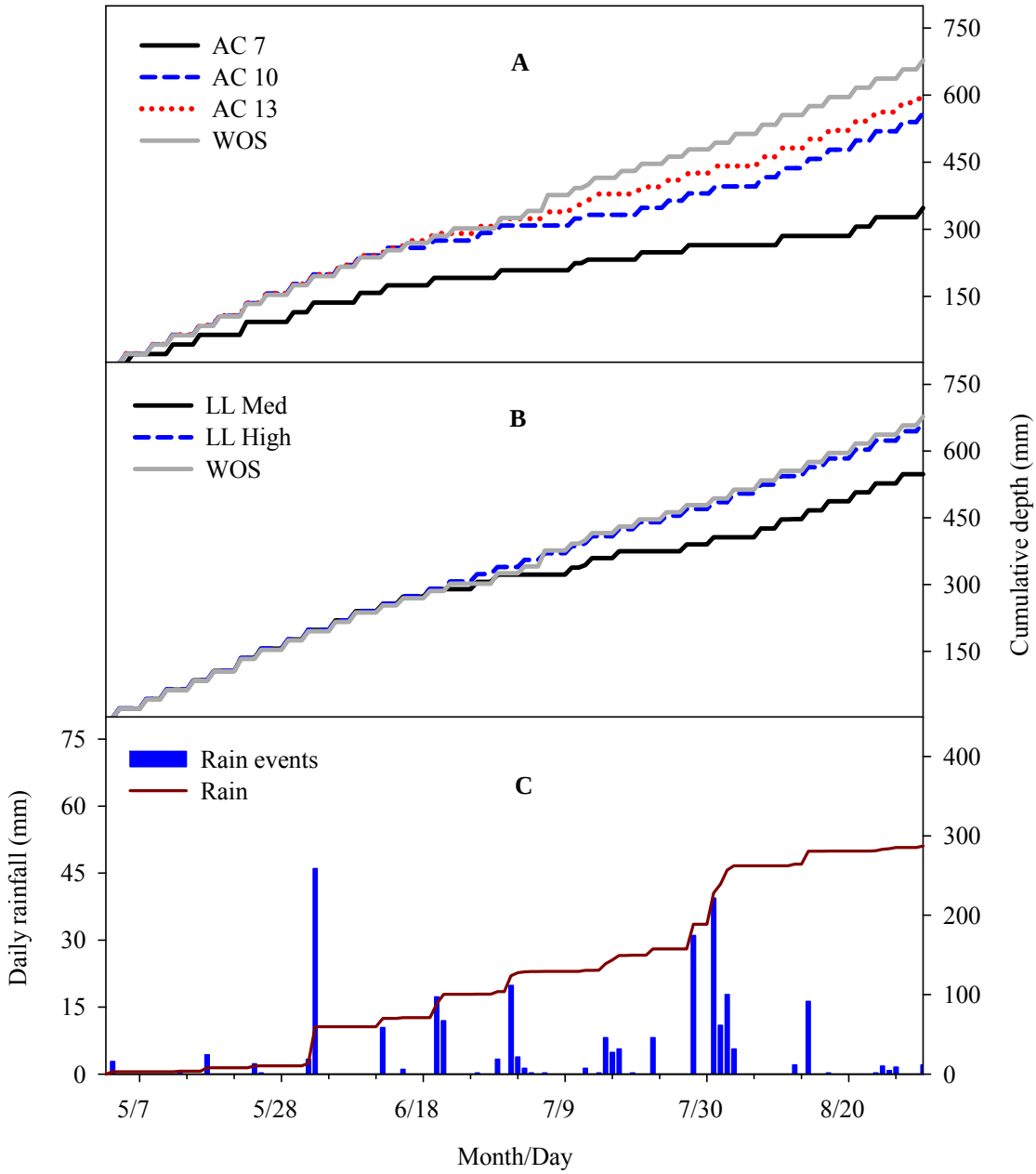


Figure 2-24. Cumulative irrigation applied during S07 by treatments A) AC 7, AC 10 and AC 13 and B) LL Med and LL High. Total cumulative rainfall and daily rainfall are also shown (C). Treatment LL Low was ended early in the treatment period due to poor turf quality.

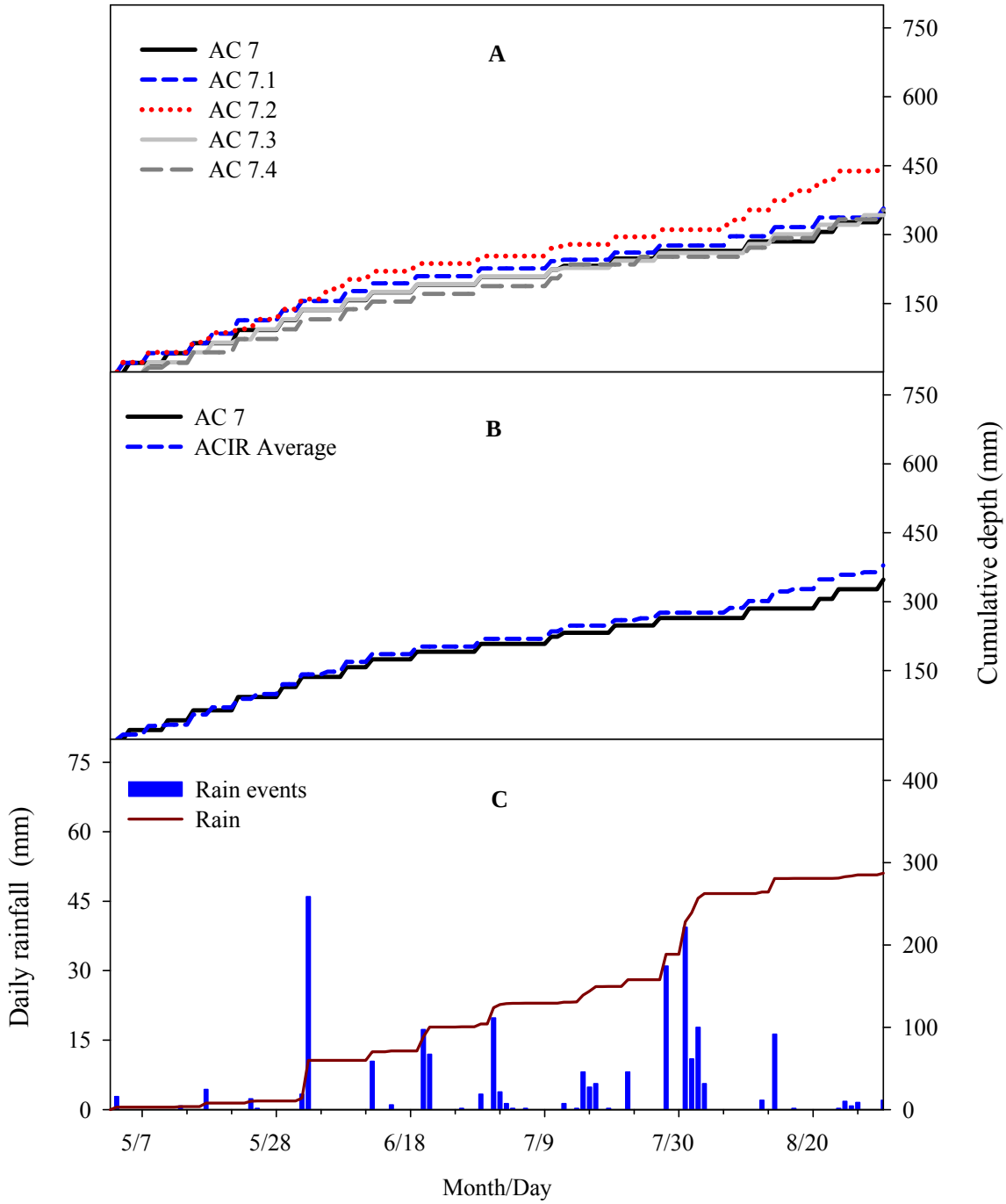


Figure 2-25. Cumulative irrigation applied during S07 by treatments A) AC 7 (sensor in block 2), AC 7.1, AC 7.2, AC 7.3 and AC7.4 B) AC 7 and AC IR average. Total cumulative rainfall and daily rainfall are also shown (C). AC 7.1 through AC 7.4 are the four plots that constitute the AC IR treatment.

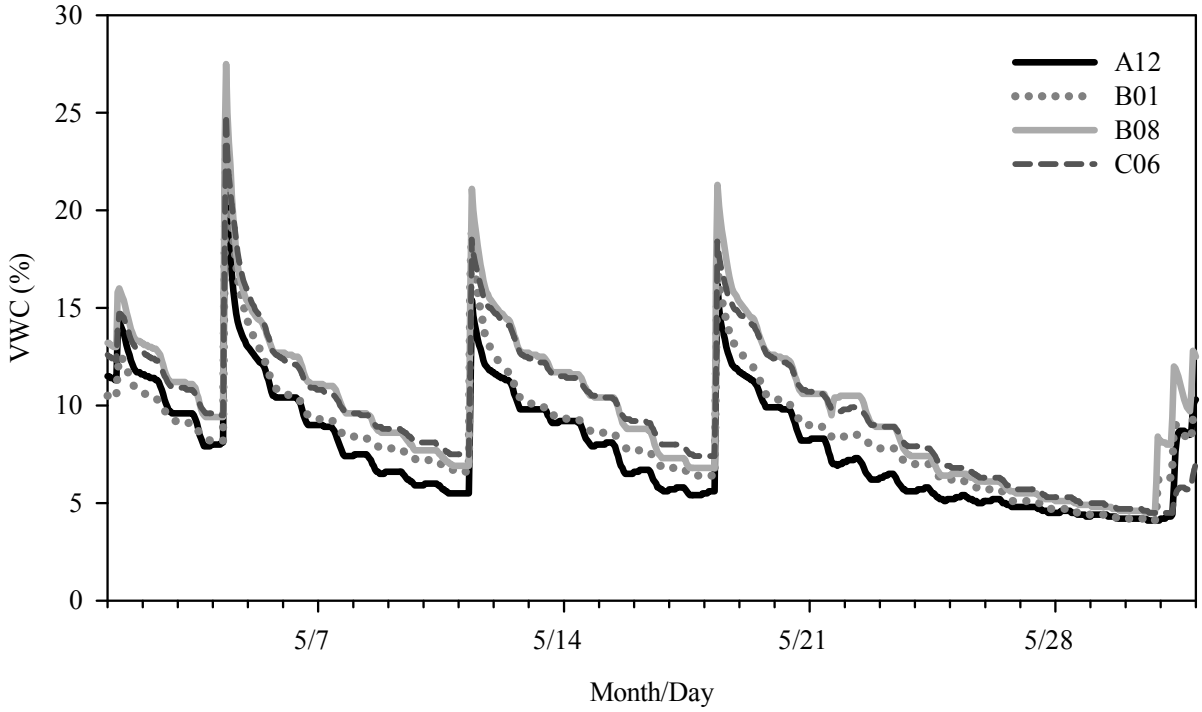


Figure 2-26. Volumetric water content (VWC; %) for RS1-3mm plots before supplemental irrigation was applied during S07 treatment period.

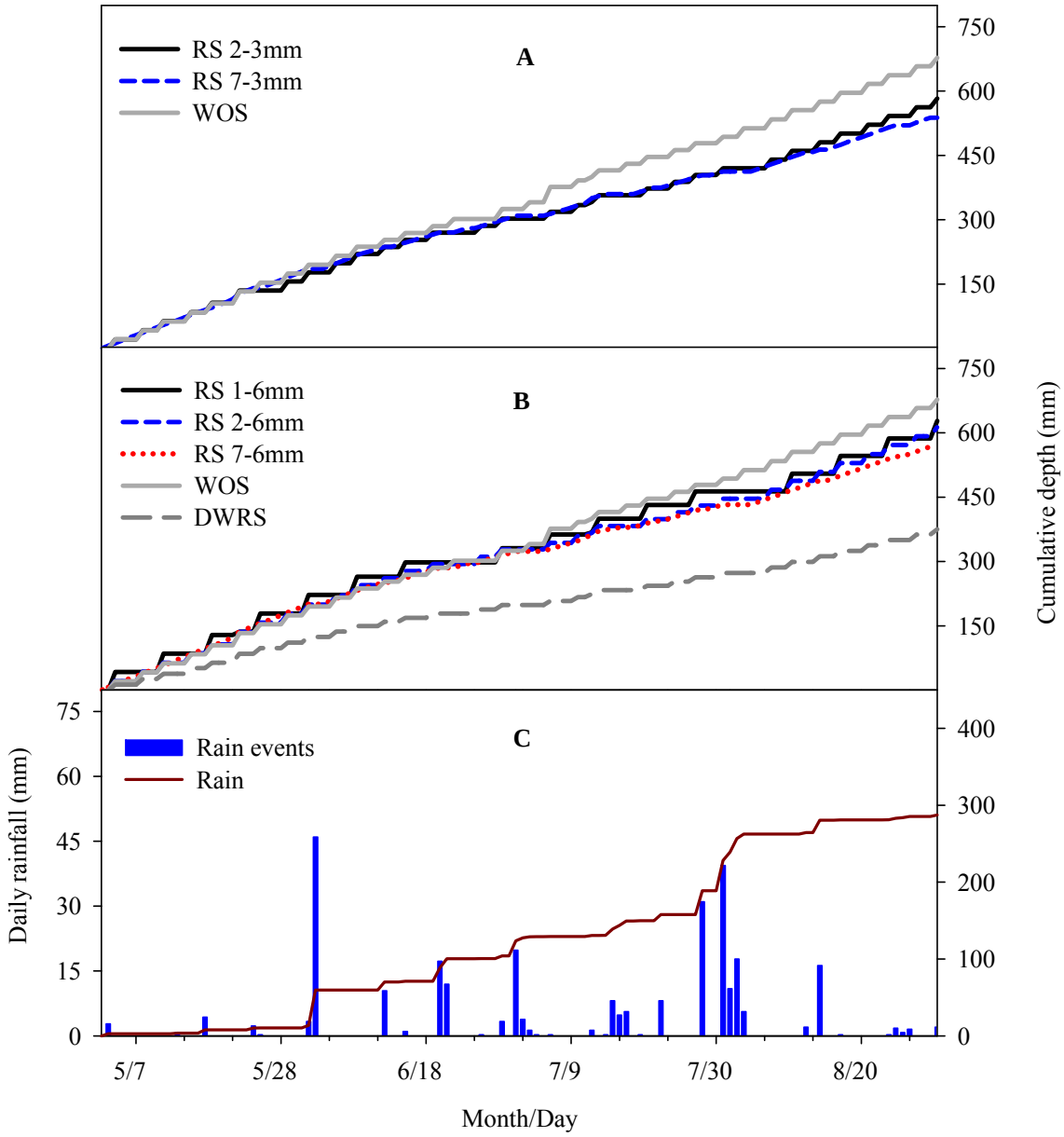


Figure 2-27. Cumulative irrigation applied during S07 by treatments A) RS2-3mm, RS7-3mm B) RS1-6mm, RS2-6mm, RS7-6mm and DWRS. Total cumulative rainfall and daily rainfall are also shown (C). Treatment RS 1-3mm was ended early due to poor turf quality.

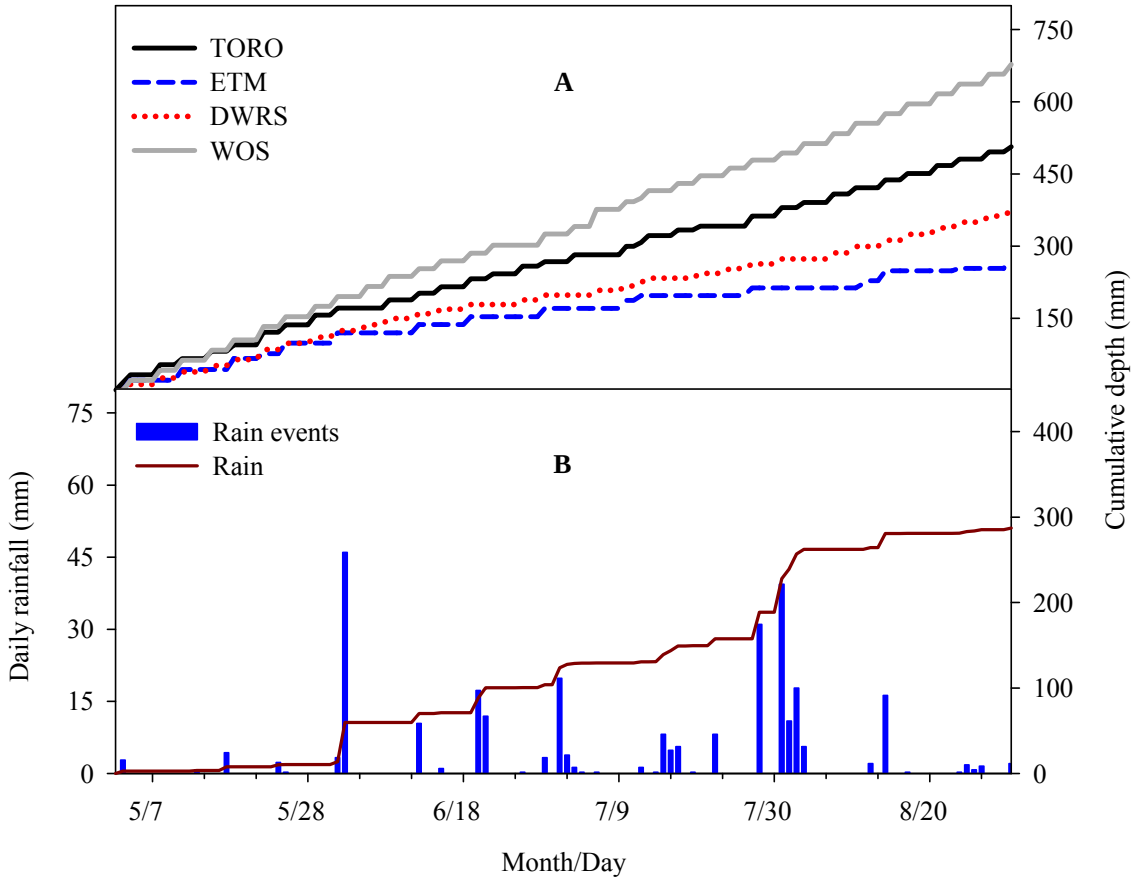


Figure 2-28. Cumulative irrigation applied during S07 by treatments A) TORO, ETM and DWRS. Total cumulative rainfall and daily rainfall are also shown B).

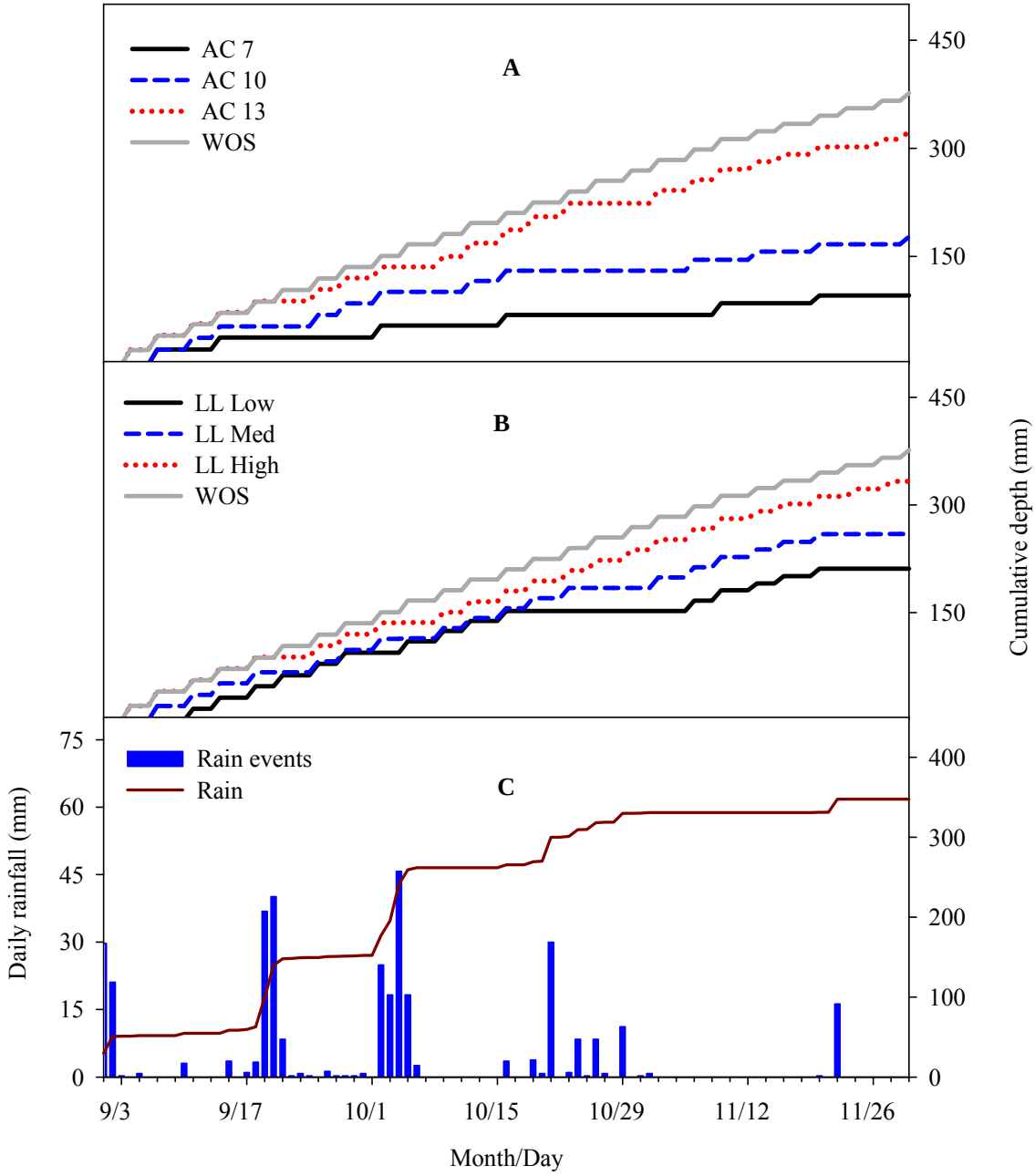


Figure 2-29. Cumulative irrigation applied during F07 by treatments A) AC 7, AC 10 and AC 13 and B) LL Low, LL Med and LL High. Total cumulative rainfall and daily rainfall are also shown C).

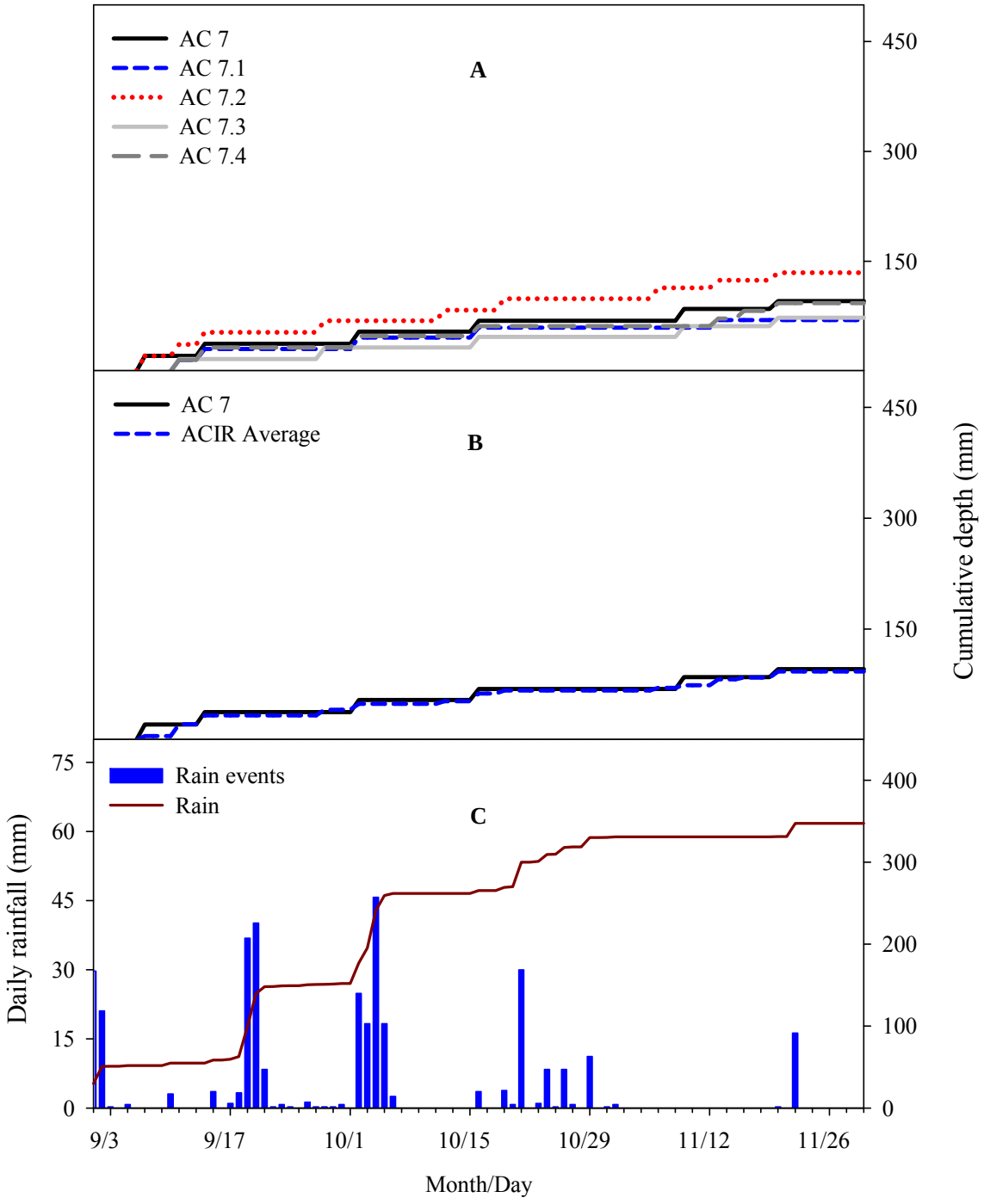


Figure 2-30. Cumulative irrigation applied during F07 by treatments A) AC 7 (sensor in block 2), AC 7.1, AC 7.2, AC 7.3 and AC7.4 B) AC 7 and AC IR average. Total cumulative rainfall and daily rainfall are also shown C). AC 7.1 through AC 7.4 are the four plots that constitute the AC IR treatment.

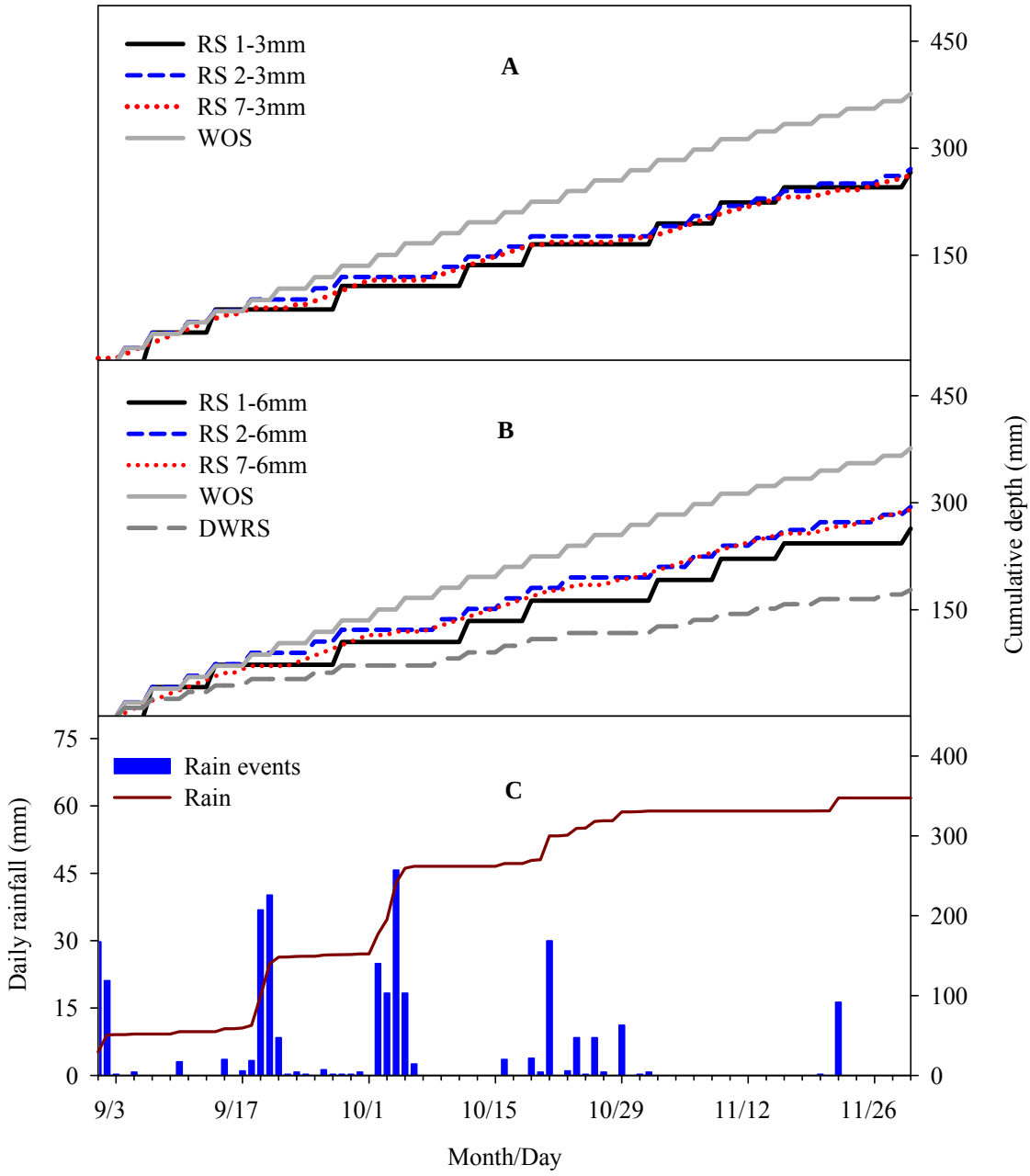


Figure 2-31. Cumulative irrigation applied during F07 by treatments A) RS1-3mm, RS2-3mm, RS7-3mm B) RS1-6mm, RS2-6mm, RS7-6mm and DWRS. Total cumulative rainfall and daily rainfall are also shown C).

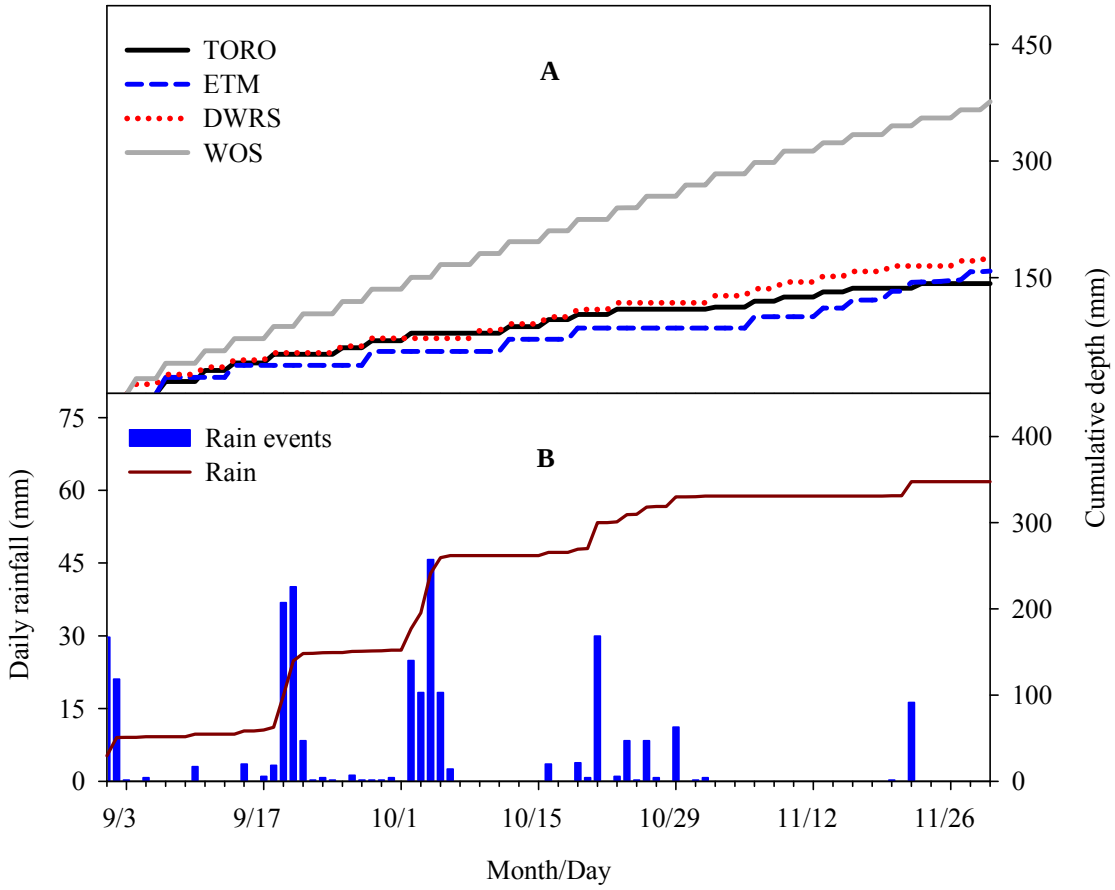


Figure 2-32. Cumulative irrigation applied during F07 by treatments A) TORO, ETM and DWRS. Total cumulative rainfall and daily rainfall are also shown B).

CHAPTER 3
SOIL MOISTURE SENSOR IRRIGATION CONTROL PERFORMANCE AND ACCURACY

Introduction

There are various ways to measure soil moisture content including both direct and indirect methods. Direct methods, such as gravimetric measurements obtained by taking soil samples, tend to be more disruptive to the soil and do not provide instantaneous measurements. Indirect methods, such as soil moisture sensors, can obtain instant information concerning the soil moisture present without disturbing the soil. Soil moisture sensors measure water content in the soil using either tensiometric or volumetric methods. Tensiometric sensors estimate soil water by measuring capillary effects in the soil as water moves in and out of the soil profile. Some volumetric sensors are designed to estimate soil water content based on the dielectric constant of the soil (Muñoz-Carpena et al., 2005).

Volumetric Soil Moisture Sensors

The relationship between the dielectric constant and the volumetric water content (VWC; reported as volume of water per volume of sample in this chapter) of soil was demonstrated by Topp et al. (1980). The dielectric constant is dependent on the type, composition and the moisture content of the soil. Soil is a composite material consisting of water, air and minerals and each of these components affect the dielectric constant of the soil as a whole. The dielectric constant of the soil increases as the water content of the soil increases, this is due to the fact that the dielectric constant of water is much larger ($K_a = 81$) then the other soil components ($K_a = 2$-5 for minerals and 1 for air) and so the presence of water in the soil profile has a much stronger impact on the dielectric constant compared to other properties of the soil (Muñoz-Carpena et al., 2005).

Soil moisture sensor irrigation controllers consist of one or more sensors and a controller. In many brands, the controller is a separate attachment to the time clock. In some brands, the controller is embedded within a single control package that has time clock functionality. In a bypass configuration (Dukes, 2005), soil moisture based irrigation controllers use the reading from a soil moisture sensor to bypass time-based irrigation events if the moisture content at the beginning of the irrigation event is higher than a pre-set threshold value for moisture content. A single sensor can be used to set the irrigation for many zones or more than one sensor can be used to irrigate multiple zones. In the case of one sensor for several zones, the zone that is typically driest, or most in need of irrigation, should be selected for placement of the sensor in order to ensure the entire irrigated area is provided with adequate irrigation.

Previous studies have shown that soil moisture sensors are an effective tool for reducing the amount of residential water used for landscape irrigation. Cardenas-Lailhacar et al. (2008) found that water savings for three commercially available soil moisture sensors ranged from 69% to 92% without adversely affecting turf quality in bermudagrass (*Cynodon dactylon*). One sensor tested in the study did not perform as well as the other three sensors tested saving between 27 and 53%. This study was performed in Gainesville, FL in a field setting during rainy weather with rainfall frequency that was normal for that region.

Soil moisture sensor controllers have shown the potential for water conservation when installed in the field. Allen (1997) performed a one year study in Utah looking at soil moisture based control systems in a residential setting. A total of 27 homes had sensors installed and water applied was compared with 39 homes without sensors. The homes with sensors installed used 10% less water than the homes in the control group while maintaining adequate turf quality. The homes with sensor also had a 10% reduction in water use compared to their previous water

use in 1994 and 1995. Researchers in the project used a "hands off" approach to observe results when the homeowners were allowed to operate the system on their own. A study conducted in Pinellas County, FL from June 2006 to March 2007 found that homes with soil moisture sensors installed applied 51% less water compared to homes that used only a time-clock to control irrigation (Haley and Dukes, 2007). Qualls et al. (2001) noted, during a 1997 study involving homeowners in Colorado, that homeowners and landscape contractors were reluctant to use soil moisture sensors due to concerns with the possible life expectancy and difficulty of use of the devices. The study was performed using granular matrix soil moisture sensors which were installed for three years in 23 sites. During the three year project no sensors had to be replaced and researchers reported time required for the initial installations was minimal. Compared to theoretical water requirement the sensors reduced water applied by an average of 73%.

The accuracy of soil moisture sensors affects the ability of the sensor to produce water savings without damage to the turfgrass. Ideally, the sensors allow irrigation when soil moisture reaches a specified threshold. If there is error present in the VWC reading of the soil this can affect the threshold at which irrigation is allowed. Sensor readings that are lower than actual VWC could lead to excessive water application. If the reading of the sensor is higher than actual conditions this could cause irrigation to be bypassed too often, possibly causing damage to turf quality. The difference between the actual VWC and the SMS reading is equal to half the width of the confidence interval of the sensor (Schmitz and Sourell, 2000).

Schmitz and Sourell (2000) looked at the variability in soil moisture measurements made by three types of soil moisture sensors, TDR, granular matrix (GMS), and electrical conductivity (EC). Twenty five sensors of each type were buried in loamy sand under turf at 15 cm and readings were taken daily for ten weeks. The width of the confidence interval for each of the soil

moisture sensors was calculated using the mean absolute deviation of the measurements. The findings showed that the mean absolute deviation within the data from the various sensors was up to 16% of the depth of available water, leading to the need for multiple sensors to ensure adequate irrigation scheduling. The largest scatter was seen in the data collected using the EC sensors.

A study conducted by Blonquist et al. (2005) compared performance characteristics of the Acclima Digital TDT sensor with two TDR sensors. The study showed that all of the sensors operated within ±3 permittivity (or dielectric constant) units of each other, with a testing permittivity range of 9-80. They also saw that the frequency of the TDT sensor was similar to that of the TDRs. In additional testing on the Acclima Digital TDT, Blonquist et al. (2006) found that plots where irrigation was scheduled based on ET applied 16% more water than plots controlled by the TDT system. The TDT system reduced water applied by 53% when compared to a fixed irrigation rate of 55 mm/month. The researchers also used the HYDRUS-2D numerical simulation model to predict water content in the soil. The modeling showed that the TDT system applied water so that there was no drainage below the estimated root zone (30 cm). This study was conducted on Kentucky bluegrass (*Poa pratensis* L.) with silt loam soil in Utah over a period of 49 days during the months of August and September. The sensor was connected to an Acclima CS3500 controller (Acclima Inc., Meridian, ID) which uses two soil moisture thresholds one to initiate irrigation (during times specified by the user) and one to stop irrigation.

Tensiometers

Tensiometers estimate the amount of water present in soil by measuring the energy that would be required by the plant to extract water from the soil. These sensors consist of a porous ceramic cup connected to a vacuum gauge and these are attached by rigid tubing which is filled

with water (Or, 2001). Tensiometers have commonly been used for agricultural purposes, assisting farmers to make irrigation scheduling decisions.

Some research has been performed concerning the use of switching tensiometers for irrigation control purposes on turfgrass. One study by Augustin and Snyder (1984) looked at the use of these devices for irrigation on 'Tifgreen' Bermudagrass (*Cynodon dactylon C. transvaalensis*) with sandy soil conditions. The researchers found that water savings of between 42 to 95% were achieved in south Florida using the switching tensiometers compared to turfgrass maintained using typical golf course fairway management practices.

To measure the moisture content of soil, the porous cup of the tensiometer is buried in the soil at a particular measurement depth. For irrigation purposes the cup should be placed in the root zone of the plant. The ceramic cup allows water to move through it into unsaturated soil until the pressure in the tensiometer equilibrates with the pressure in the soil. The suction that is formed in the tensiometer due to the movement of water is equal to the matric potential of the soil (Or, 2001). Irrigators using tensiometers usually select a maximum depletion allowed based on the soil water characteristic curve and when the soil water content reaches the allowed depletion, irrigation is applied. Optimally irrigation is applied so as to bring the soil moisture content of the soil up to field capacity (FC).

Field capacity is the soil water content left in the soil after gravity drainage has occurred and it is based on the texture and structure of the soil. Typically field capacity for sandy soils is based on the soil moisture content when the matric potential is 10 kPa (Obreza et al., 1997). The permanent wilting point (PWP) is the soil water content at which no water is available to the plant and is equal to a matric potential of 1,500 kPa (Haman and Izuno, 1993; Paramasivam,

2000). Water-filled tensiometers only measure matric potentials that are in the range of 0 to -85 kPa (Mullins, 2001).

The objective of this research was to evaluate the accuracy and effectiveness of two commercially available soil moisture sensors when considering: i.) the VWC at which the different SMS controllers bypass timed irrigation events compared to the set point used on the controller and ii) the absolute soil VWC corresponding to readings of a relative soil moisture sensor controller.

Materials and Methods

Field Testing

This study was performed at the Plant Science Research and Education Unit in Citra, Florida. There were four treatment periods during 22 April 2006 to 30 June 2006 (S06), 23 September 2006 to 15 December 2006 (F06) and 1 May 2007 to 31 August 2007 (S07) and 1 September 2007 to 30 November 2007 (F07). The experimental area is shown in Figures 2-1, the SMS controllers and the irrigation timer set is shown in Figures 2-10 and 2-11. The three mapped soil types present in the research area are Tavares sand, Candler sand, and Arredondo fine sand (Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults) (USDA, 2006).

Soil testing was performed at the research area to develop values for FC and PWP at the research site (see Soil Physical Properties, Chapter 2). Figure 2-6 shows the range of field capacities and permanent wilting points within the field and in each block. Both field capacity and permanent wilting point values increase moving across the field from west to east (moving from block 1 to block 4) as seen in Figure 2-6 (see Chapter 2). Due to the variation in soil water holding capacity across the field, the experimental treatments in the field were in a randomized block design. Blocks were established west to east, with the easternmost end of the field (block

3 and 4) having the highest soil water holding capacity and the blocks to the west having the lowest water holding capacity (blocks 1 and 2).

Two commercially available soil moisture sensors were tested: Acclima Digital TDT® RS500 (Acclima Inc., Meridian, ID.) and the LawnLogic® LL1004 (Alpine Automation, Inc., Aurora, CO.). Each soil moisture sensor (SMS) based system was tested at three different volumetric moisture content thresholds. The three VWC threshold settings were considered low (dry), medium, and high (wet) VWC conditions. The settings for the Acclima Digital TDT sensors were 7%, 10%, and 13% VWC. The LawnLogic, which uses site specific calibration methods, was set for relative low, medium and high levels of moisture content in the soil. The manufacturers suggest calibration 24 hours after a significant rainfall or irrigation event that fills the soil profile to field capacity. Once the calibration is performed, the controller has relative set points from 1 (dry) to 9 (wet). During calibration at field capacity, the sensor measured VWC is equated with a setting of 5 on the controller. The settings used as experimental treatments were 2, 5 and 8 for S06 and 4, 5 and 6 for all other testing periods.

Six of the SMS treatments utilized one sensor buried in the driest plot to control the irrigation for all plots in the treatment. All of these sensors were placed in the same block, which was selected based on soil moisture testing conducted previous to the experiment. One treatment, AC IR (threshold of 7%), was set up with each plot having its own sensor controlling the irrigation. These sensors were placed throughout the field, with one in each block. Acclima sensors were installed horizontally at a depth of 8 cm and the LawnLogic sensors were buried with rods placed vertically with the top of the rods buried at a depth of 6 cm.

Soil moisture sensors were connected to an irrigation timer to function in bypass mode operation so that a scheduled irrigation event would be bypassed if soil moisture exceeded the

soil moisture sensor threshold. The monthly irrigation schedule was based on recommendations for two-day-per-week operation by Dukes and Haman (2002b) and is presented in Table 2-3. The two-day-per-week operation was used to emulate typical water restrictions in Florida.

An additional treatment, WOS (without sensor) was established to monitor turf quality combined with water applied in plots irrigated twice weekly with the same schedule as the SMS treatments but without any control device. The final treatment was NON (non-irrigated) which was established as the control treatment receiving no irrigation. Treatment codes and descriptions are summarized in Table 3-1.

Water use was monitored using flow meters as discussed in Chapter 2. These flow meters were used to determine daily when irrigation was allowed or bypassed. The timing of irrigation events was compared to soil moisture data collected using time domain reflectometry (TDR) sensors (CS616 Water Content Reflectometer, Campbell Scientific, Logan, UT). Measurements made with the TDR probes are accurate +/-2.5% VWC (Campbell Scientific, Inc., 2006). These sensors were connected to a CR-10X datalogger. The TDR sensors were buried in the center of every plot with the top of the sensor at a depth of 8 cm and the bottom of the sensor at a depth of 18 cm. Figure 2-8 shows the burial of sensors in an experimental plot (see Chapter 2).

Volumetric water content readings were taken from the Acclima Digital TDT® RS500 controllers three times a week. Date and hour the readings were taken were recorded at the same time. These values were used for later comparisons with TDR data recorded for the plot in which each sensor was buried.

Turfgrass quality was rated at least once every two weeks during S06 and F06 and at least once a month during S07 and F07 based on NTEP procedures described in Chapter 2.

Statistical analyses were performed on the field collected data using Statistical Analysis System software (SAS Institute, Inc., Cary, NC) using the General Linear and Mixed models, proc GLM and proc MIXED. Duncan's Multiple Range Test was used to perform means separation and the differences between means for pairwise comparisons were performed with least-squares means. Water applied was analyzed weekly for each treatment period.

Laboratory Testing

Additional testing was performed on the LawnLogic® LL1004 (Alpine Automation, Inc., Aurora, CO.) in the Water Resources Lab at the University of Florida Agricultural and Biological Engineering Department, Gainesville, Florida. The testing was performed from 2 February 2007 to 8 March 2007. Arredondo fine sand (loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults) (USDA, 2006) soil profiles were collected and were hand packed into three PVC cylinders 0.30 m high and 0.285 m in diameter The total volume of these cylinders was 19.1 L and packing was intended to mimic the bulk density of soil in the field. The base of the cylinders was comprised of a ceramic plate that allowed suction to be applied to the bottom of the soil column using a vacuum pump. All of the buckets were connected using the one suction line. Suction was applied a maximum of ten minutes at a time.

Water content of the soil in the buckets was measured using two different methods and used to develop soil water characteristic curves. Three MLT-RSU model tensiometers (Irrometer Company, Inc., Riverside, CA) and one capacitance ECH_2O probe (Decagon Devices, Inc., Pullman, WA) were used in each bucket. Photos of experimental set up are shown in Figures 3-1 and 3-2. The documented accuracy of the tensiometers used is +/- 1.2 kPa. Soil moisture content measured by the ECH_2O probes was recorded by a HOBO Micro Station data logger (Onset Computer Corporation, Bourne, MA). The ECH_2O probes were buried at a depth of 5.0 cm to 8.9 cm horizontally with the thin edge oriented horizontally to prevent pooling of

water on the flat surface of the probe. The tensiometers were buried vertically with the top of the ceramic cup at depth of 6 cm. Data was collected from the tensiometers (Irrometer Company, Inc., Riverside, Calif.). All sensors were buried so that the center of the sensor was located at a depth of 8 cm (± 0.5 cm).

Each PVC cylinder contained one LawnLogic® LL1004 (Alpine Automation, Inc., Aurora, CO). LawnLogic sensors were buried at a 45 degree angle with the top of the sensor at 6 cm and the bottom of the sensor was at 10 cm (Figure 3-2). LawnLogic sensors were calibrated after saturating the buckets and applying a vacuum to each bucket. Soil water tension and VWC in the buckets at the time of calibration are shown in Figure 3-3. After calibration soil profiles were saturated again and readings were taken as the soil profile dried. Suction was applied for ten minutes on 2/2/2007 and for five minutes on 2/5/2007 and 2/6/2007 to bring the soil water content closer to field capacity. No suction was applied after LawnLogic sensors began reacting to soil moisture conditions. Due to the relative calibration and output method of LawnLogic sensors, testing of whether or not the controller would bypass irrigation was the only way to evaluate current soil moisture content. These values were on the 1 to 9 relative scale or dry to wet. The recordings were then compared to soil moisture content readings measured by the tensiometers and the GMS sensors.

Results and Discussion

Field Testing

Rainfall

Three of the four treatment periods were relatively dry compared to historical rainfall for the research area (see Chapter 2, Figure 2-13). During these testing periods total rainfall depths were less than half of the values of the historical rainfall received. Infrequent rainfall events and below average rainfall amounts led to dry conditions for the research site. The number of days

per month with a rainfall event with a depth greater than 2.5 mm was fewer than the monthly historical averages for every time period except in F07 (see Chapter 2, Figure 2-13). During October 2007 there were 60 percent more rainy days than the historical average. Overall the treatment periods S06, F06 and S07 can be considered drier than normal for the testing area both in frequency of rainfall events and total depth received by the area.

Sensor performance and accuracy

SMS controllers are designed to be programmed with a threshold and if VWC is above that threshold than irrigation is always bypassed or when VWC is below that threshold the irrigation is always allowed. This would ensure adequate water in the soil for plant needs as long as the proper threshold was selected for the soil type. According to TDR collected soil moisture data there is a range in VWC values where SMS controllers will bypass irrigation. In this section TDR collected soil moisture data is correlated with the occurrence of irrigation for each plot to determine the range in VWC values over which the soil moisture sensors allowed or bypassed irrigation and with what accuracy and predictability. The range is shown graphically in Figures 3-4 through 3-19 as a shaded region. The upper bound of the region is the highest VWC at which the controller allows irrigation and the lower bound of the region is the lowest VWC at which the controller bypasses irrigation. Ideally, there would be no range or shaded region because the irrigated events occur when VWC is lower than the VWC at which events are bypassed and the delineation between the bypassed and irrigated events will be the programmed threshold of the SMS controller. There is only a value for range when the irrigated event occurs at a VWC greater than the bypassed event. A summary of the range for each sensor tested during the four testing periods is provided in Table 3-3.

Ten sensors were tested in S06 (7 Acclima and 3 Lawn Logic). Figure 3-4 shows the volumetric water content and the scheduled irrigation events, both bypassed and allowed, of the

AC IR treatment. The percentage of irrigation events bypassed by the AC IR sensors ranged from 25 to 40%. TDR data showed that the sensors bypassed events at similar water contents (6-7%) even though they produced different water savings ranging from 22 to 45% due to the different number of events bypassed. Differences in the number of irrigation events bypassed by the individual AC IR sensors are due to the inherent differences in soil moisture content across the field. Prior to testing, analysis showed that the soil in the eastern end of the experimental area had higher water holding capacities than the western end of the field. Blocks of treatments were established in the field from west to east. The four replications of the AC IR treatment had similar depths of weekly water application (Table 2-9; P=0.112). The AC 7 sensor bypassed 40% of the scheduled irrigation events (Table 3-2). Both the AC 7 controller and all of the AC IR controllers bypassed irrigation when the VWC was within ±2 of 7% VWC (Figures 3-4 and 3-5). Average weekly water applied between the AC 7 and AC IR treatments was similar during the S06 season, with AC IR applying only 2.5 mm/wk more water (Table 2-6; P=0.151).

The AC 10 sensor bypassed three irrigation events (Figure 3-6), which all occurred when soil moisture content was at 12% VWC or higher. Conversely, when the soil moisture content was 11% or lower, irrigation was allowed. AC 13 did not bypass any irrigation events during the testing period; this was due to the fact that VWC in the plot with the sensor was never above 11% at the time of irrigation.

The LawnLogic sensors did not bypass irrigation as predictably as the Acclima sensors during the S06 testing period. The range of VWC values at which the LL treatment sensors did not bypass irrigation was larger than the AC treatments. The LL Low sensor bypassed irrigation events when the soil VWC was as low as 5% and allowed irrigation when the VWC was as high as 10%. The range of the LL Low sensor can be seen graphically in Figure 3-5 alongside the

range for the AC 7 sensor. The AC 7 sensor acted more predictably; the highest VWC at which the SMS system allowed irrigation was 9.3% and the lowest VWC when irrigation was bypassed was 8.4%. The LL Med sensor bypassed 35% of the irrigation events (Table 3-2). The lowest VWC that sensor bypassed irrigation for was 7% and the highest the VWC at which the sensor allowed irrigation was 10% (Figure 3-6). LL High bypassed 10% of the scheduled irrigation events when the VWC was at 10% or 11% but allowed other irrigation events when the VWC was as high as 13% (Figure 3-7). All of the LawnLogic treatments bypassed more irrigation events during the S06 treatments than the comparable Acclima treatments.

In total, seven sensors were tested over the F06 treatment period (6 Acclima and 1 LawnLogic). The LL Low sensor bypassed all of the first four irrigation events during the first two weeks of the experiment, and during that time the VWC fell as low as 4%. Due to the low VWC, turfgrass quality declined and the treatment was ended in order to prevent total loss of the turfgrass. The threshold setting was adjusted (increased from a 2 to a 4) before F06 due to damage to turf quality during the S06 treatment period. Even after increasing the threshold setting, which should increase the soil moisture content at which the controller will bypass irrigation, irrigation still had to be applied to prevent death of the turfgrass. The AC IR sensors produced similar results in F06 compared to S06. The percentage of irrigation events bypassed by these sensors ranged from 30 to 74%, but these events were bypassed when VWC was close to 7% (±0.6%; Figure 3-8). The highest VWC value for all four controllers at which irrigation was allowed was 7.3% and the lowest VWC at which irrigation was bypassed was 6.3%. The medium threshold AC treatment (AC 10) bypassed eight irrigation events (35% of the total number of events) all when the soil VWC was at 12% or higher prior to irrigation (Figure 3-9). There was no range for this treatment during the F06 time period, because the irrigated events

never occurred at a VWC higher than that of any events that were bypassed. The AC 10 controller was set to bypass irrigation when VWC was greater than 10% and according to TDR data irrigation was allowed at VWC values of up to 11%. The sensor for treatment AC 13 bypassed three irrigation events (13% of the scheduled irrigation events) when the soil VWC was at 12% or higher prior to irrigation events (Figure 3-10). LL Med bypassed four of the scheduled irrigation events (17% of the total possible irrigation events) compared to AC 10 which bypassed eight irrigation events. The lowest VWC when irrigation was bypassed by LL Med was 8% and there was an irrigation event that was allowed by the controller when VWC was at 10% (Figure 3-9).

During S07 nine sensors were tested (7 Acclima and 2 LawnLogic). The LL Low (setting of 4) treatment was ended on 5/21 due to poor turf quality. From the start of the treatment period (5/2) until 5/21 the sensor had bypassed four irrigation events and allowed one. With little rainfall the soil VWC dropped as low as 3 to 4% in some of the plots (Figure 3-11). The range in VWC over which the LL Low controller bypassed irrigation for the two weeks where the treatment was allowed to run was 2.0%.

The AC IR sensors bypassed between 34 and 49% of the scheduled irrigation events and, considering all the sensors, the lowest VWC at which irrigation was bypassed was 5% and the highest VWC at which the irrigation was allowed was 7.5% (Figure 3-12). Similarly treatment AC 7 (same threshold setting as the AC IR controllers) bypassed 49% of the scheduled irrigation events and the range of values over which the events were bypassed was 5.9% (lowest bypassed) to 6.9% VWC (highest irrigated; Figure 3-13). Weekly water applied was similar between the AC 7 and the AC IR treatments, with the AC IR treatment applying 1.7 mm/wk more on average (Table 2-6; P=0.193).

Sensor AC 10 bypassed 20% of the possible irrigation events. The lowest VWC where the controller bypassed irrigation was 10.5% and the highest VWC at which the controller allowed irrigation was 11.4%, resulting in a range of 0.9 % VWC for the AC 10 SMS control system. The LL Med sensor also bypassed 20% of the irrigation events, but the range of the control system was much larger than for the AC 10 treatment (Figure 3-14). The lowest VWC at which LL Med bypassed irrigation was 6.7% and the highest VWC at which irrigation was allowed was 11.1%, which is a range of 4.4% VWC compared to 0.9% for AC 10. AC 13 bypassed 11% of the irrigation events while LL High did not bypass any irrigation events, even when VWC was as high as 16.0% (Figure 3-15).

For the F07 testing period all the sensor treatments ran the entire length of the testing period so there were a total of 10 sensors tested (7 Acclima and 3 LawnLogic). The AC IR treatment bypassed between 65 and 81% of the irrigation events, with an average of 75% for the entire treatment. The AC 7 treatment bypassed 77% of the possible irrigation events. The average weekly depth of water applied for the two treatments was similar with 9.1 mm/wk (AC 7) and 8.4 mm/wk (AC IR) (Table 2-6; P=0.665).

The highest value of VWC at which irrigation was allowed by the AC IR SMS systems, considering all sensors, was 6.8% and the lowest VWC at which irrigation was bypassed was 4.8%. The AC IR sensors averaged over all four treatment periods had similar VWC values at which they bypassed irrigation. The lowest VWC at which they bypassed irrigation was between 5.5% and 6.5% (P=0.995). The highest VWC at which the SMS controllers irrigated was between 6.4% and 7.3% (P=0.994). AC 7 bypassed 77% of the possible irrigation events and the range of soil VWC values at which irrigation was bypassed was 0.3% VWC (Figure 3-17). The highest value at which the AC IR controller treatment irrigated was 7.2% and the lowest value

seen when irrigation was bypassed was 6.7%. The LL Low sensor bypassed 42% of the irrigation events with a range of 4. The highest value at which the treatment irrigated was 11.1% and the lowest value seen when irrigation was bypassed was 6.7%. A comparison of the ranges over which the LL Low bypassed irrigation and the AC 7 sensor bypassed irrigation can be seen in Figure 3-17.

The AC 10 treatment bypassed 54% of the irrigation events, which is more than the LL Low sensor. The soil VWC values at which the sensor bypassed irrigation were between 10.9% and 11% (Figure 3-18). The LL Med sensor bypassed 31% of the irrigation events and the range of the soil moisture sensor was 1.7% VWC (Figures 3-18). AC 13 and LL High bypassed 19 and 12% of the irrigation events respectively (Figure 3-19). The AC 13 sensor bypassed five irrigation events while the LL High sensor bypassed 3. The range of the AC 13 sensor was 0.2% VWC and the range of the LL High sensor was 2.5% VWC. Figure 3-20 shows a graphical summary of the percentage of irrigation events bypassed by each sensor during the four testing periods.

Data collected from the AC sensors in the form of VWC (%) was compared with readings taken by the TDR sensors buried in the corresponding plots. This data was plotted with AC readings on the x-axis and TDR readings on the y-axis in a scatter plot. Ideally, the linear regression for the data when plotted will be a 1:1 line and all the data points will fall on the line. Figure 3-21 shows the scatter plots for all seven AC sensors along with the linear regression for each line. The values of r^2 for all of the sensors were between 0.77 and 0.89 which shows that there was close correlation between TDR data and AC data. While there was good precision of the sensors, compared to the TDR every sensor did not have good accuracy. Some of the AC sensors (AC 7.1, AC 7.2, AC 7.3 and AC 7.4) tended to read soil moisture higher than the TDR

sensors. The majority of readings taken with the AC 7, AC 10 and AC 13 sensors matched (majority of differences between readings equal to 0) the corresponding TDR reading. It is important to note that the most frequent differences for all of the sensors were within the range of accuracy of the TDR readings (+/-2.5% VWC).

Laboratory Testing Sensor Performance and Accuracy

Testing of three LawnLogic sensors showed differences in the performance between the sensors. Table 3-4 shows the threshold at which the sensors bypassed irrigation, values above the threshold would allow irrigation. Comparing the corresponding tensiometer and capacitance probe values for soil water content at the time of the bypass threshold reading gives an estimation of the performance of the sensors (Table 3-4). Using the tensiometer data and the capacitance probe data, the LawnLogic thresholds were plotted against soil tension (kPa) and VWC (%) in Figures 3-22 and 3-23. One of the capacitance probes (bucket 2) appears to have malfunctioned during testing and so was excluded from data analysis. Differences in the tensiometer readings for the different threshold levels of the three LawnLogic sensors were between 0.1 kPa and as high as 4.5 kPa, while the capacitance probes (only considering bucket 1 and bucket 3) showed differences of between 1.5% and 2.4% VWC. Some data is unavailable due to a missed reading of the LawnLogic controller when it changed from one threshold to another. At higher soil moisture contents there is a smaller range in performance between the three controllers that were tested. At the higher water contents the threshold settings (9 through 6) occurred at similar water contents, varying between sensors by 0 to 0.7 kPa. The lower threshold settings (6 through 1), which correlate with drier soil moisture conditions, had larger differences in the correlating soil moisture contents, varying by 1.4 to 4.5 kPa (Figure 3-24 and Table 3-4).

During laboratory testing it appeared that LawnLogic sensors had an error range that was within the range of the capacitance-based sensors used to measure VWC (+/-2.2%). However, in the field study they appeared to have a larger error range (1.7 to 5.4%) than during the laboratory testing. During the field study one sensor had an error range that was larger than the TDR used for measuring VWC (+/-2.5%).

Conclusions

The range of accuracy of the sensors tested, or the range over which they bypassed irrigation, was smaller for the AC sensors than the LL sensors. The range is the difference between the highest VWC (i.e. wet conditions) at which the sensor allowed irrigation and the lowest VWC (i.e. dry conditions) at which the sensor bypassed irrigation. The smallest error range for the AC sensors during all treatment periods was 0% and the largest was 3.4% VWC. The LL sensors had a range of between 2.0% and 4.4% VWC. During S06 the LL Low controller bypassed irrigation when soil VWC was as low as 4.7% (approximately 0.2 cm or 9% of total available water), leading to a less than acceptable average turf quality rating of 4.2 (Table 2-3). The same controller during the same testing period allowed irrigation when soil VWC was 8.6%.

Further testing of the Acclima sensors showed good precision of the sensors and good correlation between TDR and AC VWC data. The VWC data collected from the AC controllers was compared to the TDR data. The trend line for the data from the AC controllers had r^2 values between 0.77 and 0.89 indicating that the TDR data explained most of the variability in the AC data. While there was good precision of the sensors, compared to the TDR, accuracy varied. Some of the sensors tended to read VWC higher than the correlating TDR. Sensors for AC IR, AC 7 and AC 13 recorded lower values for VWC than the TDR readings, with average differences with the TDR readings of between 0.1% VWC and 2.3% VWC. One sensor (AC 10)

tended to record soil VWC values lower than the TDR by only 0.2%. The TDR sensors used in this testing have a published error range of +/-2.5% VWC (Campbell Scientific, Inc., 2006). This means that the AC sensors throughout the four seasons of testing had an error range that fell within the known range of accuracy of the TDR sensors used in testing.

Laboratory testing of the LawnLogic sensors showed differences in the tensiometer readings (soil water tension) between 0.1 kPa and as high as 4.5 kPa for the different threshold levels of the three LawnLogic sensors. At higher LawnLogic threshold levels (9 through 6) the corresponding soil water tension values varied between sensors by 0 to 0.7 kPa. The lower threshold settings (6 through 1), which correlate with drier soil moisture conditions, had larger differences in the correlating soil water tension, varying by 1.4 to 4.5 kPa. In both laboratory and field testing the LawnLogic SMS systems had wider ranges in accuracy compared to the Acclima SMS systems.

Table 3-1. Irrigation treatment codes and descriptions.

Treatment code	Treatment description
AC 7	Acclima set at 7% VWC
AC 10	Acclima set at 10% VWC
AC 13	Acclima set at 13% VWC
AC IR	Acclima set at 7% VWC individually controlled plots
LL Low	LawnLogic set at low setting[a]
LL Med	LawnLogic set at medium setting (#5)
LL High	LawnLogic set at high setting[b]
WOS	Without sensor
NON	Non-irrigated

[a]Setting was a #2 for S06 and then changed to #4 for F06, S07 and F07. [b]Setting was a #8 for S06 and then changed to #6 for F06, S07 and F07.

Table 3-2. Summary of the percentage of irrigation events bypassed by the different irrigation control devices.

	Irrigation events bypassed (%)			
Treatment	S06	F06	S07	F07
SMS-based				
AC 7	40	--*	49	77
AC 10	15	35	20	54
AC 13	0	13	11	19
AC IR	33	58	45	75
LL Low	60*	~	~	42
LL Med	30	17	20	31
LL High	--	--	0	12

* Treatments that produced less than acceptable turf quality. ~ Treatments that were ended before the treatment period was over. -- Treatments where the irrigation system was malfunctioning. --*Sensor was installed incorrectly.

Table 3-3. Summary of the range in volumetric water content over which the soil moisture sensor controllers bypassed irrigation. The range is the difference between the VWC at which the SMS controller always irrigated and at which it always bypassed irrigation.

	Threshold range (% VWC)				
	S06	F06	S07	F07	Average
AC 7	0.9	/*/	1.0	0.5	*NA*
AC 10	0.4	0.0	0.9	0.1	0.4 ***bc***
AC 13	--*	0.0	0.0	0.2	*NA*
AC 7.1	0.0	0.1	0.1	0.0	0.05 ***c***
AC 7.2	1.9	0.0	0.5	0.0	0.6 ***bc***
AC 7.3	1.5	0.5	1.5	1.5	1.3 ***b***
AC 7.4	1.0	0.7	1.3	0.1	0.8 ***bc***
LL Low	3.9	*	*	4.4	*NA*
LL Med	2.9	2.0	4.4	1.7	2.8 ***a***
LL High	5.4	--	--*	2.5	*NA*

/*/ Sensor installed incorrectly. --* Controller did not bypass any irrigation events. * Treatments ended early during both F06 and S07 due to poor turf quality. In F06 the treatment did not have a range during the time it was operational because irrigation was never allowed. In S07 the range for the two weeks where the treatment was allowed to run was 2.0. -- Excluded in F06 due to malfunctions in the irrigation system. *NA* Treatments that did not have values during all treatment periods.

Table 3-4. Summary of laboratory testing results for LawnLogic soil moisture sensors. Threshold at which the sensor bypassed irrigation compared to the corresponding VWC values measured using capacitance based soil moisture sensors, and the soil water tension values measured using tensiometers.

LawnLogic threshold 1 to 9 scale	Volumetric water content (in buckets 1 through 3) (%)			Soil water tension (in buckets 1 through 3) (kPa)		
	1	2	3	1	2	3
9	9.1	*NA*	--	6.7	6.0	--
8	--	*NA*	11.2	--	6.3	6.3
7	7.8	*NA*	10.2	7.5	--	6.8
6	7	*NA*	9.0	8.5	--	7.2
5	6.8	*NA*	8.5	8.8	7.3	7.3
4	5.8	*NA*	--	10.6	8.1	--
3	5	*NA*	6.5	12.9	9.0	8.4
2	--	*NA*	--	--	9.3	--
1	--	*NA*	5.4	--	11.7	10.3

VWC and soil water tension values have a possible range of ±2.2% and ±0.05 kPa. *NA* indicates that values were excluded due to a malfunction in the capacitance based probe. -- Reading was missed and is not available for analysis.

Figure 3-1. Image of bucket used in laboratory testing of LawnLogic sensors including (1) a LawnLogic sensor, (2) a capacitance based soil moisture sensor and (3) a tensiometer.

Figure 3-2. Image of the controller and datalogger used for laboratory testing of the LawnLogic sensors. Shown are the (1) LawnLogic controller and the (2) Watermark monitor (datalogger).

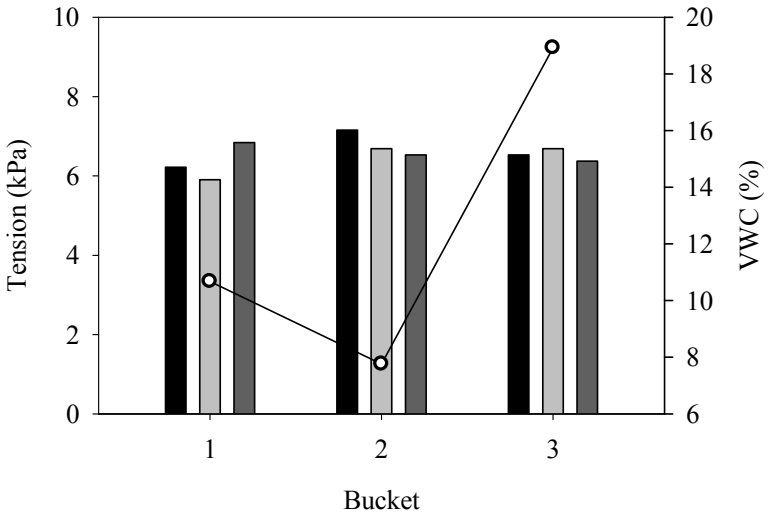


Figure 3-3. Water content, after LawnLogic calibration, measured by three tensiometers (bars) and by the capacitance based soil moisture sensor (circles) in each of the buckets used for LawnLogic testing. Tensiometer readings are in units of kPa and capacitance probe readings are in percent volumetric water content (VWC; %).

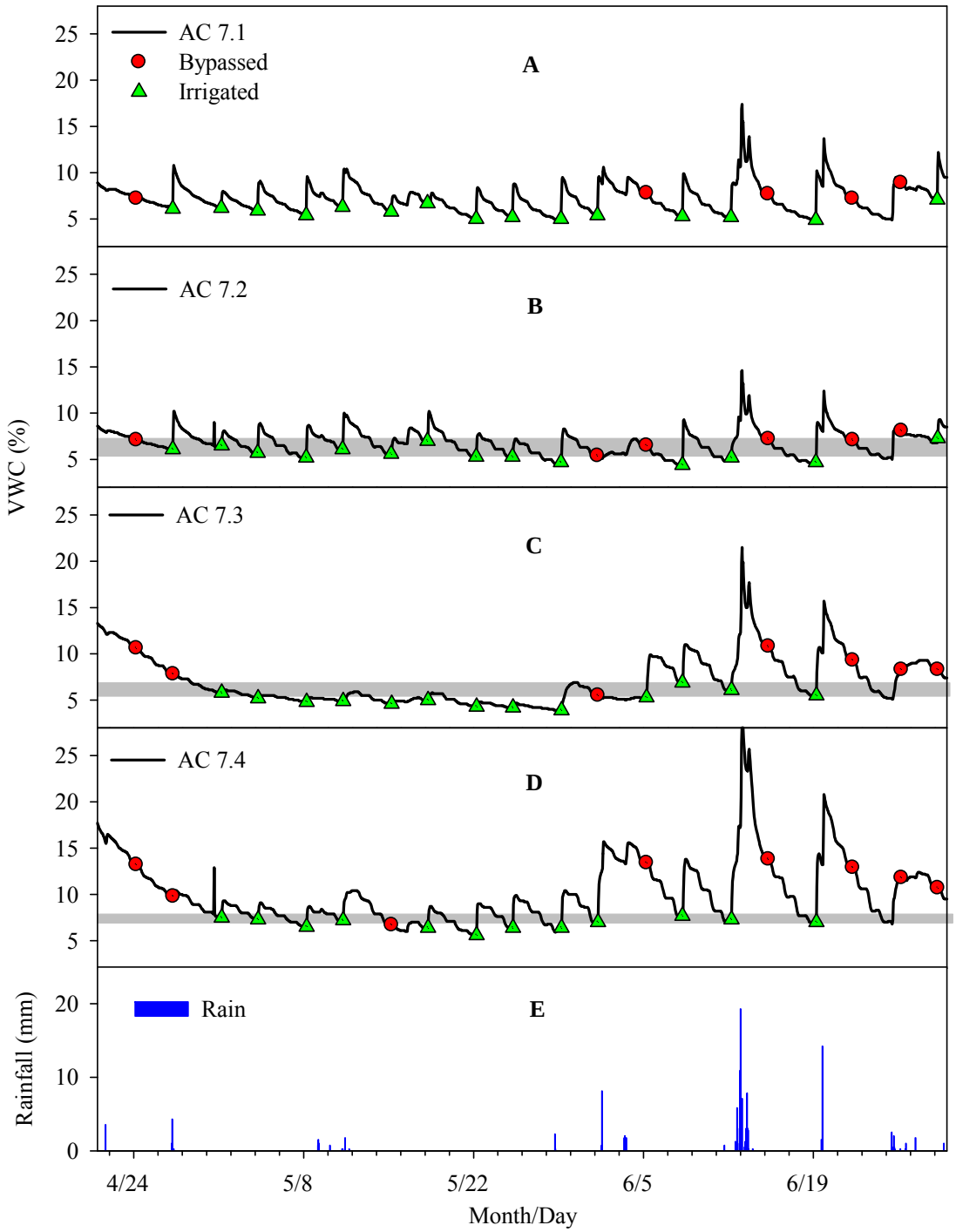


Figure 3-4. Volumetric water content (VWC; %) for plots in the AC IR treatment (A) AC 7.1, (B) AC 7.2, (C) AC 7.3 and (D) AC 7.4 in S06. Triangles mark irrigation events allowed while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below, irrigation was always allowed. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (E).

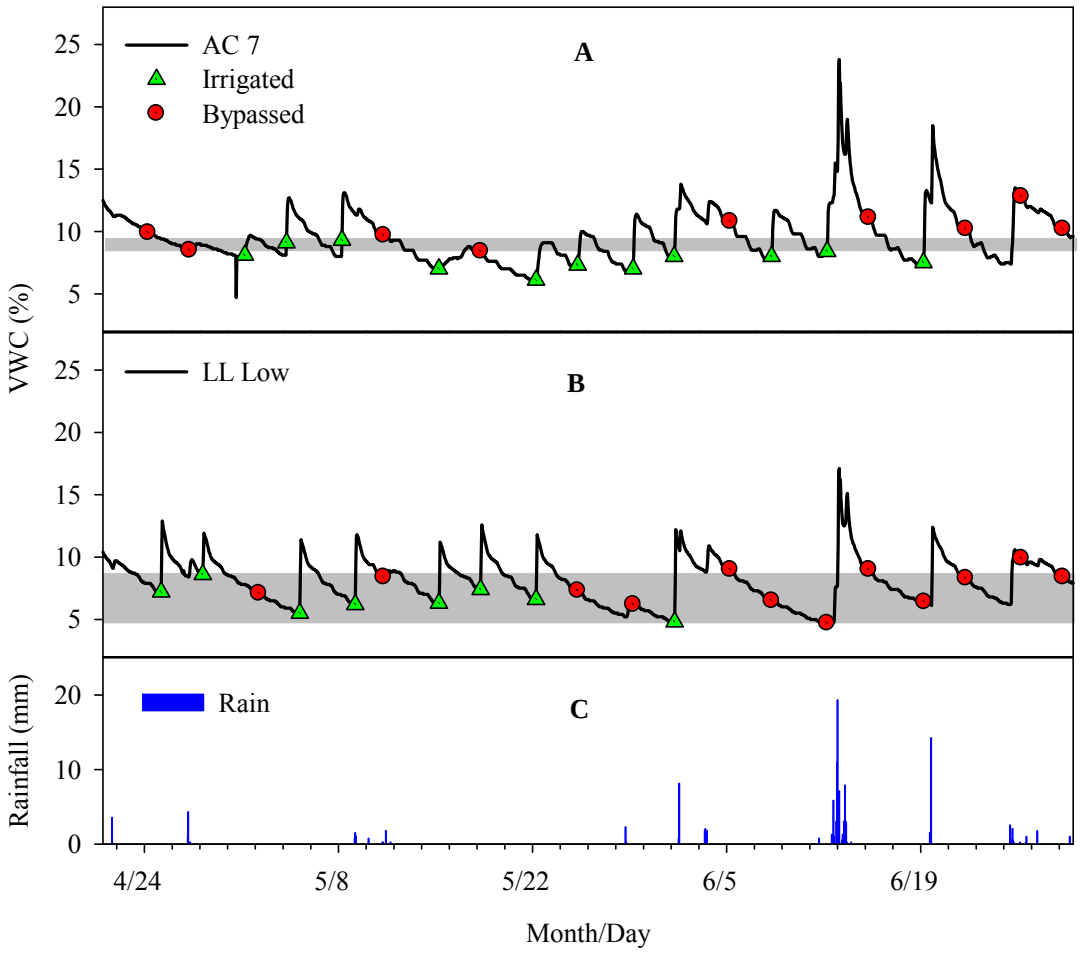


Figure 3-5. Volumetric water content (VWC; %) for the treatments A) AC 7 and B) LL Low in S06. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown C.

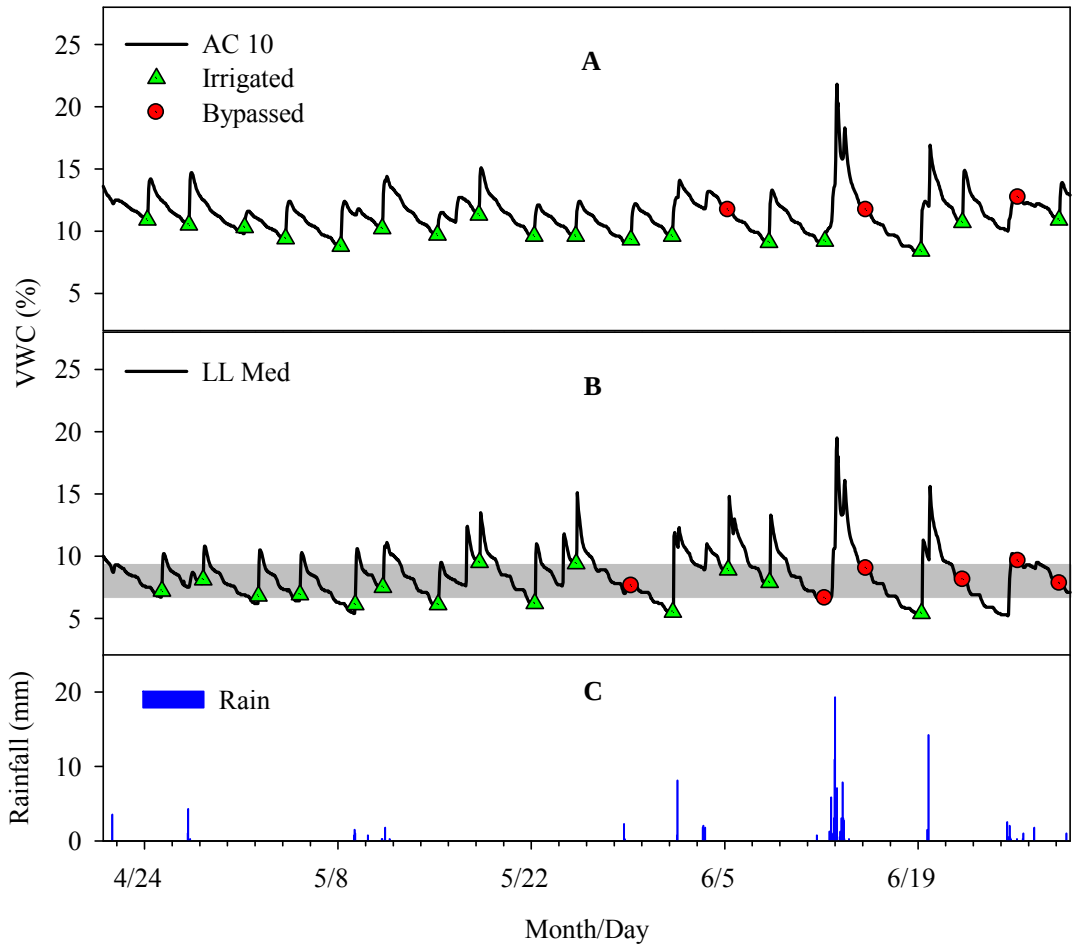


Figure 3-6. Volumetric water content (VWC; %) for the treatments A) AC 10 and B) LL Med in S06. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (C).

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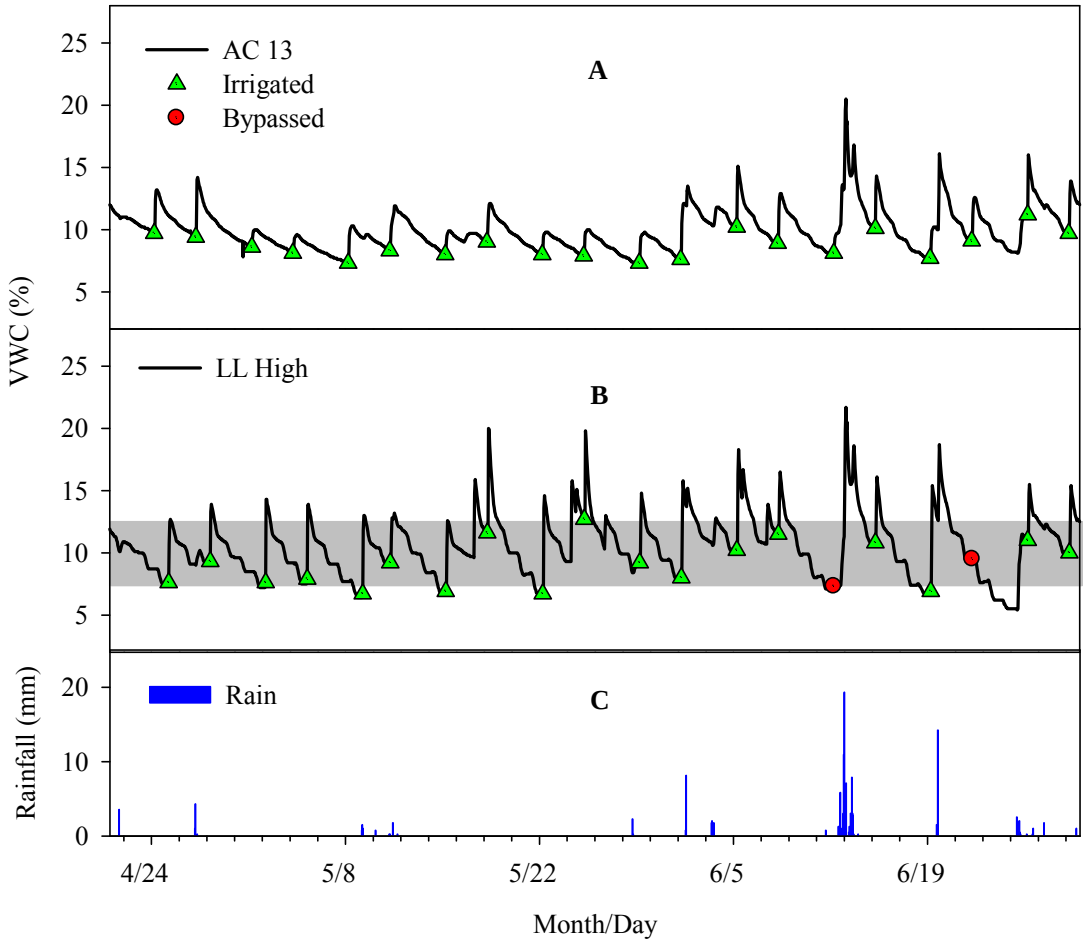

Figure 3-7. Volumetric water content (VWC; %) for the treatments A) AC 13 and B) LL High in S06. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (C).

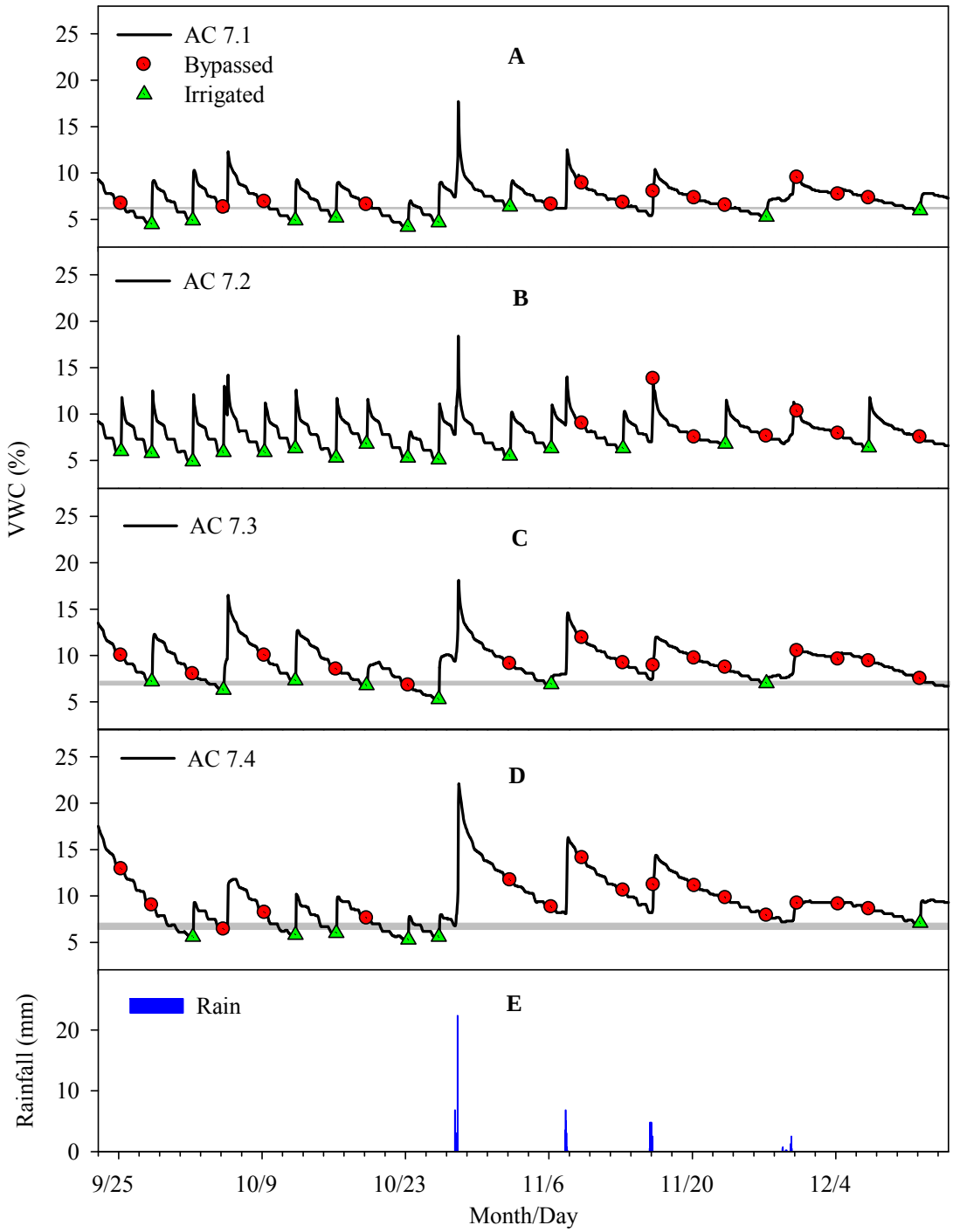

Figure 3-8. Volumetric water content (VWC; %) for the plots in the AC IR treatment A) AC 7.1, B) AC 7.2, C) AC 7.3 and D) AC7.4 in F06. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (E).

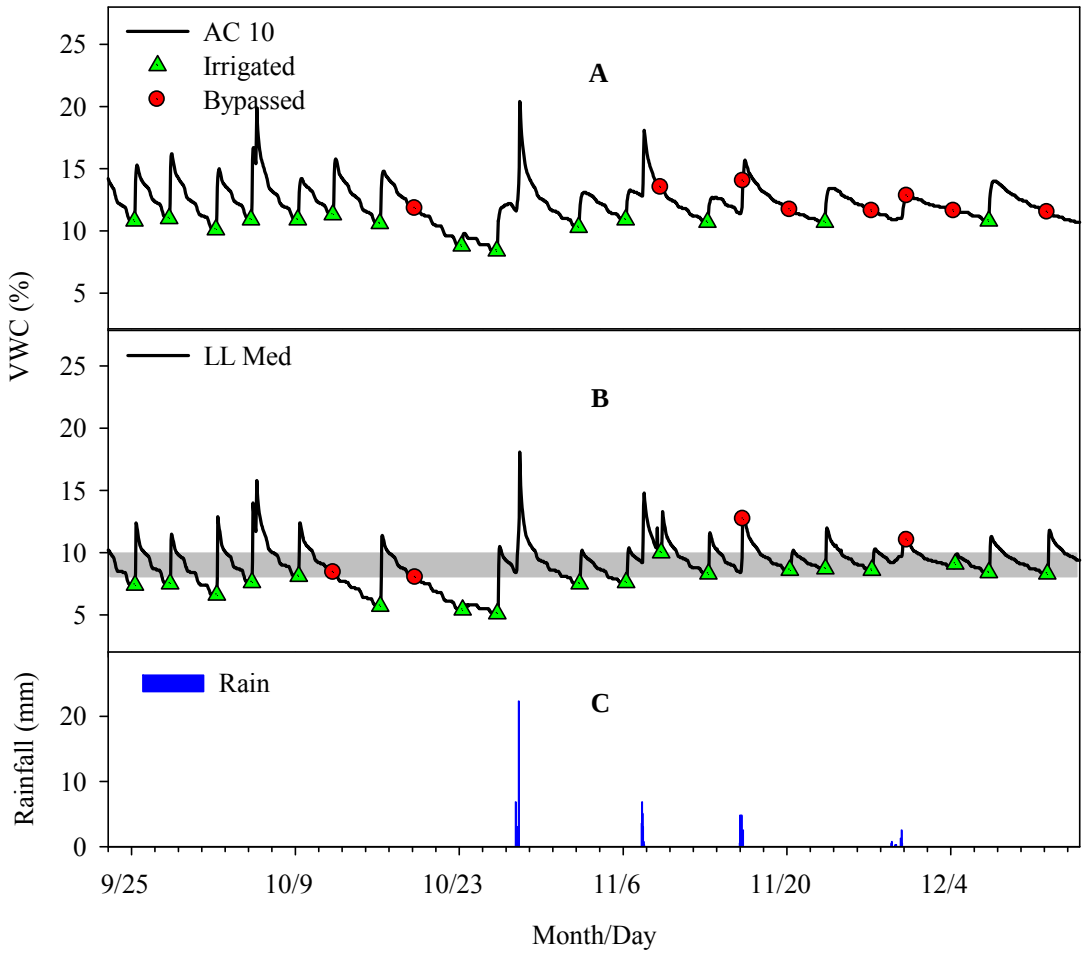

Figure 3-9. Volumetric water content (VWC; %) for the treatments A) AC 10 and B) LL Med in F06. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (E).

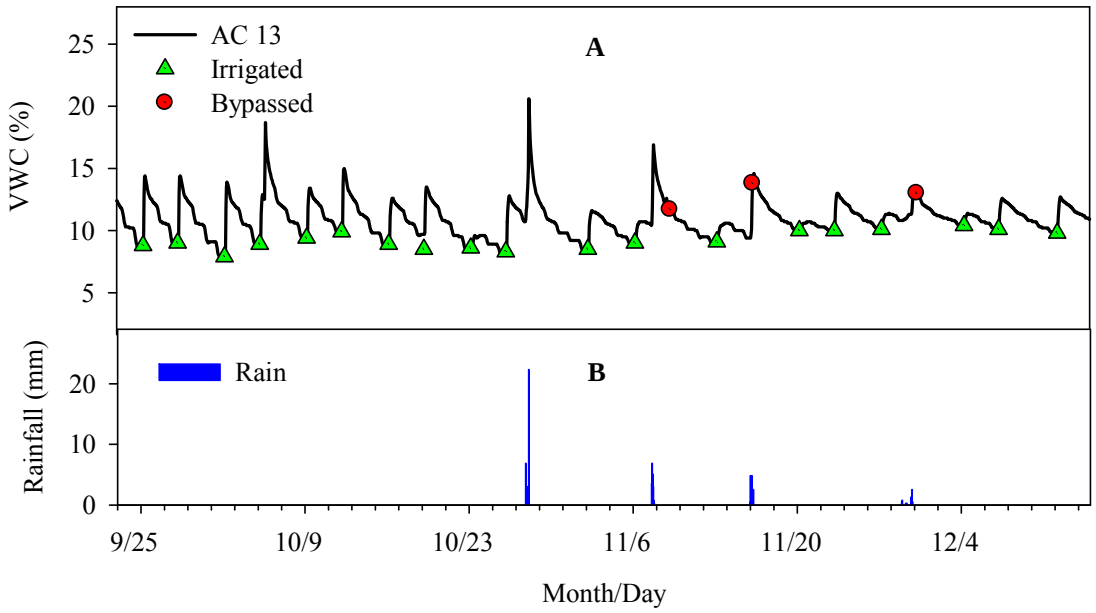

Figure 3-10. Volumetric water content (VWC; %) for the treatment A) AC 13 in F06 along with B) daily rainfall. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. There is no shaded region because bypassed irrigation events always occurred at higher VWC values than irrigated events. On 10/25 there was a power outage so all treatments went without irrigation on that day.

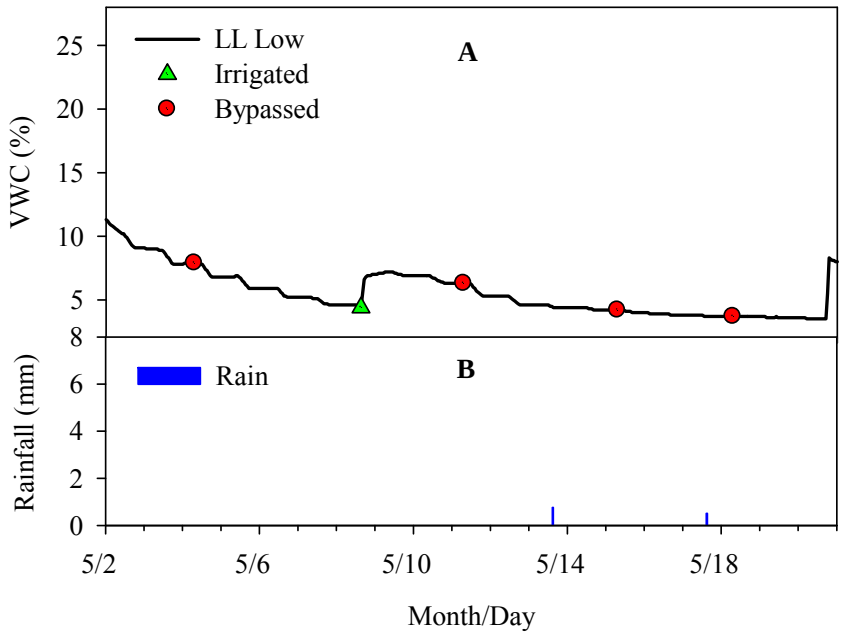

Figure 3-11. Volumetric water content (VWC; %) for the LL Low treatment A) at the beginning of the S07 treatment period. Triangles mark irrigation events allowed by the sensor while circles mark the irrigation events bypassed. Daily rainfall is also shown (B).

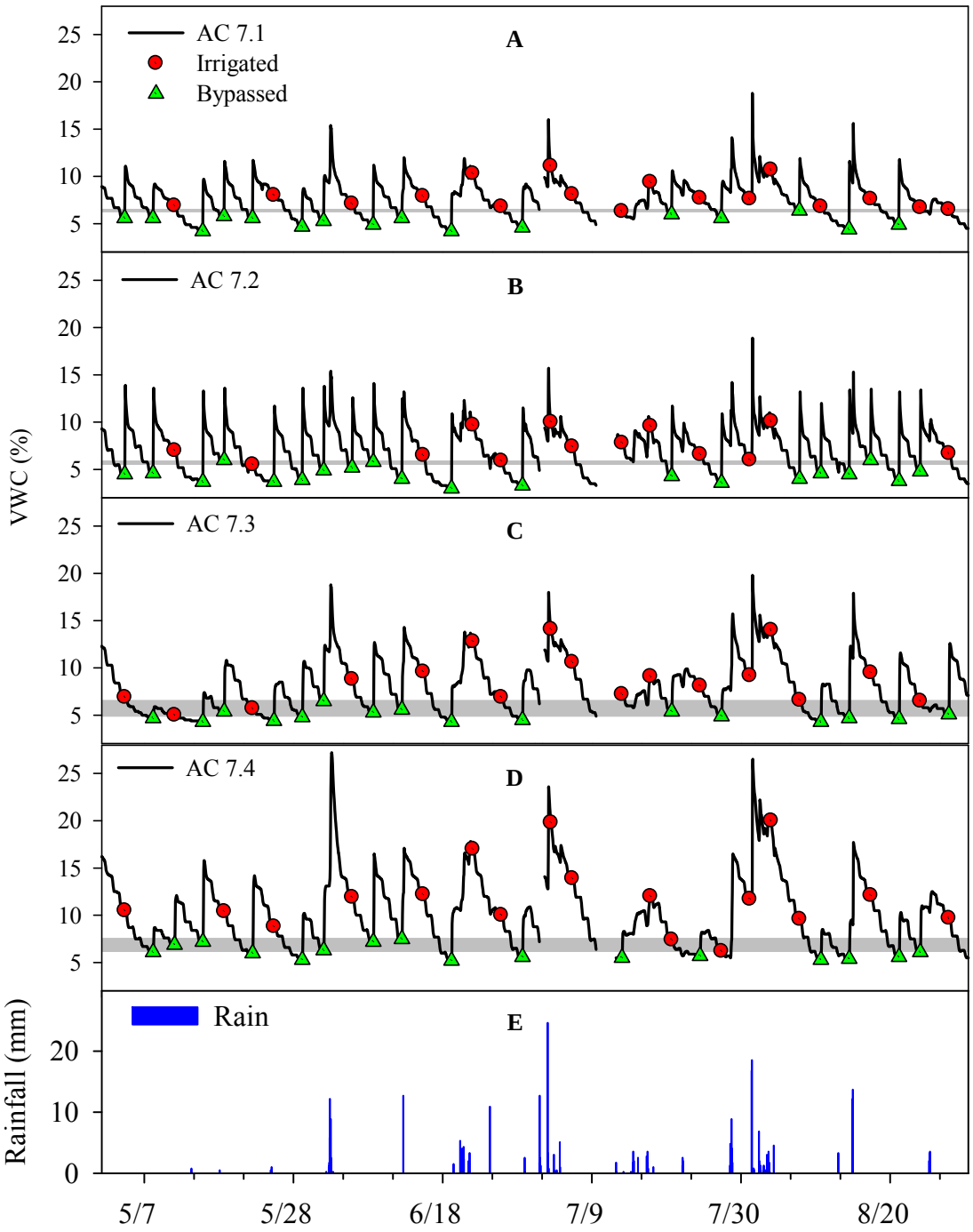

Figure 3-12. Volumetric water content (VWC; %) for the plots in the AC IR treatment A) AC 7.1, B) AC 7.2, C) AC 7.3 and D) AC7.4 in S07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (E).

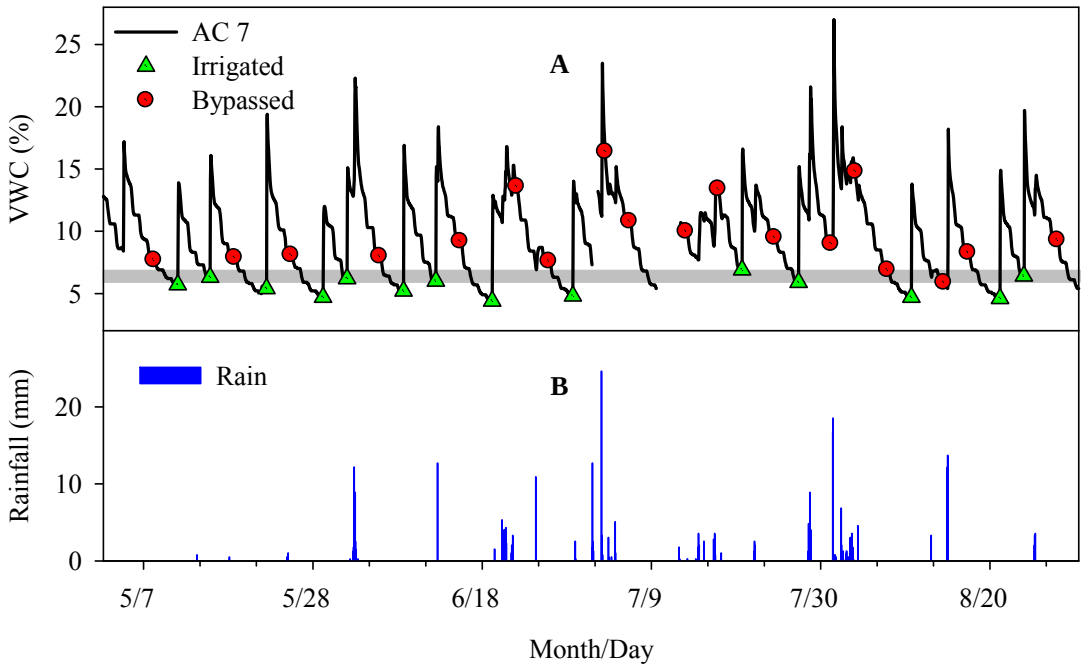

Figure 3-13. Volumetric water content (VWC; %) for treatment A) AC 7 in S07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (B).

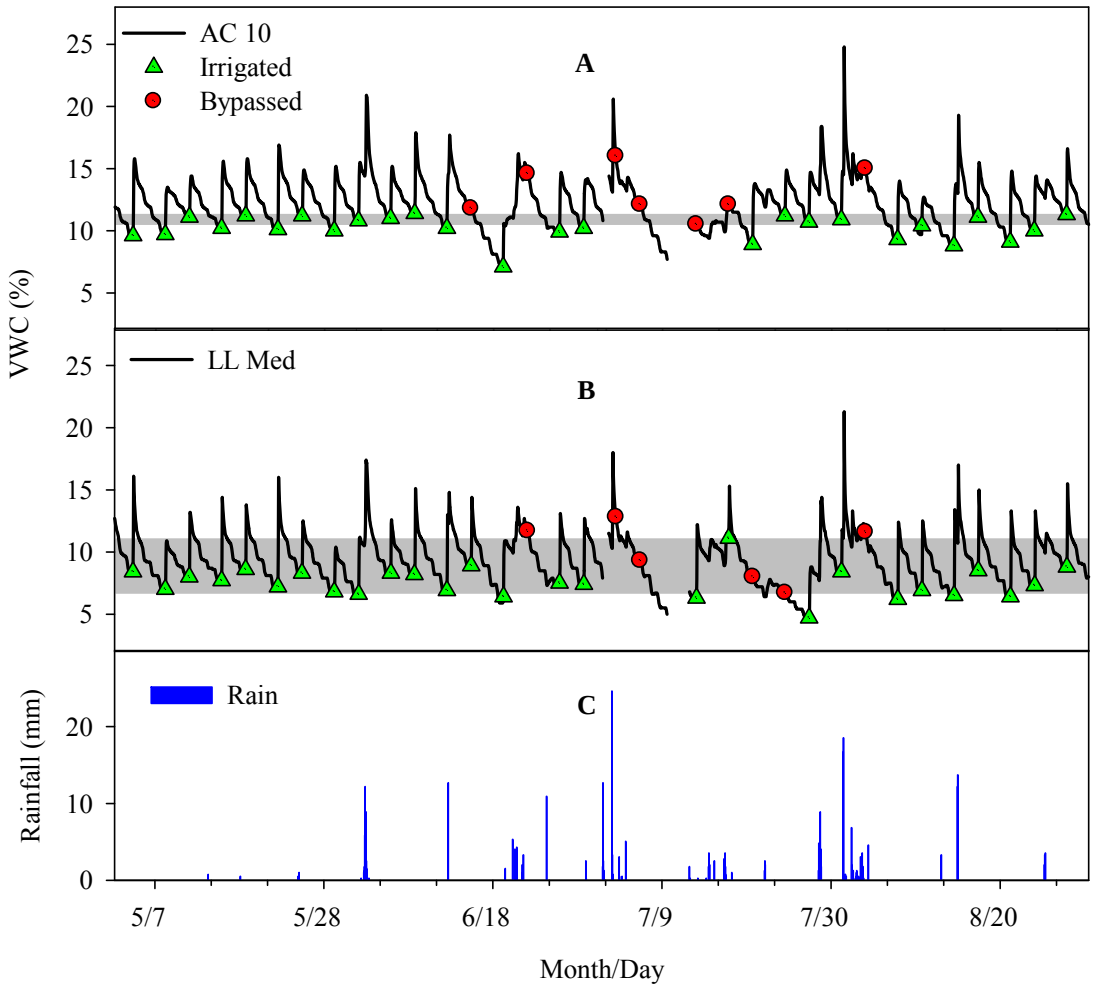

Figure 3-14. Volumetric water content (VWC; %) for the treatments A) AC 10 and B) LL Med in S07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (C).

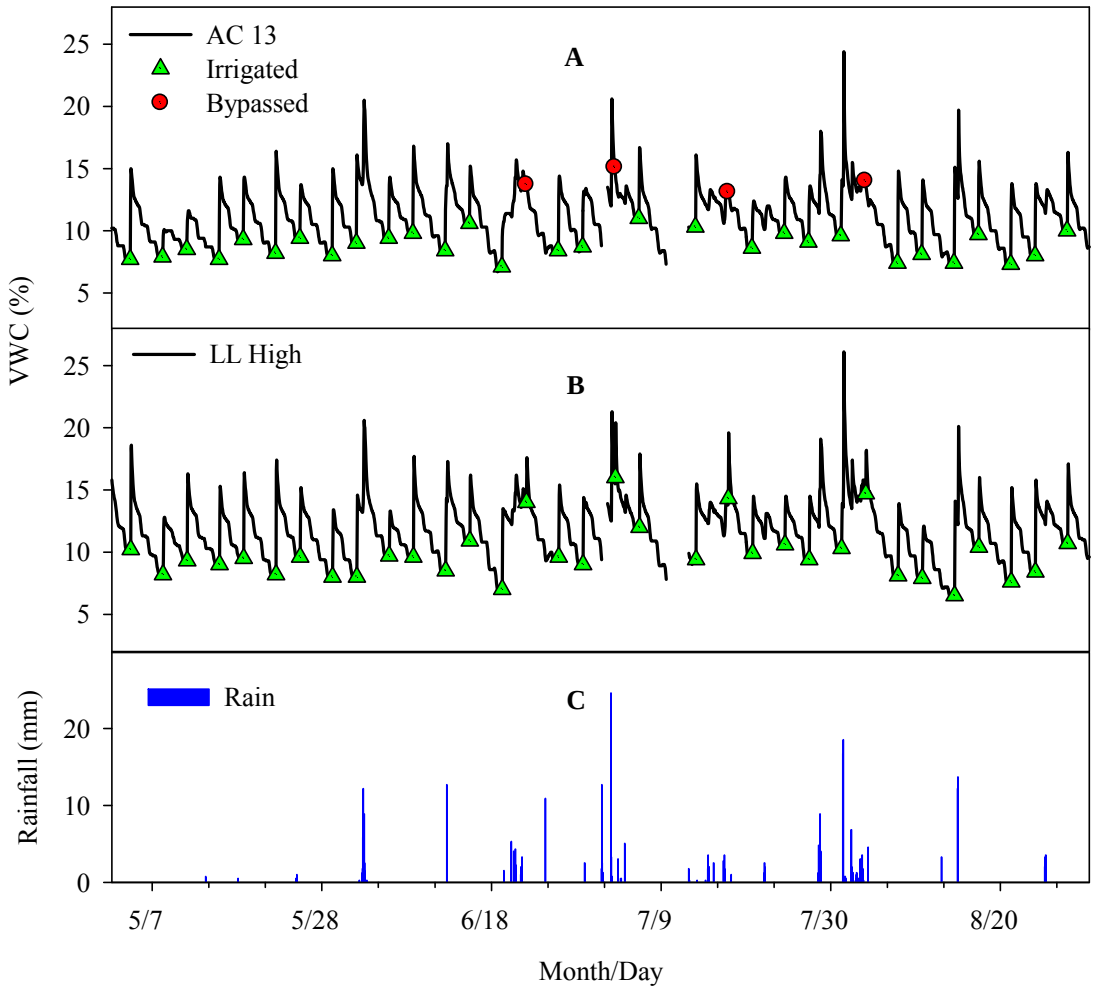

Figure 3-15. Volumetric water content (VWC; %) for the treatments A) AC 13 and B) LL High in S07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. No shaded region is shown for AC 13 because bypassed irrigation events always occurred at higher VWC values than irrigated events, while no shaded region is shown for LL High because irrigation was never bypassed. Daily rainfall is also shown (E).

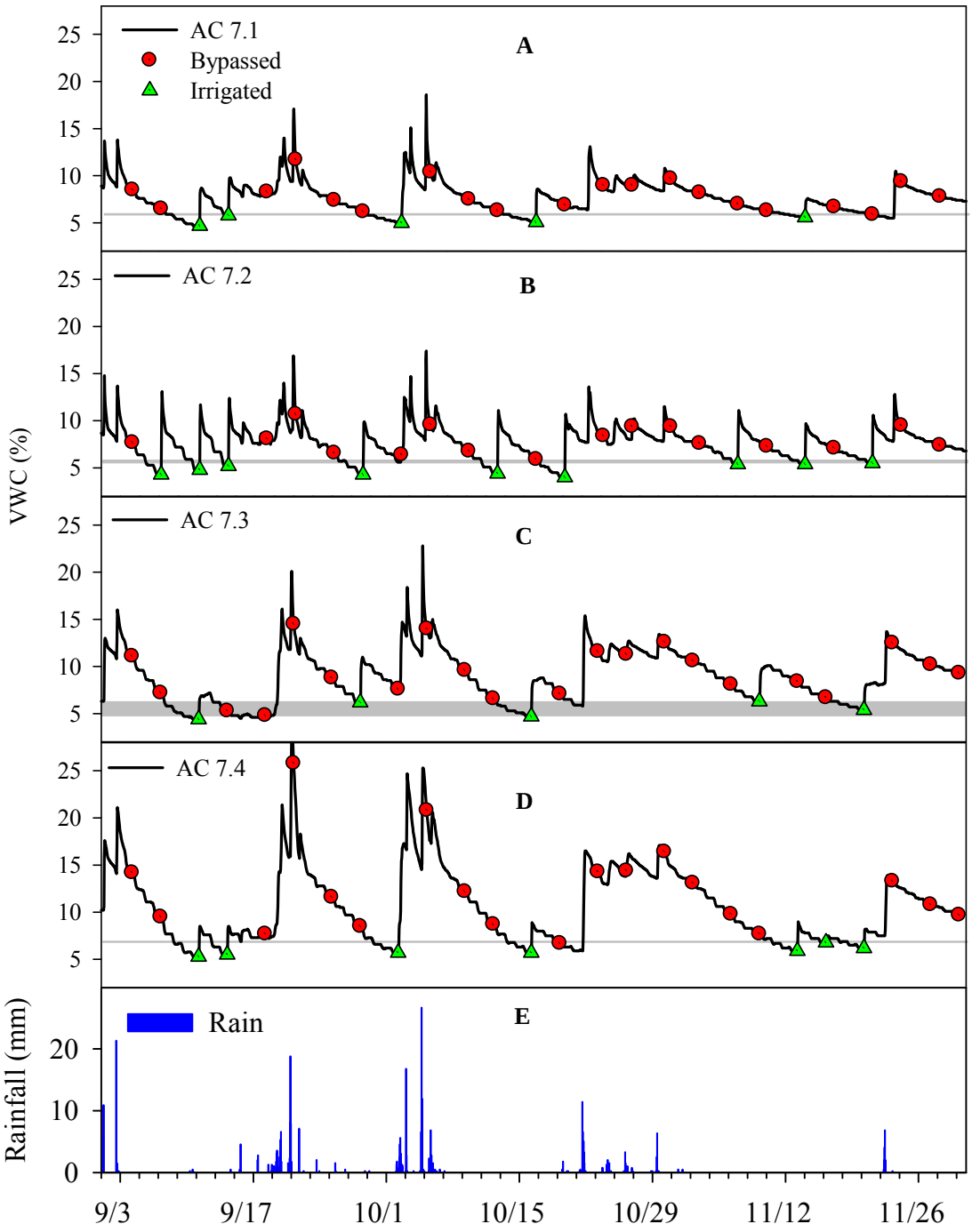

Figure 3-16. Volumetric water content (VWC; %) for the plots in the AC IR treatment A) AC 7.1, B) AC 7.2, C) AC 7.3 and D) AC7.4 in F07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (E).

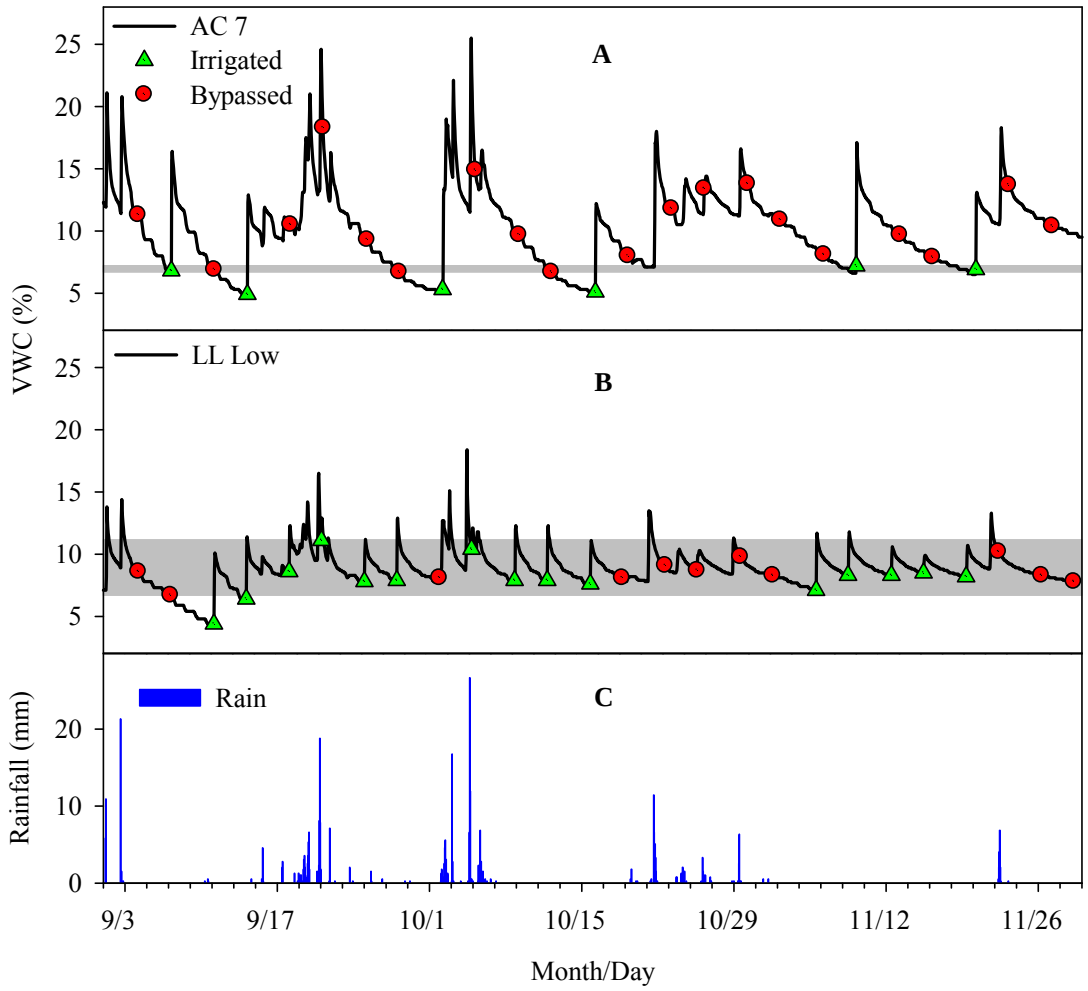

Figure 3-17. Volumetric water content (VWC; %) for the treatments A) AC 7 and B) LL Low in F07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (C).

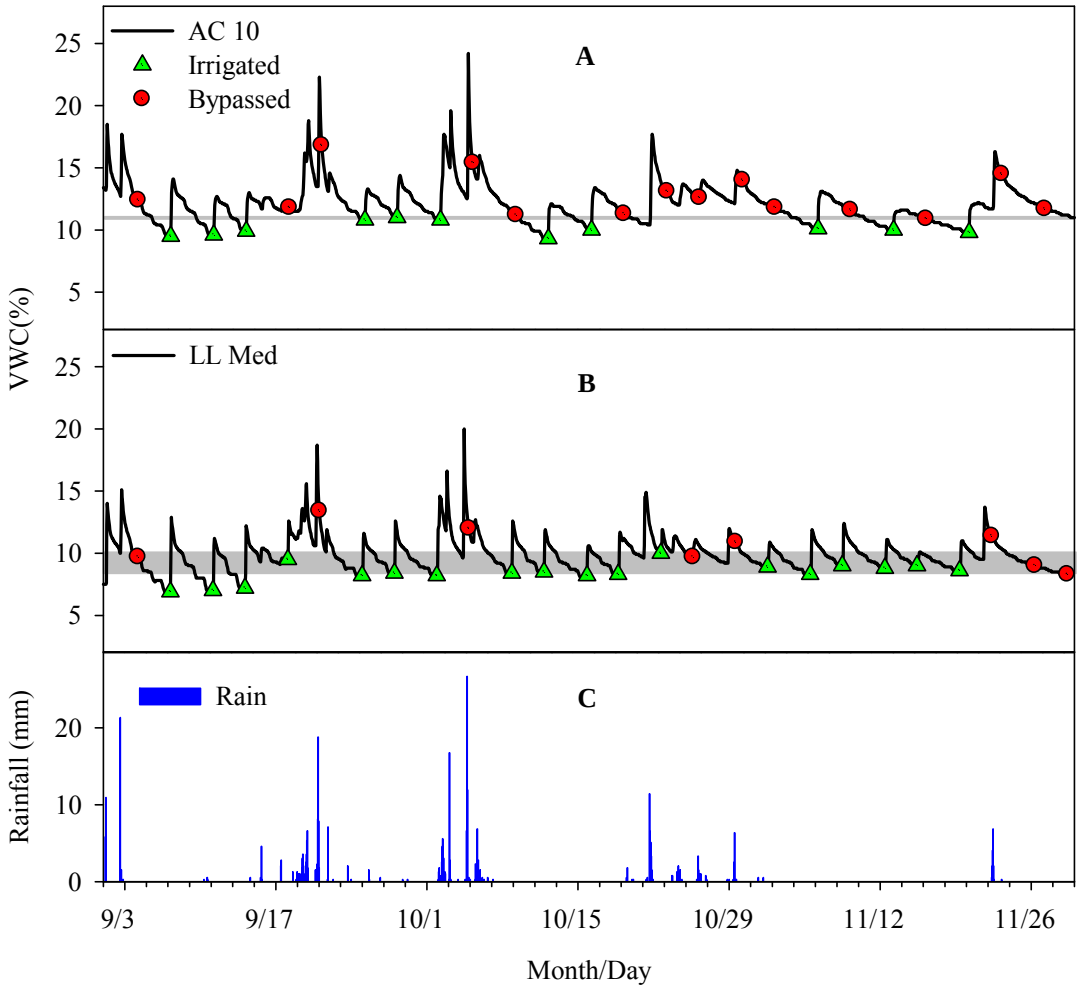

Figure 3-18. Volumetric water content (VWC; %) for the treatments A) AC 10 and B) LL Med in F07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (C).

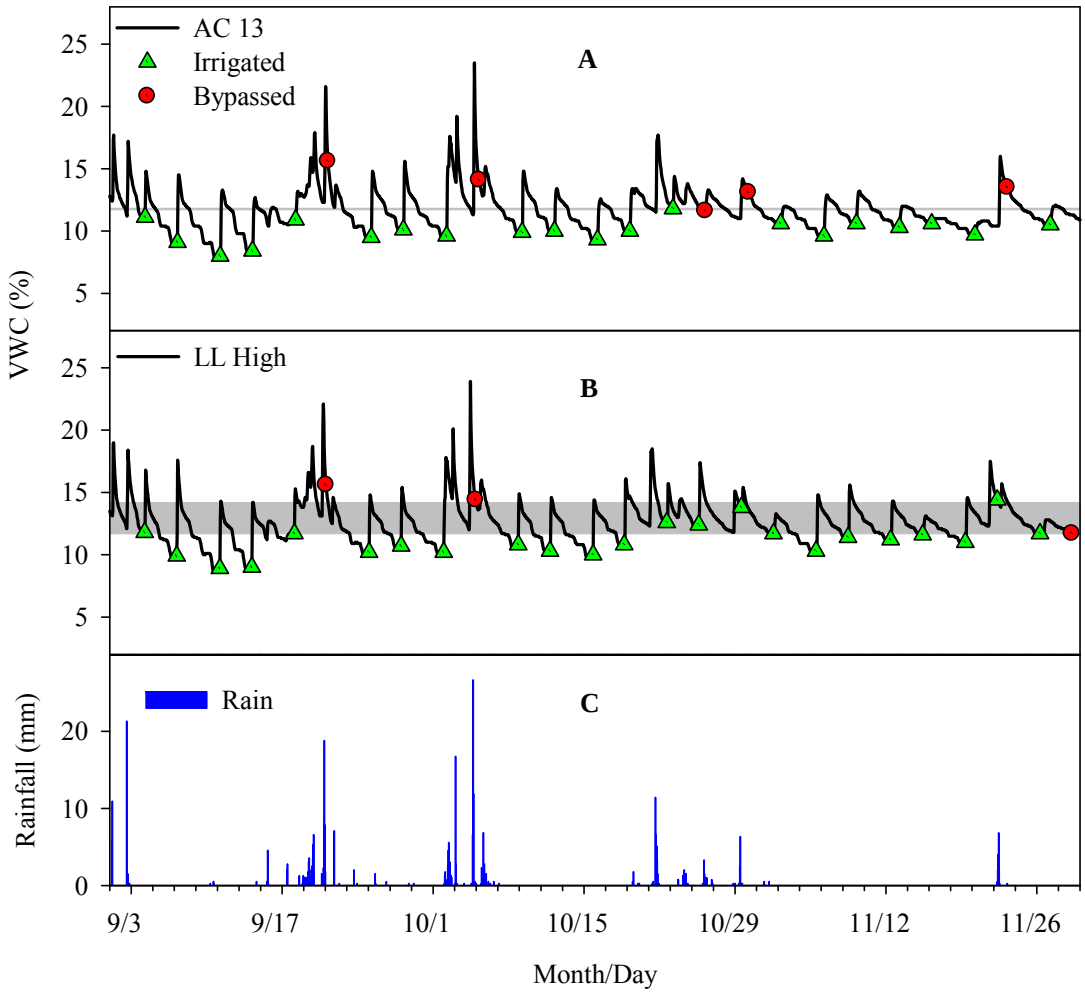

Figure 3-19. Volumetric water content (VWC; %) for the treatments A) AC 13 and B) LL High in F07. Triangles mark irrigation events allowed by the sensor while circles mark bypassed irrigation events. At VWC values above the shaded region irrigation was always bypassed and at values below irrigation was always allowed. As the shaded region gets smaller, the response of the sensor to certain values of VWC becomes easier to predict. When no shaded region is present that means bypassed irrigation events always occurred at higher VWC values than irrigated events. Daily rainfall is also shown (C).

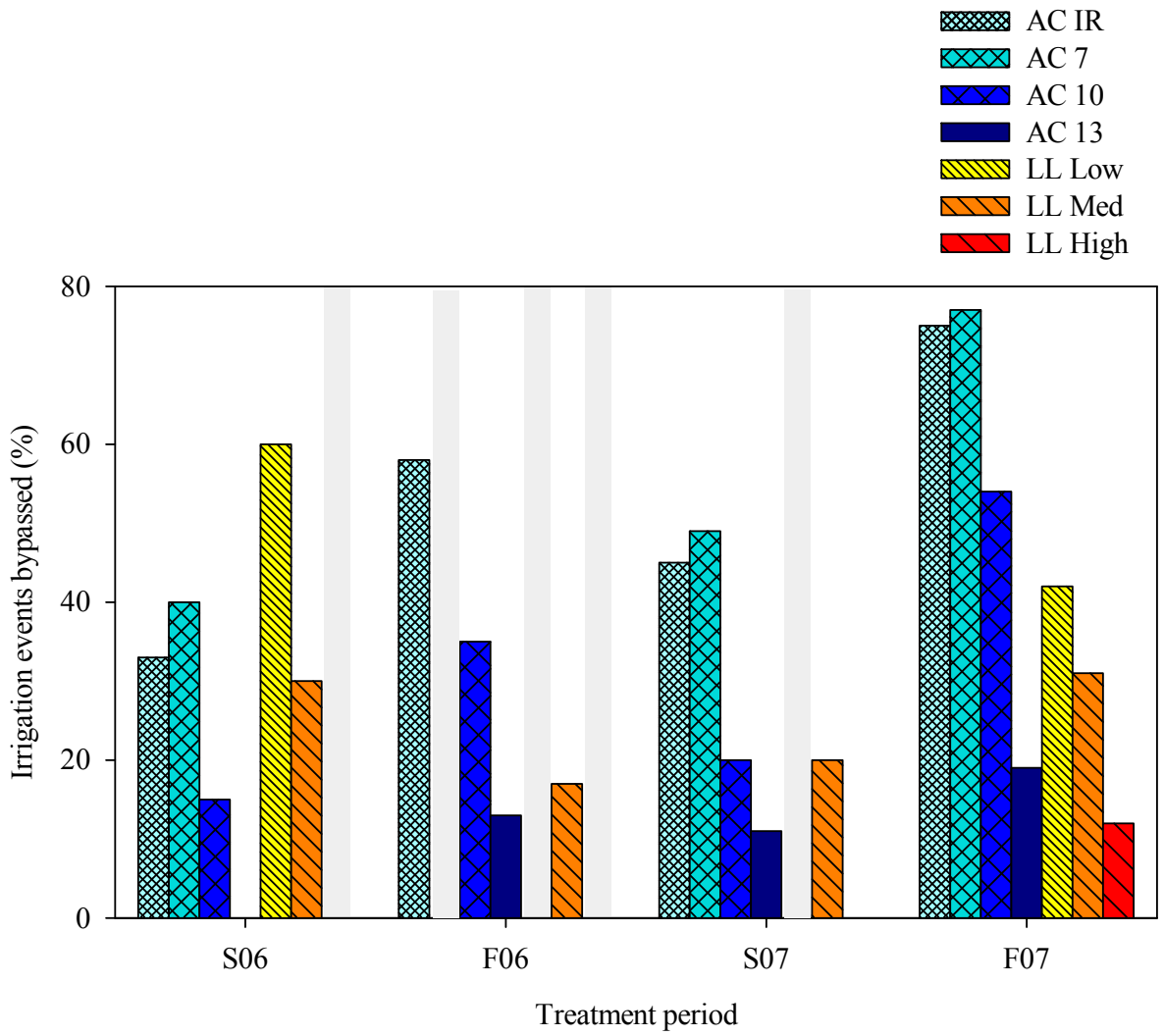

Figure 3-20. Summary of the percentage of irrigation events bypassed by the SMS controllers in each experimental time period. Gray areas represent when data was not available for a treatment because either the treatment was ended before the treatment period was over due to poor turf quality (LL Low), or the irrigation system was malfunctioning (LL High in S06 and F06 and AC 7 in F06).

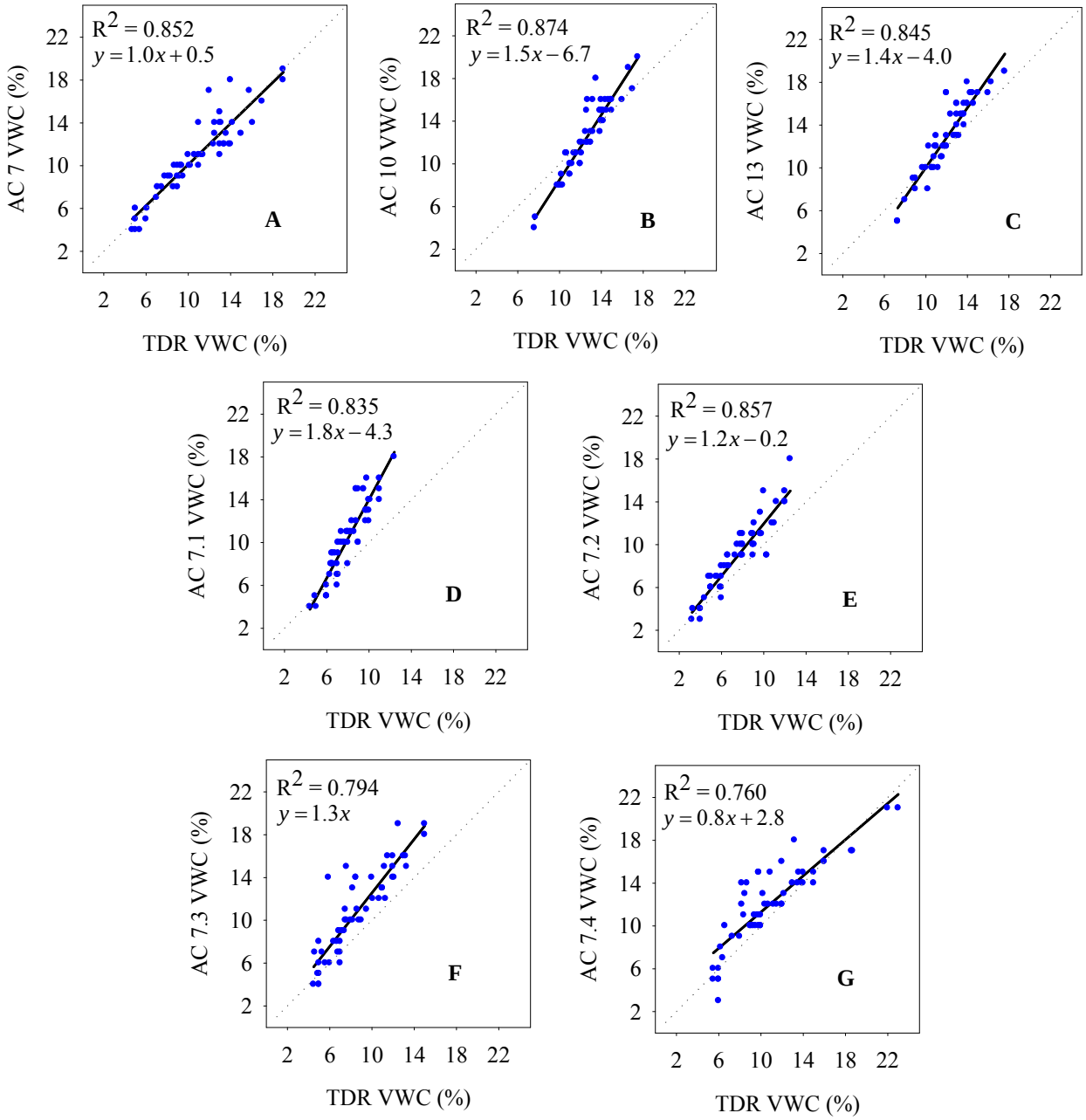

Figure 3-21. Scatter plot of volumetric water content (VWC; %) readings for AC sensors vs. corresponding readings from TDR sensors. Treatments shown are A) AC 7, B) AC 10, C) AC 13, D) AC 7.1, E) AC 7.2, F) AC 7.3, and G) AC 7.4. Linear regression lines are shown along with the equation of the line and the r-squared value of the data to the line. A 1:1 line is shown as a dotted line on each graph for comparison.

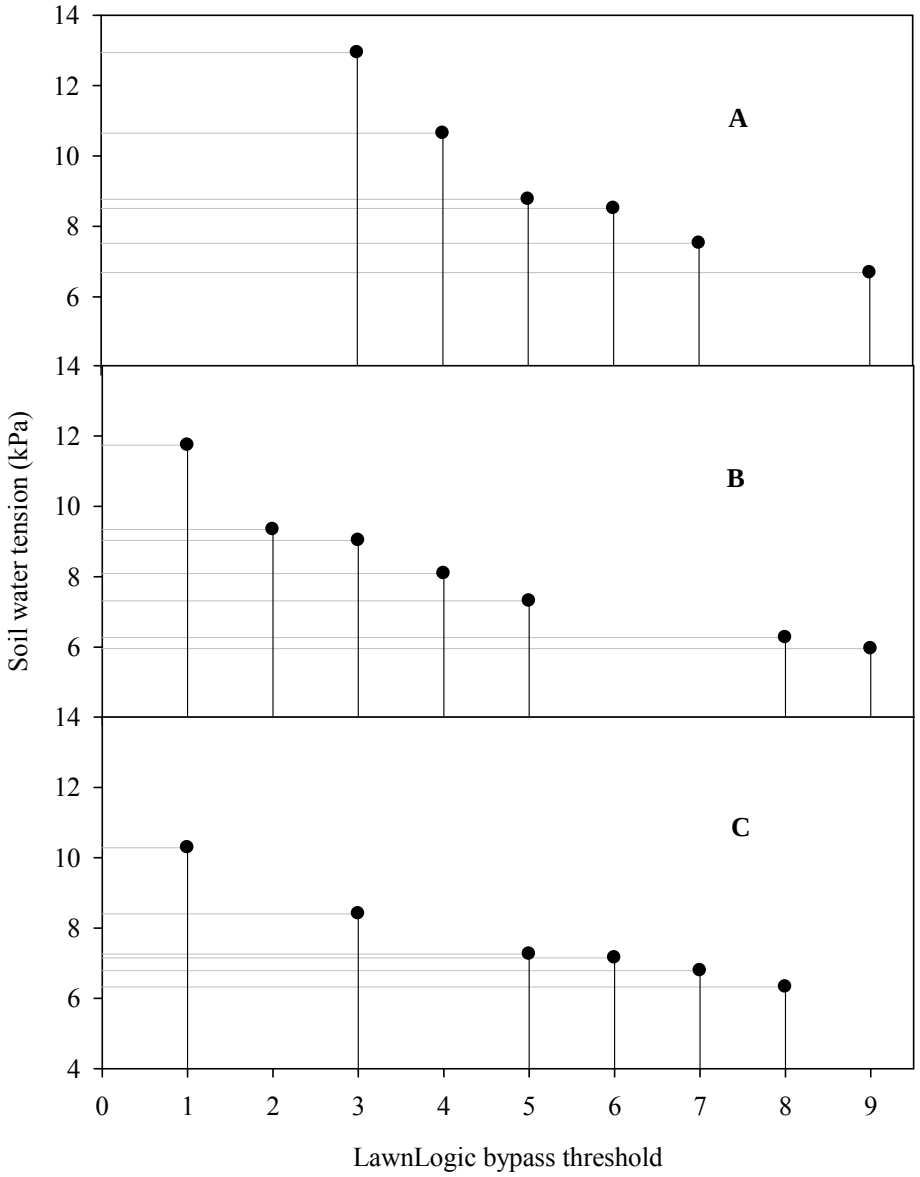

Figure 3-22. LawnLogic bypass thresholds compared to the corresponding tensiometer readings during laboratory testing for A) bucket 1, B) bucket 2, and C) bucket 3.

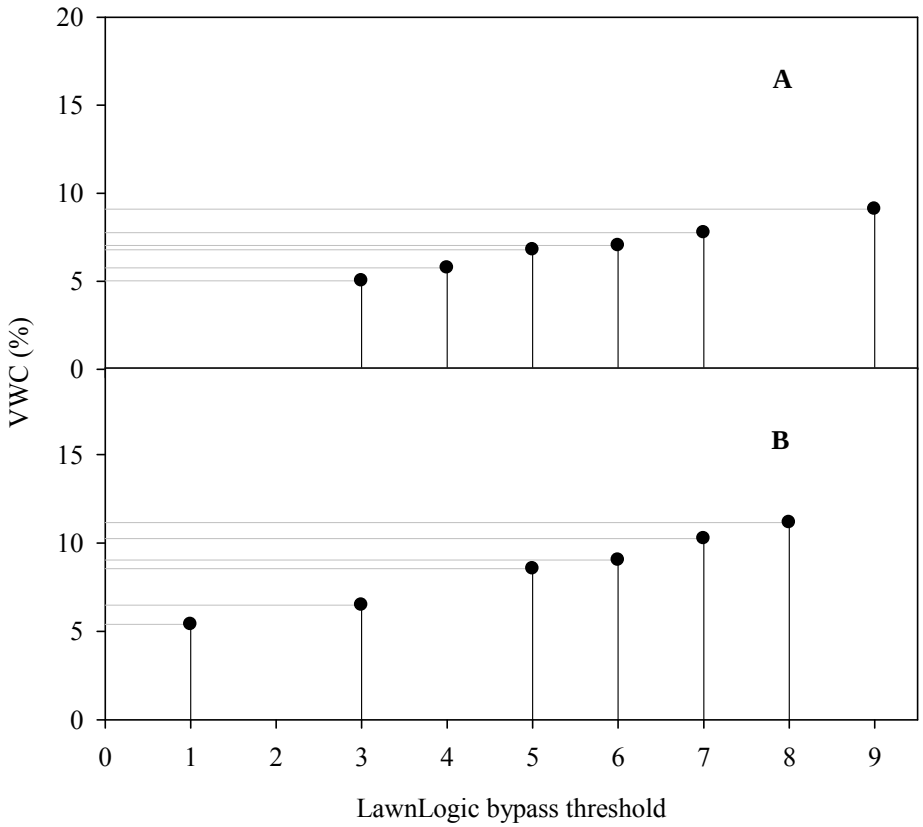

Figure 3-23. LawnLogic bypass thresholds compared to the corresponding capacitance based soil moisture content readings during laboratory testing for A) bucket 1 and B) bucket 3. The data from bucket 2 was excluded from analysis due to a malfunction of the capacitance based probe.

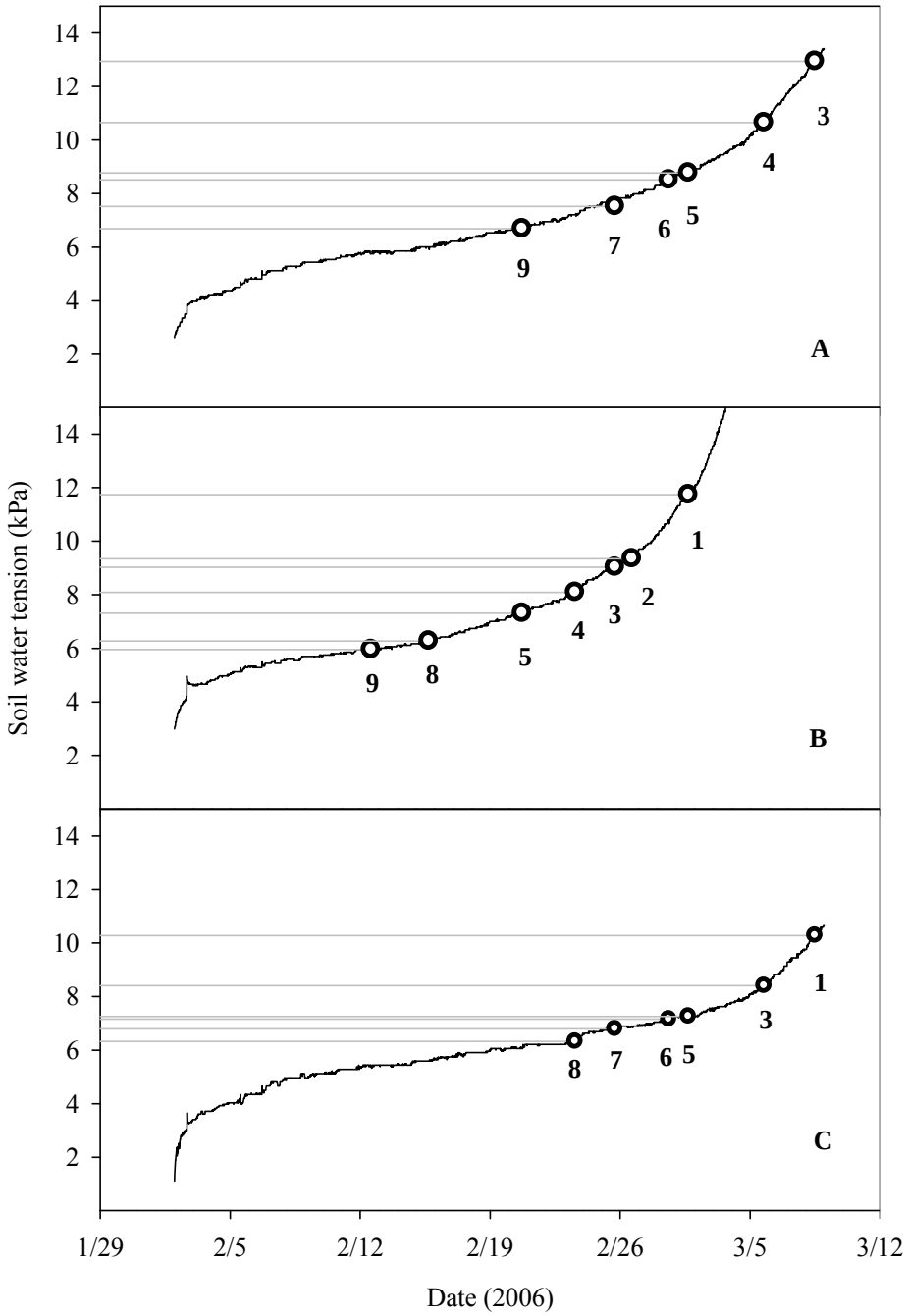

Figure 3-24. LawnLogic bypass thresholds compared to the corresponding tensiometer readings during laboratory testing for A) bucket 1, B) bucket 2, and C) bucket 3.

CHAPTER 4
EVAPOTRANSPIRATION CONTROLLER PERFORMANCE AND ACCURACY

Introduction

Evapotranspiration (ET)-based irrigation controllers ideally apply irrigation according to plant needs using ET data to make irrigation decisions. Evapotranspiration is the water lost from the soil and plant surface by the process of evaporation and lost from the plant by the process of transpiration. Since the two processes occur simultaneously and are very difficult to separate, they are combined into one process (Allen et al., 1998). There are several types of ET-based irrigation controllers and they differ in how they obtain weather data and how they use that data to determine irrigation schedules. Some systems are based on historical data developed for the site where irrigation is being applied. Some systems use on-site sensors to measure weather information used to calculate ET, while others (signal-based systems) receive reference ET information from nearby weather stations (Center for Irrigation Technology, 2006) ET controllers can be purchased as an addition to an existing irrigation timer or as a replacement to the timer. General values of ET may not be closely representative of the area where the irrigation is being applied due to localized environmental conditions such as shade. Controllers use various inputs including soil type, plant type and irrigation application rate to make the irrigation control more site specific. These inputs are typically input to the controller during installation.

Reference ET (ET_o) is the rate at which ET occurs from a uniform surface of actively growing vegetation with a specified growing height and that is well-watered. ET_o is calculated using weather parameters such as solar radiation, relative humidity, air temperature, and wind speed. The ASCE standardized reference evapotranspiration equation is generally used to calculate ET_o (Allen et al., 2005).

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{C_n}{T+273}\right)(e_s - e_a)u_2}{\Delta + \gamma(1 + C_d u_2)} \quad (4\text{-}1)$$

ETo = reference evapotranspiration, (mm day-1)
Rn = net radiation at the crop surface, (MJ m-2 day-1)
G = soil heat flux density at the soil surface, (MJ m-2 day-1)
T = mean daily air temperature at 2 m height, (oC)
u2 = mean daily wind speed at 2 m height, (m s-1)
es = saturation vapor pressure, (kPa)
ea = mean actual vapor pressure, (kPa)
Δ = slope of the saturation vapor pressure-temperature curve, (kPa oC-1)
γ = psychometric constant, (kPa oC-1)
Cn = numerator constant that varies with reference type and time step of calculations, (short reference with daily time step = 900 K mm s3 Mg-1 d-1)
Cd = denominator constant that varies with reference type and time step of calculations, (short reference with daily time step = 0.34 s m-1)

Adjustments to ET_o for particular plant types are made using crop coefficients (K_c). A crop coefficient is a fraction of the calculated reference evapotranspiration. The crop coefficient is used to adjust ET_o due to differences such as plant type, annual climate cycle, and horticultural differences. The equation for crop evapotranspiration (ET_c) according to Allen et al. (2005) is:

$$ET_c = K_c \times ET_o \quad (4\text{-}2)$$

Soil Water Balance

Generally, ET controllers schedule irrigation by using some form of the soil water balance. This equation uses a series of inputs and outputs to the soil profile. Inputs for the soil water balance include rainfall and irrigation. Water outputs include drainage, runoff and evapotranspiration. The equation for the soil water balance is:

$$\Delta S = R + I - ET_c - D - RO \quad (4\text{-}3)$$

ΔS = change in soil water storage (mm)
R = rainfall (mm)
I = irrigation depth (mm)
ET_c = crop evapotranspiration (mm)

D = drainage (mm)
RO = surface runoff (mm)

Ideally irrigation is scheduled so that there is no drainage and a negligible amount of surface runoff. The maximum amount of water that can be held in the soil profile is related to the soil type and root zone depth. The amount of water in the soil that is available for plant use is called available water (AW) and is calculated using the following equation (Cassel and Nielsen, 1986):

$$AW = \frac{(FC - PWP) \times RZ}{100} \tag{4-4}$$

where

FC = field capacity (% or cm^3 of water per cm^3 of soil)
PWP = permanent wilting point (% or cm^3 of water/cm^3 of soil)
RZ = root zone depth (mm)

The field capacity (FC) of the soil is the water content 2 to 3 days after wetting event has occurred and the downward movement of water due to gravity is negligible (Soil Science Society of America SSSA, 2008). Permanent wilting point (PWP) is the amount of water in the soil where indicator plants wilt and do not recover (Cassel and Nielsen, 1986). Soil water should not get as low as PWP before irrigation is applied. When available water is reduced by a certain percentage, the maximum allowable depletion (MAD), irrigation should be applied. The soil water content at the point of maximum allowable depletion is the readily available water (RAW) and is calculated as follows (Irrigation Association, 2005):

$$RAW = MAD \times AW \tag{4-5}$$

The irrigation depth required to replace the water lost through ET_c that has not been replaced by rainfall is the net irrigation requirement. The actual application of water is not perfectly efficient so the net irrigation requirement has to be increased to account for the

inefficiency of the irrigation system. The actual amount of water that needs to be applied to account for the efficiency of the irrigation system is the gross irrigation. For irrigation scheduling purposes, the low half distribution uniformity (DU_{lh}) has been recommended (IA, 2005) and is calculated as follows:

$$E = \frac{100}{DU_{lh}} \tag{4-6}$$

The value for DU_{lh} is calculated based on the equation from the Irrigation Association (2005):

$$DU_{lh} = 38.6 + 0.614 \times DU_{lq} \tag{4-7}$$

DU_{lq} is the low quarter distribution uniformity and is calculated using the following formula:

$$DU_{lq} = \frac{\overline{D}_{lq}}{\overline{D}_{tot}} \tag{4-8}$$

where, $\overline{D}_{tot}$ is the average of the total depth of water applied and $\overline{D}_{lq}$ is the average depth of the lowest 25% of depths collected (Merriam and Keller,1978). The gross irrigation depth is then calculated by multiplying the net irrigation requirement by the efficiency factor.

Previous Research

Evapotranspiration-based controllers have been tested in the western U.S. but have undergone little research in humid climates like that of Florida. A study that was conducted in Florida by Davis et al. (2007) during the summer (July 1 through August 31) and fall (September 1 through November 30) of 2006 found that three brands of ET controllers compared to a two-day-per-week irrigation schedule with no irrigation control devices were capable of reducing water applied. These reductions were between 20 to 60% with the exception of one controller

which applied more water than the two-day-per-week comparison treatment during the fall of 2006. The water savings were produced while maintaining acceptable turf quality.

A study conducted in Irvine, California in 40 single-family homes demonstrated the effectiveness of scheduling irrigation based on localized ET conditions for reducing residential water use. The study was conducted by the Irvine Ranch Water District (IRWD). The irrigation schedules in the homes were controlled through a remote signal and adjustments were made weekly based on the ET for the previous week. The value for ET was used to develop a "percentage change" factor which was sent to the individual homes controllers and applied to the existing irrigation schedule that was input during installation. The baseline irrigation schedule was site specific based on plant type, slope, etc. The controller was able to reduce outdoor water applied by 16% compared to water use in the same homes prior to installation of the test controller. The results showed that the homes selected for the "ET" controller had a predisposition towards water conservation. It was concluded that scheduling irrigation based on ET could produce larger water savings in homes that do not have the same predisposition. All participants in the study believed the automatic "ET" controller was convenient and 97% reported that they observed either no change or an improvement in the quality of their landscape (IRWD, 2001).

Based on the previous study further research was conducted by the Municipal Water District of Orange County (MWDOC), in California, and IRWD to investigate the usefulness of this technology at reducing runoff from residential lawns. The number of homes in the study was expanded. The study included five neighborhoods, each having their own single point of discharge for the runoff from the entire neighborhood. The ET based systems produced 10% water reductions in total household water use. During the dry season runoff was reduced by

approximately 50% compared to the runoff volumes prior to installing the ET based system (MWDOC and IRWD, 2004).

A study by the Los Angeles Department of Water and Power was conducted to look at the usefulness of ET controllers in settings with medium to large landscapes such as homeowners associations, schools and parks. Two commercially available ET controllers, both using signal based technology, were tested. The two controllers managed to reduce water applied by 17.4% and 28.3% compared to water use prior to the installation of the ET controllers.

Devitt et al. (2008) found that using signal based ET controllers in Las Vegas could reduce water applied by up to 61.6% compared to sites without an ET based controller. The study had 16 ET controller sites and 10 control sites. Results showed that 13 out of 16 ET controller sites reduced water applied compared to 4 of 10 sites without ET controllers. In a survey of the homeowners conducted after the experiment, 87% of the study participants stated that their landscape quality either stayed the same or improved during the testing.

The objective of this research was to evaluate two commercially available ET controllers comparing turf quality, and the accuracy of ET estimates, irrigation scheduling and potential water savings in a humid climate.

Materials and Methods

Site Description

This study was performed at the Plant Science Research and Education Unit in Citra, Florida. There were four treatment periods during 22 April 2006 to 30 June 2006 (S06), 23 September 2006 to 15 December 2006 (F06) and 1 May 2007 to 31 August 2007 (S07) and 1 September 2007 to 30 November 2007 (F07). Experimental plots were 4.27 m X 4.27 m in size and irrigated using four Toro 570™ Series (The Toro Company, Bloomington, MN.) quarter circle pop-up spray heads with an application rate of 51 mm/hr (see Chapter 2, Figure 2-1).

The three mapped soil types present in the research area are Tavares sand, Candler sand, and Arredondo fine sand (Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults) (USDA, 2006). Soil analysis methods were used on site to determine more specific values for field capacity and permanent wilting point (see Soil Physical Properties, Chapter 2). Figure 2-6 shows the range of field capacities and permanent wilting points within the field and in each block. Both field capacity and permanent wilting point values increase moving across the field from west to east (moving from block 1 to block 4) as seen in Figure 2-6 (see Soil Physical Properties, Chapter 2). Soil testing also showed that the soil present at the field site consisted of 1.7% clay, 1.1% silt and 97.3% sand.

Experimental Design

Two commercially available ET controllers were selected for the study: the Toro Intelli-sense (The Toro Company, Bloomington, MN) and the ET Manager™ (Rain Bird Corporation, Glendora, CA). Each ET controller controlled the irrigation for four individually monitored plots. The ET Manager was connected to a Rain Bird® ESP Modular Irrigation Controller (Rain Bird International, Inc., Glendora, CA) for scheduling irrigation events.

There was one control treatment in the experimental design and one time-based comparison (Table 4-1). The control was a non-irrigated (NON) treatment and the comparison treatment was time-based without a rain sensor (WOS). The irrigation schedule for the WOS treatment was based on recommendations by Dukes and Haman (2002b) (Table 2-3).

Both ET controllers utilize paging technology to receive daily ET_o. These controllers perform a soil water balance based on daily ET, rainfall, and other inputs and use the calculated moisture content for irrigation decisions. The Toro Intelli-sense controller (TORO) calculates irrigation runtime based on application rate and other inputs. A rain sensor can be connected to the Toro controller; however a rain sensor was not used in this study. Also, the Toro controller

has a “rain pause” function which allows the controller to delay watering when rainfall is measured at a remote weather station. This rain pause (in days) is sent to the controller along with weather data and prevents irrigation from occurring during the days when the rain pause is activated. The controller assumes the soil water profile as full after a rain pause is received. The ET Manager (ETM) is connected to an irrigation time clock to function in bypass mode similar to a soil moisture sensor or rain sensor. The ET Manager has a tipping bucket rain gauge attached to the controller that uses measured rainfall depth to adjust the calculated soil water balance. The ETM controller uses historical ET as a backup if the signal to the controller is lost. The ETM treatment was set for irrigation depths based on the same methods used for the time-based comparison treatment WOS.

The two ET controllers use different inputs to the systems and have different approaches to irrigation scheduling. The TORO controller schedules irrigation depth and frequency while the ETM controller is designed to be an add-on device used with an existing timer. The ETM controller does not schedule depth or frequency of irrigation events it only bypasses irrigation events scheduled into the irrigation timer.

Software provided with the ETM controller uses inputs such as soil type, plant type and application rate of the irrigation system to assist the user in developing an irrigation schedule. The depth of water applied per scheduled irrigation event is then programmed into the ETM controller. The ETM controller uses this depth as the amount of water that can be lost from the soil profile before irrigation is allowed to occur. The manufacturer suggests that the irrigation amount should be equal to half the depth of AW. One input that is programmed into the ETM controller is called the saturation allowance. This value is the amount of water the soil can hold in addition to the irrigation amount without causing runoff to occur. This means the depth of the

irrigation amount plus the depth of the saturation allowance is the saturation value of the soil. The saturation allowance is equal to the difference between FC and saturation. When the depth of water in the soil profile reaches saturation all of this water has to be lost from the soil profile before irrigation is allowed to occur. The ETM controller also uses a landscape adjustment percentage input by the user to modify the ET for localized landscape conditions.

The TORO controller uses crop coefficients based on the plant type selected during set up. Other inputs to the TORO controller include plant type, soil type, slope, and microclimate. For this experiment the plant type was warm-season turfgrass and the soil type was sandy. The experimental area had a 0 to 5% slope. The microclimate input is for adjusting the irrigation based on the amount of sun exposure in the irrigated area. In this study the microclimate was set for full sun exposure because there was no shade present at the research site. A summary of inputs for both ET controllers is provided (Table 4-2). Both the ET-based treatments were restricted to irrigating twice per week according to typical Florida day of the week water restrictions.

Data Collection

Water use for each plot was monitored using pulse-type displacement flow meters, specifically AMCO PSMT 20 mm x 190 mm flow meters (Elster AMCO Water, Inc., Ocala, FL). These flow meters were wired to multiplexers connected to a CR-10X datalogger (Campbell Scientific, Logan, UT.) to monitor daily water use. The meters were also read manually at least every two weeks.

ET values (daily) were collected manually from each controller three times per week. The day and time of the last weather signal were also collected to ensure the ET reading was for the proper day. When there were missing manually collected ET data for one of the controllers, only dates when both controllers had data were used for comparisons. Periodically, the manufacturers

supplied the ET signal data that was sent to the controllers daily. These data were compared with the manually collected ET signal data. The source of the data provided by the manufacturers was unknown. A FAWN (Florida Automated Weather Network) weather station is located at the research site and is available for public use, whether or not either manufacturer use this data is unknown. Data from the manufacturer for the Toro Intelli-sense controller was limited to daily ET, while data received for the RainBird ET Manager included maximum and minimum temperature (^{o}C), wind speed (m/s), solar radiation (W/m^2), relative humidity (%) and ET (mm). The manufacturers provided data for the two ET controllers was only compared for periods of time when data was available for both controllers. The time periods where data was available for both controllers were; 6/13 to 6/18, 7/3 to 7/17, 8/5 to 8/10, 9/2 to 9/7, 10/2 to 10/19 and 10/23 to 10/28 (all in 2007). Local weather data for comparison was collected using an automated weather station (Campbell Scientific, Logan, UT) within 900 m of the experimental site. Rainfall data at the weather station was collected with both a tipping bucket rain gauge and with a manual rain gauge located at the research plots. Manual rain gauge data was used to verify depths measured by the tipping bucket rain gauge. Weather station data was used for calculating reference ET (ET_o). Solar radiation, relative humidity, air temperature, and wind speed were used in the ET_o calculations. The quality of data obtained from the on-site weather station was verified based on procedures outlined by Allen et al. (2005). The verification of the parameters solar radiation, temperature, relative humidity and wind speed for both 2006 and 2007 is shown in Figures 4-1 and 4-2. According to Allen et al. (2005) solar radiation (R_s) data can be validated by plotting it against clear sky radiation (R_{so}) which is calculated using the following equation:

$$R_{so} = \left(K_B + K_D\right) \times R_a \tag{4-9}$$

where K_B is a clearness index for direct beam radiation, K_D is a transmissivity index for diffuse radiation and R_a is extraterrestrial radiation ($MJ/m^2/day$). The values for K_B were also calculated based on an equation from Allen et al. (2005):

$$K_B = 0.98 \exp\left[\frac{-0.00146 \times P}{K_t \sin\beta} - 0.075\left(\frac{W}{\sin\beta}\right)^{0.4}\right] \quad (4\text{-}10)$$

where P is the atmospheric pressure at the site elevation (kPa), K_t is the turbidity coefficient which was assumed to be 1.0 for clean air, β is the angle of the sun above the horizon (radians) and W is the precipitable water in the atmosphere (mm). Allen et al. (2005) provided the following equation for calculating W:

$$W = 0.14 \times e_a \times P + 2.1 \quad (4\text{-}11)$$

where e_a is the actual vapor pressure of the of the air at a height of approximately 2 m above the ground (kPa). The angle of the sun averaged over the daylight period was calculated using latitude (φ) measured in radians, and the day of the year (J) which is unitless, based on the following equation:

$$\sin\beta_{24} = \sin\left[0.85 + 0.3 \times \varphi \times \sin\left(\frac{2\pi}{365} \times J - 1.39\right) - 0.42 \times \varphi^2\right] \quad (4\text{-}12)$$

When graphed the maximum values of R_s in a data set should lie close to the line indicating R_{so}. On cloudy days the values for R_s will fall below the R_{so} data.

Minimum daily temperature data (shown in Figures 4-1B and 4-2B) was compared with the dew point temperature calculated using (Allen et al., 2005):

$$T_{dew} = \frac{116.91 + 237.3 \times \ln(e_a)}{16.78 - \ln(e_a)} \quad (4\text{-}13)$$

The maximum and minimum daily values for relative humidity were plotted (Figures 4-1C and 4-2C) to look for extreme values. The maximum relative humidity should be below 100% or

within 5% of that value and the minimum relative humidity in a humid region should be above 30% the majority of the time (Allen et al., 2005).

Wind speed was plotted (Figures 4-1D and 4-2D) to look for values or trends in the data that were not realistic. Consistently low wind speed readings may indicate dirty anemometer bearings. Average daily wind speed readings over an extended period of time that are less than 1.0 m/s may indicate a problem with the anemometer (Allen et al., 2005). During the testing periods in 2006 and 2007 all weather data was verified and found to be valid.

Turfgrass quality was rated at least once every two weeks during F06 and at least once a month during S07 and F07. Quality evaluations were made using the National Turfgrass Evaluation Program (NTEP) procedures (Shearman and Morris, 1998). The ratings were on a 1 to 9 scale, with 1 representing dead or dormant grass and 9 representing grass with good color and density, and without weeds (Shearman and Morris, 1998). A quality rating of 5 was considered minimally acceptable for a homeowner lawn. An example of the appearance of the turfgrass for quality ratings of 2 (almost dead, with some green), 5 (minimally acceptable) and 8 (almost perfect quality) can be seen in Figure 2-9 (see Chapter 2).

Results and Discussion

Rainfall

Three of the four treatment periods were relatively dry compared to historical rainfall for the research area receiving less than half of the depth received in the area historically (see Chapter 2, Figure 2-13). Rainfall events were infrequent and, combined with the low total volume of rainfall received, led to dry conditions for the research site. The number of days per month with a rainfall event of a depth greater than 2.5 mm was fewer than the monthly historical averages for every time period except in F07 (see Chapter 2, Figure 2-13). During October 2007 there were 60 percent more rainy days than the historical average. Overall the treatment periods

S06, F06 and S07 can be considered drier than normal for the testing area both in frequency of rainfall events and total depth received by the area.

Water Savings and Turf Quality

In F06 and S07 the NON treatment was ended early by implementing a timed irrigation schedule to prevent complete loss of the turfgrass. During both testing periods where treatments with no irrigation were continued (S06 and F07) it was seen that turf quality ratings for these plots were lower than plots in all other treatments. In F07, sufficient rainfall maintained adequate turf quality in these plots, allowing the treatment to continue throughout the season.

In F06 and F07 the two controllers both produced acceptable turf quality and high water savings (Tables 4-3 and 4-4). During F06 the TORO controller produced higher water savings than the ETM controller (63% compared to 40%) and applied less water weekly. The TORO treatment applied 8.6 mm/wk compared to 14.4 mm/wk ($P<0.001$). In F06, according to manually collected ET_o data, both ET controllers had average ET_o measurements that were within 2% (TORO) and 3% (ETM) of the ET_o measured on-site. In F07, however, the TORO had ET_o measurements that were greater than the on-site values by 36% on average and the ETM was within 11% on average. Even though the TORO overestimated ET_o in F07 but not in F06, the controller produced water savings in F07 (62%) that were close to the water savings of F06 (63%).

In S07, the ETM treatment reduced irrigation applied by 59% compared to the TORO treatment which reduced water applied by only 25% and only bypassed one irrigation event. This reduction in water applied resulted in loss of turf quality in the ETM treatment plots. The ETM manager bypassed 57% of the possible irrigation events (Table 4-5). The high number of irrigation events bypassed by the ETM controller may be due to the effective rainfall setting called the Saturation Allowance (Table 4-2). The value used for the Saturation Allowance

during S07 (9.1 mm) caused too many irrigation events to be bypassed during a period of time where little rainfall occurred. The controller used the saturation allowance as an added depth to the irrigation depth to determine how much water could be stored in the root zone of the plant. In S07 the depth for the saturation allowance was 9.1 mm, the depth of irrigation applied was approximately 17 mm for the month of July. The controller would estimate that 26.1 mm of water could be stored in the root zone after a rainfall or irrigation event. The average depth of AW for the research site was 12 mm and the average depth of RAW was 6 mm (see Chapter 2, Figure 2-7), which is less than a quarter of the depth the ETM controller used for the saturation depth (irrigation plus the saturation allowance) that could be held in the soil for plant uses. In F07, the saturation allowance parameter for the ET Manager was changed from 9.1 mm to 2.5 mm due to loss of turf quality during the previous season. The initial setting for the saturation allowance was suggested by the manufacturer as was the need to decrease the setting.

The ETM controller produces water savings by bypassing scheduled irrigation events while the. The water savings were from reducing depth applied per irrigation event instead of bypassing irrigation altogether. For example, during the F06 testing period the ET Manager had a water savings of 36%, bypassing 50% of the possible irrigation events, while the Toro Intelli-Sense controller had a water savings of 59%, bypassing 29% of the possible irrigation days. Table 4-5 summarizes the percentage of irrigation events bypassed by each controller during the three testing periods.

Evapotranspiration Comparisons

Looking at the ET_o values collected manually from both controllers compared to the onsite weather station, the TORO overestimated ET_o especially during the period from May 2007 to October 2007 (Figure 4-3). It is important to note that the source of the weather data for both controllers is unknown. The increase in ET_o values for the TORO controller may be due to a

change in the weather station used or the microzone designation of the controller. The peaks in the data from the TORO and the ETM controllers did not always match the peaks in the ET_o values from the on-site weather station. The average daily ET_o value read manually from the ETM controller (3.5 mm) was similar to the value for the on-site weather station (3.5 mm) (P=0.810; Table 4-6). The average daily ET_o for the TORO controller (4.1 mm) was higher than the ET_o calculated from data collected on-site (P=0.002). Figure 4-4 shows the manually collected ET_o values for both controllers plotted on the y-axis with the ET_o calculated based on on-site weather data on the x-axis. The trend line for the TORO controller data shows that in general the daily manual ET_o readings were higher than the calculated values (Figure 4-4). The manual data from the ETM controller appeared to have a closer correlation with the on-site data having an r-squared value of 0.63 while the TORO data had an r-squared value of 0.59 (Figure 4-4). Cumulatively, ET_o collected manually from the ETM controller was less than 2% greater than the on-site weather station, while ET_o from the TORO controller was 18% greater than the data collected on-site (Figure 4-5).

Daily ET_o provided by the manufacturer resulted in average values for the ETM controller (3.9 mm) that were similar to the on-site data (4.1 mm) (P=0.465). The ET_o values for the TORO controller (4.9 mm) were higher than the on-site values (P<0.001; Table 4-6). Figure 4-6 shows the manufacturer daily ET_o values for the two ET_o controllers compared to the on-site data. Five weeks with complete data were used to compare average weekly ET_o values and there were similar results to the daily ET_o results (Table 4-6). The TORO had the highest average weekly ET_o value (31.3 mm) compared to the ETM (25.2 mm) or the on-site value (26.3 mm). Cumulatively there was a 5% difference between the ETM and the on-site values and a 19% difference between the TORO and the on-site ET_o values.

Data provided by the manufacturer for the TORO controller over a longer period of time (14 months) shows that from September 2006 to April 2007 the TORO and the on-site had similar ET_o values, but from March 2007 to November 2007 the TORO consistently had higher ET_o values than the on-site weather station (Figure 4-7). This trend can also be seen in Figures 4-8 and 4-9, where the ET_o values for the TORO were between 19% and 28% (29 mm and 38 mm) higher than the values for the on-site weather station starting in March 2007. Using the entire 14 months of data to compare cumulative ET_o, the TORO overestimated compared to data collected on-site by 14% (Figure 4-7). Davis et al. (2007) found that TORO weather data provided by the manufacturer overestimated ET_o by only 2% during the months of August and September 2006 in South Florida.

Other data received for the ET Manager included temperature, solar radiation and relative humidity. In Figure 4-10 the average, maximum and minimum daily temperature values for the ETM are compared to the on-site collected values. The ETM minimum daily temperature was consistently higher than the on-site weather station data, with values that exceeded weather station values by 1.3^{o}C on average over the collection period. All temperature data appeared to have a good linear relationship with the on-site data having r-squared values from 0.90 to 0.95, with minimum temperature having the highest r-squared value.

The ETM data for solar radiation and wind speed appear have a lower correlation with the on-site values than the temperature values (Figure 4-11). Solar radiation provided by the manufacturer for the ETM compared to on-site solar radiation had an r-squared value of 0.78. The wind speed had the weakest relationship with on-site data; the linear relationship between the two only has an r-squared value of 0.49. The lower correlations with on-site data for these

two parameters could be due to the fact that wind speed and solar radiation are more localized parameters.

Conclusions

Even though two of three testing periods received less than half of the normal rainfall depth for the area, both ET controllers tested were able to reduce water applied compared to an irrigation system with no control device. The ETM treatment produced poor turf quality during the S07 treatment period due to an incorrect setting in the controller. During the other testing periods the ETM had acceptable turf quality with water savings of 40% and 59% and the TORO plots had acceptable turf quality with water savings of 63% and 62%.

ET_o calculations for the TORO, both supplied by the manufacturer and collected manually from the controller, tended to overestimate ET_o compared to data collected onsite. Based on manufacturer data it overestimated by 19% over a 4 month period while values of ET_o provided by the manufacturer for the ETM treatment were within 5% over the same 4 month period. Manufacturer provided ET_o data for the TORO was within 0.5% and 11% of the on-site data for the months of August 2006 to April 2007, but after the ET_o values increased to between 19% and 28% greater than on-site values. This may be due to a change in weather station used to collect data or a malfunction in the weather station used by the manufacturer.

Table 4-1. Codes and descriptions for the experimental treatments.

Treatment code	Irrigation frequency (day/week)	Treatment description
ET-based		
ETM	2	RainBird ET Manager
TORO	2	Toro Intelli-Sense
Time-based		
WOS	2	Without sensor
NON	0	Non-irrigated

Table 4-2. Summary of inputs used to program the ET controllers.

Input parameter	Input
TORO	
Soil type	Sand
Sprinkler type	Spray head
Root depth	15 cm
Plant type	Warm-season turfgrass
Sun exposure	Sunny all day
Slope	None
Usable rainfall	100%
Efficiency	95%
ETM	
Landscape adjustment	70%
Max hourly rain	20 mm
Saturation allowance	9.0 mm
Saturation allowance (F07)	2.5 mm
Irrigation amount[a]	depth changed monthly

[a]The Irrigation Amount used for ETM is the same depth used for RS and SMS treatments based on Dukes and Haman (2002b). This is the irrigation depth scheduled in the irrigation timer connected to the ET Manager. See Table 2-3 for detailed depth of irrigation scheduled monthly.

Table 4-3. Average weekly water applied (mm) along with water savings for the treatments during F06, S07 and F07.

	Average water applied				Water savings (%)			
Treatment	F06	S07	F07	Average	F06	S07	F07	Average
ETM	14.4 ***b***	15.0 ***c***	12.8 ***b***	10.7	40	59[a]	59	53
TORO	8.6 ***c***	29.1 ***b***	11.7 ***b***	16.5	63	25	62	50
WOS	23.9 ***a***	38.8 ***a***	29.6 ***a***	30.8	0	0	0	
CV %	37.7	25.5	26.8					

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level. [a]Produced poor turf quality ratings in S07.

Table 4-4. Average turf quality ratings for the ET controller treatments during the three treatment periods.

	Season average turf quality			
Treatment	F06	S07	F07	Average
ETM	7.1 ***a***	4.5 ***b***	5.7 ***ab***	5.8
TORO	6.5 ***ab***	6.1 ***a***	6.4 ***a***	6.3
WOS	6.1 ***b***	6.5 ***a***	6.3 ***a***	6.3
NON	*NA*[a]	*NA*	5.0 ***b***	
CV %	16.4	20.6	17.9	

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level. *NA* indicates that the treatment was ended before the treatment period was over due to substantial damage to the turfgrass quality.

Table 4-5. Summary of the percentage of irrigation events bypassed by the two ET controllers during the three treatment periods.

	Irrigation events bypassed (%)		
Treatment	F06	S07	F07
ETM	52	57[a]	58
TORO	26	9	35

[a]Produced less than acceptable turf quality during S07.

Table 4-6. Comparison of ET readings taken manually and supplied by the manufacturer with values collected using an on-site weather station. Manual ET_o readings were taken during testing three times per week 9/28/2006 and ending on 11/30/2007. Manufacturer data was compared during the S07 and F07 testing periods between 6/13/2007 and 10/28/2007 when data was available for both controllers.

Weather Source	Manual ET_o readings (mm)	Manufacturer provided ET_o (mm)	Weekly average ET_o provided by manufacturer (mm)
ETM	3.5 ***b***	4.0 ***c***	26.2 ***b***
TORO	4.1 ***a***	5.0 ***a***	33.1 ***a***
On-Site	3.5 ***b***	4.2 ***b***	27.8 ***b***
CV %	21.2	13.2	6.1

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level.

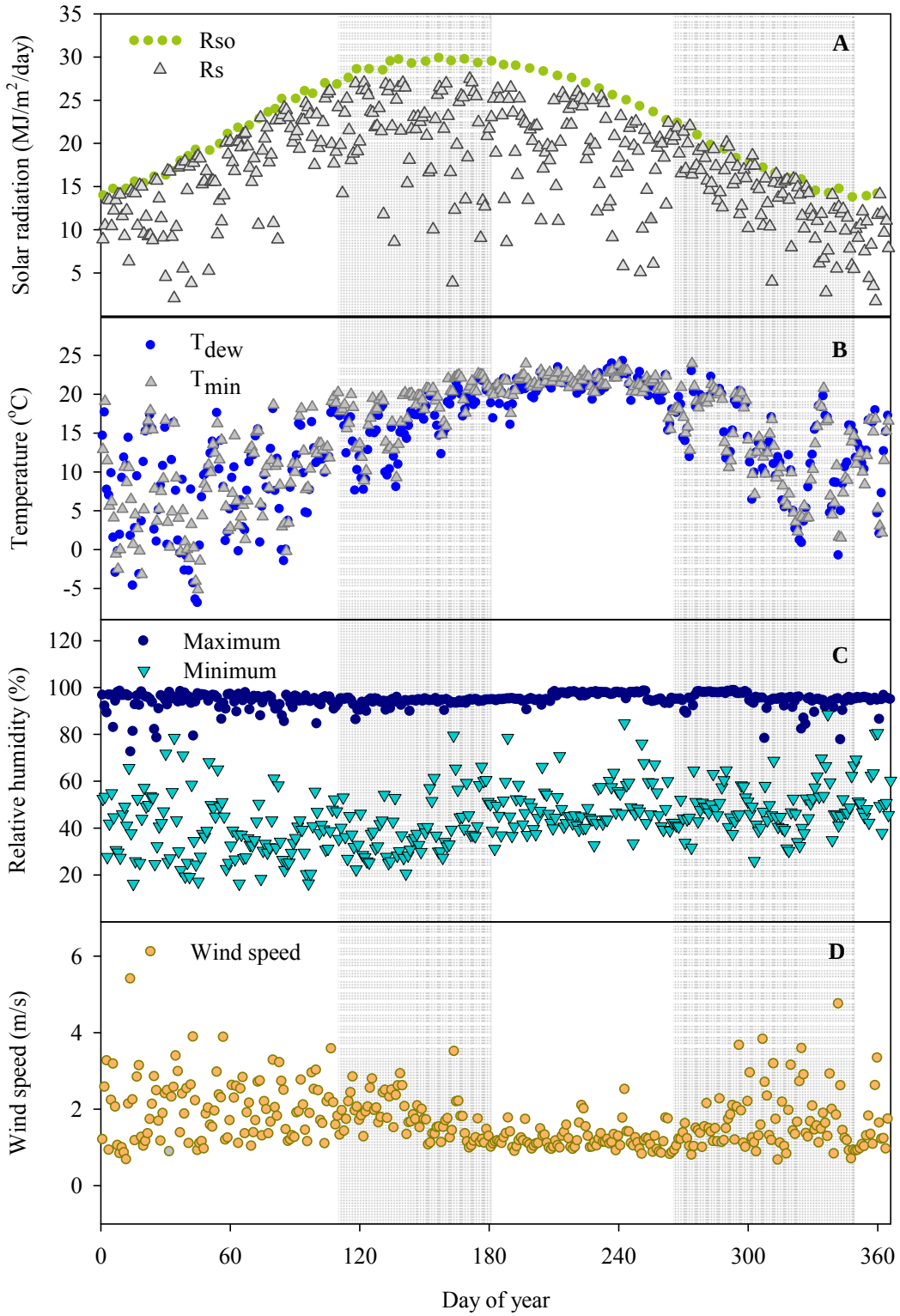

Figure 4-1. Quality analysis for data collected from onsite weather station in 2006 including: A) solar radiation, B) temperature, C) relative humidity and D) wind speed. Shaded regions are periods of experimental testing.

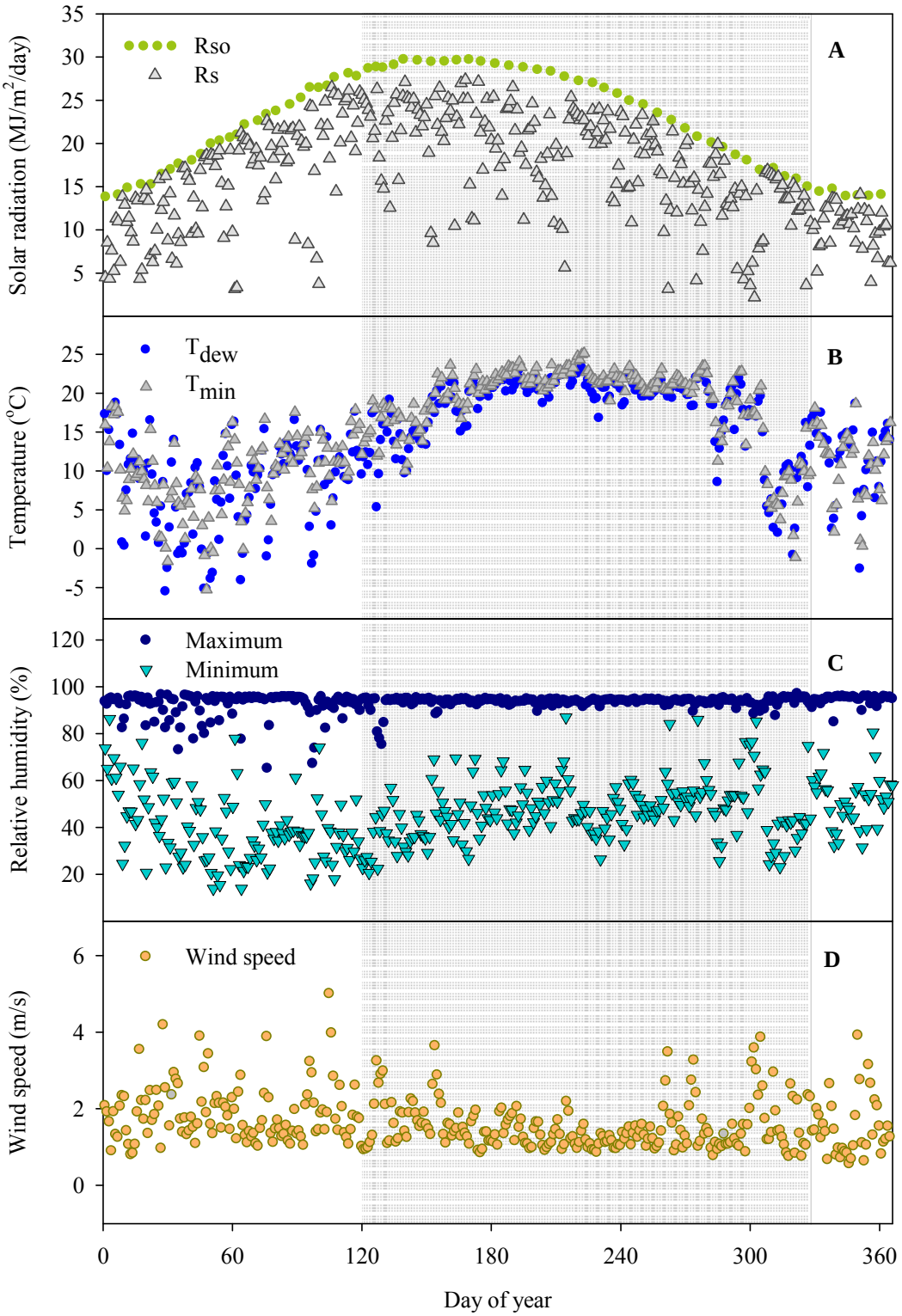

Figure 4-2. Quality analysis for data collected from onsite weather station in 2007 including: A) solar radiation, B) temperature, C) relative humidity and D) wind speed. Shaded regions are periods of experimental testing.

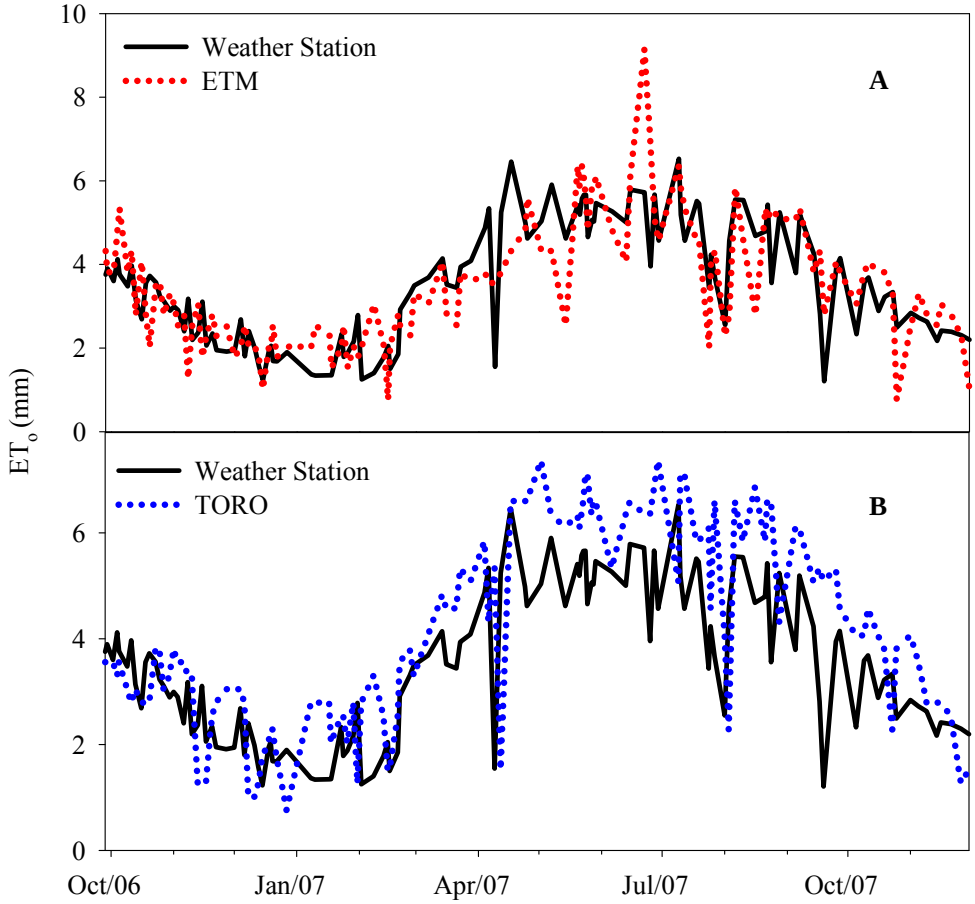

Figure 4-3. Daily ET_o values collected manually from the A) ET Manager controller and the B) Intelli-Sense controller compared to the data from the onsite weather station.

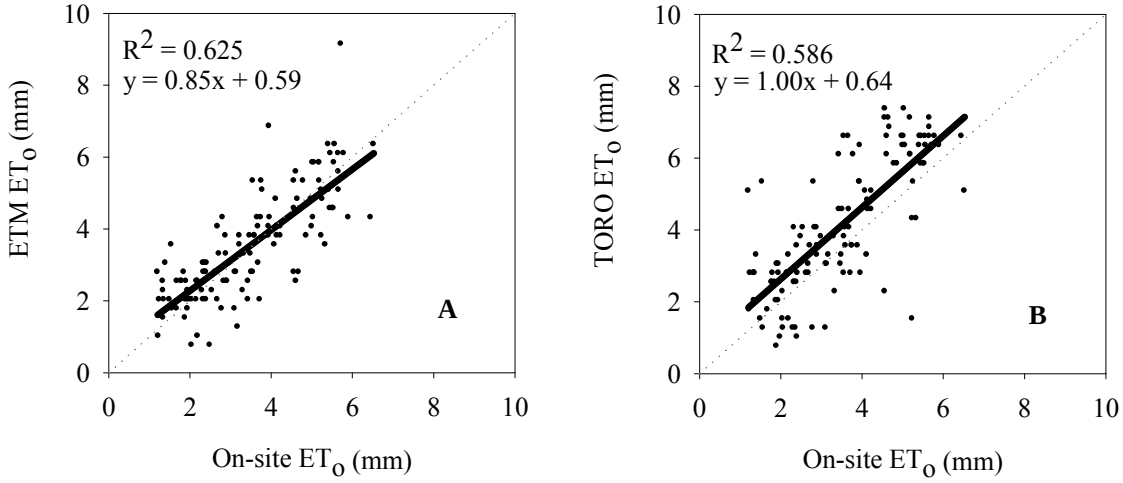

Figure 4-4. Daily ET_o values collected manually from the A) ET Manager controller and the B) Intelli-Sense controller compared to the data from the onsite weather station. The trend lines for the data are shown in black along with the r-squared value. A 1:1 line is shown in gray for comparison.

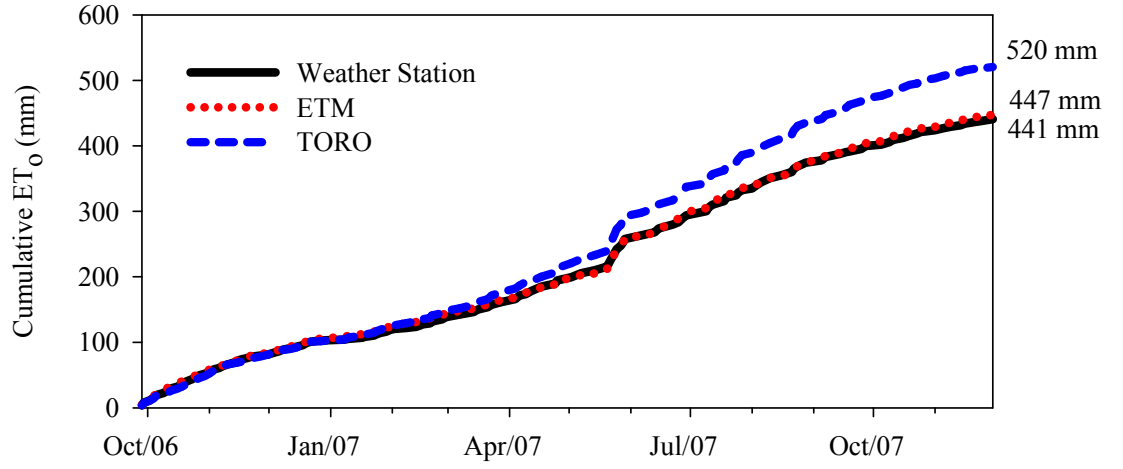

Figure 4-5. Cumulative ETo collected manually from the ET Manager controller (ETM) and the Intelli-Sense controller (TORO) compared to the data from the onsite weather station.

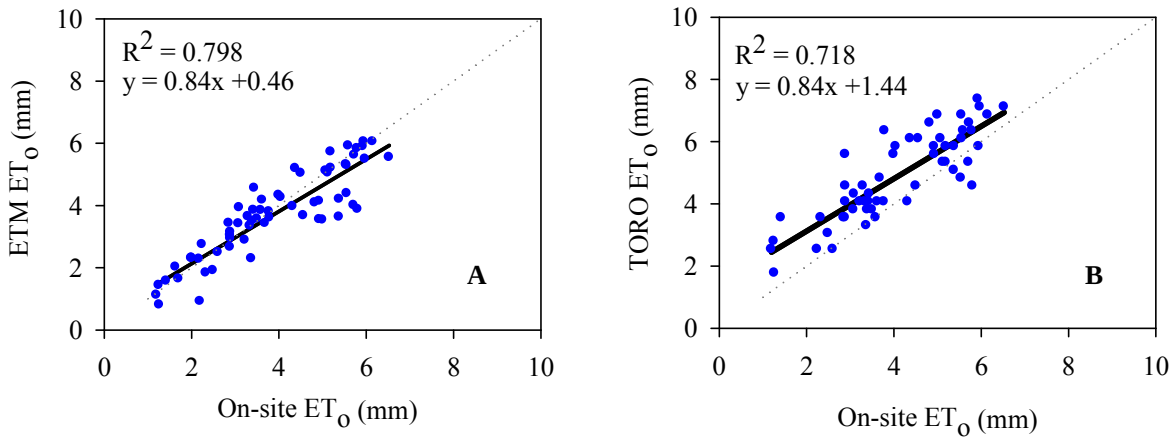

Figure 4-6. Comparisons of ET_o data calculated using the onsite weather station with manufacturer provided data for the A) ET Manager controller and the B) Intelli-Sense controller. The trend lines for the data are shown as solid black along with the r-squared value. A 1:1 line is shown as a dotted line for comparison.

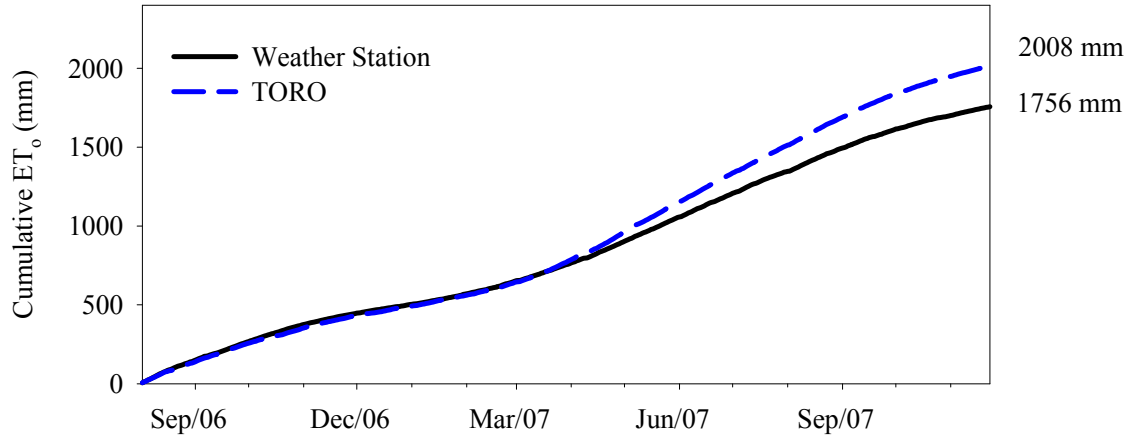

Figure 4-7. Cumulative ET_o data calculated using the onsite weather station and using manufacturer provided data for the TORO controller.

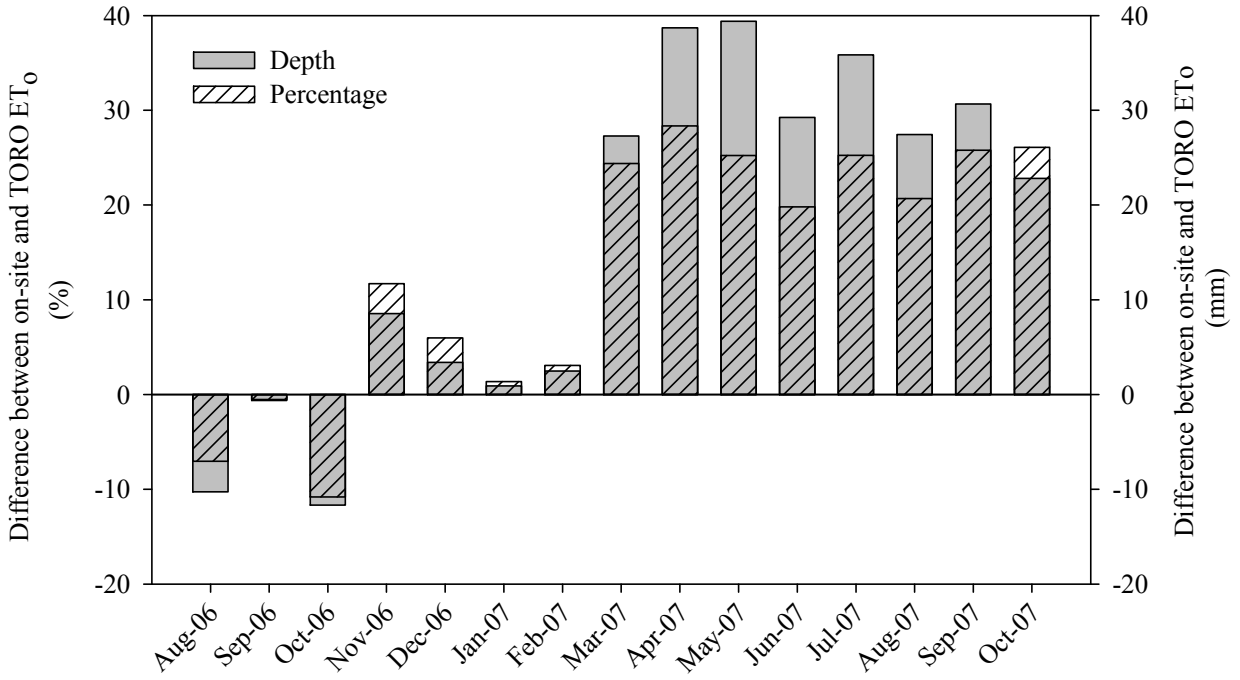

Figure 4-8. Difference between ET_o calculated using on-site weather data and ET_o provided by the manufacturer for the TORO treatment by month. The differences between values are presented in both percentages (left y-axis, vertical bars with diagonal lines) and as a depth in millimeters (right y-axis, shaded vertical bars). Negative values show when TORO weather data underestimated ET_o compared to data collected on-site.

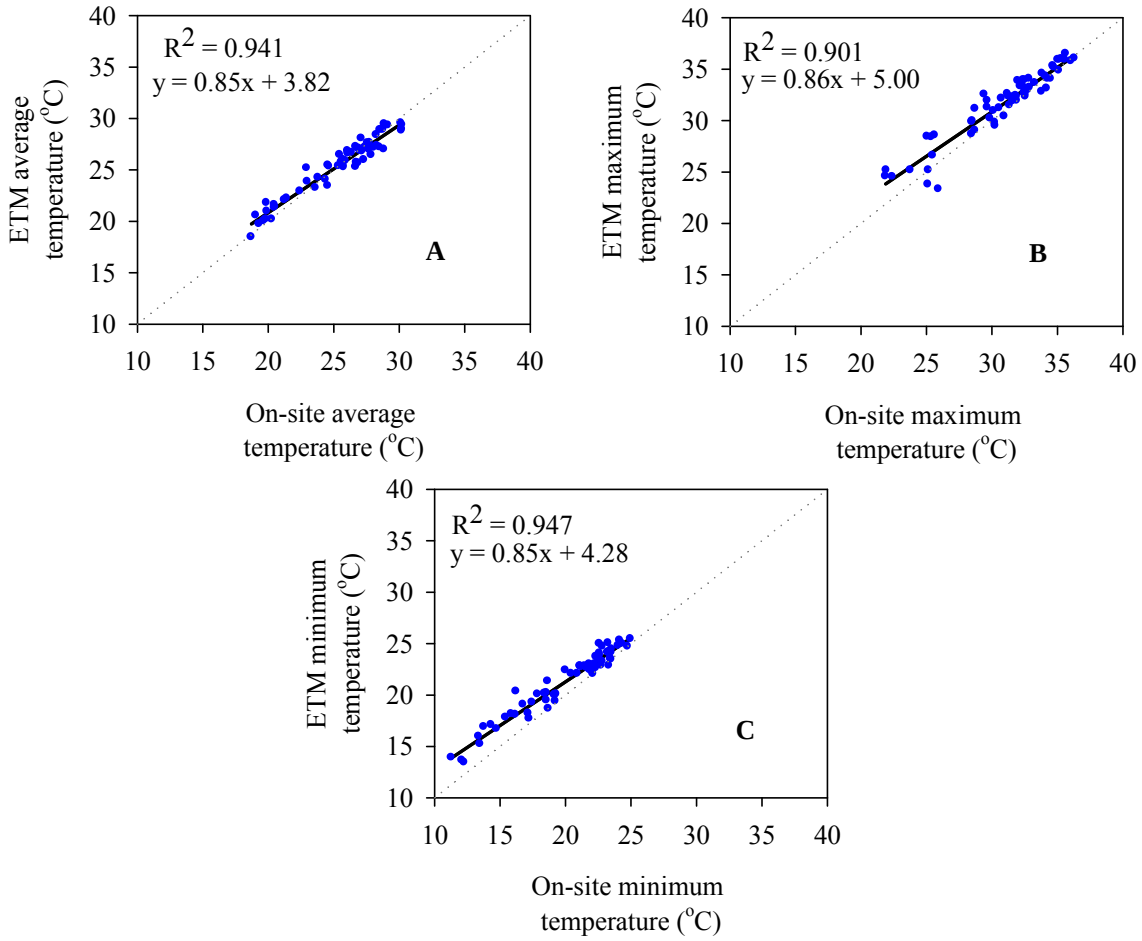

Figure 4-9. Daily temperature data from the onsite weather station and the ET Manager controller. Data includes A) average, B) maximum, and C) minimum temperature values. The trend lines for the data are shown in black along with the r-squared value. A 1:1 line is shown in gray for comparison.

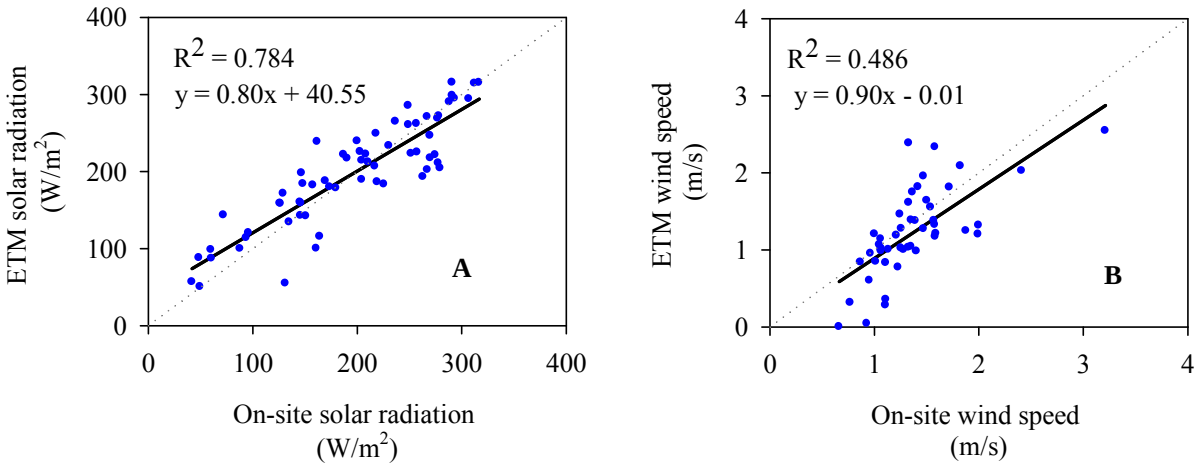

Figure 4-10. Daily A) solar radiation and B) wind speed data from the onsite weather station and the manufacturer data for the ET Manager controller. The trend lines for the data are shown in black along with the r-squared value. A 1:1 line is shown in gray for comparison.

CHAPTER 5
IRRIGATION CONTROL EFFECTS ON TURFGRASS QUALITY AND ROOT GROWTH

Introduction

Turfgrass has many beneficial attributes making it highly desirable for homeowners. Functional benefits of turfgrass include; soil erosion control, dust stabilization, groundwater recharge, organic chemical decomposition, soil improvement, temperature moderation, noise abatement, and glare reduction. Due to its high shoot density and dense root system, turfgrass can provide one of the most cost efficient methods for controlling water and wind erosion of soil surfaces. Turfgrass reduces runoff by trapping water, allowing it to infiltrate to the soil. Temperature in urban areas where there is little turfgrass can be up to 5 to 7°C warmer than nearby rural areas that have a higher percentage turf for groundcover. In addition to the environmental benefits turfgrass also provides aesthetic benefits (Beard and Green, 1994).

Water is required for the basic growth and maintenance of turfgrass along with sustaining the quality and health of a landscape desired by homeowners. All plants, including turfgrass, require water and nutrients to support growth and maintenance (Aldous and G.J. Connellan, 1999). Temperature, wind, relative humidity and solar radiation affect the amount of water used by the plant. When a sufficient amount of water is not present for plant needs, the plant may go into stress.

Florida receives an average of 1,300 mm of rainfall per year, but the average amount throughout the state and during the year varies (Marella, 1992). However, in Florida irrigation is still necessary due to the sporadic nature of these rainfall events and the low water holding capacity of the sandy soils present throughout the state. Annual rainfall can vary greatly depending on the season of the year, the year itself or the area of the state receiving the rainfall.

Higher water demands mean a need to increase the efficiency of current practices that require water. A better understanding of plant water needs, both the total volume and the timing of delivery can lead to more efficient irrigation practices.

Current Irrigation Practices

In Florida, there are five water management districts responsible for establishing regulations on water use, including irrigation, in the counties located within the water district. Landscape irrigation is regulated in most, if not all, areas in Florida due to water shortages. In the SJRWMD irrigation is restricted to a maximum of two days-per-week between 4 pm and 10 am (SJRWMD, 2008). A study conducted in Colorado looked at the effectiveness of day of the week watering restrictions at reducing water use during drought conditions. The study found that mandatory watering restrictions along with educational material reduced water use by 13 to 53% with the highest water savings seen in the cities where watering was limited to either one or two days-per-week (Kenney et al., 2004).

Over-watering or inefficient irrigation of turfgrass can lead to the presence of weeds and diseases and can reduce the effectiveness of fertilizers and other management practices (Harivandi et al., 1984). Proper irrigation practice is generally thought to be infrequent, deep applications of water in order to encourage deeper rooting of the grass.

Rooting Characteristics

Rooting characteristics influence the amount of soil moisture available to a plant for growth. The amount of soil moisture available then affects the frequency of irrigation that is necessary for optimum plant response. Understanding the rooting characteristics of plants can assist in developing more effective and efficient irrigation practices (Peacock and Dudeck, 1985).

In one study performed by Peacock and Dudeck (1985) the rooting response of 'Floratam' St. Augustinegrass (*Stenotaphrum secundatum)* to varied irrigation intervals was studied. The testing was performed under field conditions with loamy siliceous hyperthermic Grosarenic Paleudult soil, similar to soil conditions present in this study. Both root mass and root lengths were examined. Total irrigation volume was equal for all treatments; only frequency was varied with 2, 3, 4 or 6 days of irrigation per week. The study was conducted over two growing periods in 1980 and 1981. During both growing seasons no treatment effect was seen. While irrigation interval had no effect on root length, applying irrigation increased root mass. In 1980 over 40% of the root mass occurred below 30 cm, while in 1981 only 9% of the root mass was found below 30 cm.

According to a study reported by Doss et al. (1960) the rooting depth of warm-season forage species was decreased as soil moisture was increased indicating that deeper rooting is encouraged by watering less frequently and that deeper rooting may be a drought avoidance mechanism (Peacock and Dudeck, 1985).

Turf Quality

Peacock and Dudeck (1984) used varying irrigation intervals of 2, 3, 4 or 6 days to simulate different plant stress conditions. All treatments received the same volume of irrigation. This study found that turfgrass quality and density were not affected by the different irrigation intervals applied. The measured parameters of the study were; carbon exchange rates (CER), ET, plant water potential component changes, leaf diffusive resistance, transpiration and turfgrass quality. An irrigation interval of every 6 days resulted in a decrease in CER and ET. After irrigation, both of these values increased. The season average values for CER, ET, leaf water potential components, and transpiration were all lowest for the treatment receiving irrigation every 6 days.

The objectives of this experiment were to evaluate the differences in irrigation water application, rooting depth and turfgrass quality of St. Augustinegrass comparing irrigation scheduled for 1, 2 and 7 days-per-week and to correlate the presence of wilt in the turfgrass with corresponding soil VWC values.

Materials and Methods

Site Description

This study was performed at the Plant Science Research and Education Unit in Citra, Florida. There were four treatment periods from 22 April 2006 to 30 June 2006 (S06), 23 September 2006 to 15 December 2006 (F06) and 1 May 2007 to 31 August 2007 (S07) and September 2007 to 30 November 2007 (F07). In August 2005, 'Floratam' St. Augustinegrass (*Stenotaphrum secundatum [Walt.] Kuntze*.) sod was laid in the center 1.8 m X 1.8 m (5.9 ft) of each 4.3 m X 4.3 m (14 ft) plot. The three soil types present in the research area are Tavares sand, Candler sand, and Arredondo fine sand. Arredondo fine sand has a field capacity (FC) of 10% (soil water content expressed as a volumetric basis in this manuscript), a permanent wilting point (PWP) of 3% and is 94% sand, 2% silt and 4% clay. Candler sand has a field capacity of 6%, a permanent wilting point of 1% and is 96% sand, 2% silt and 2% clay. Tavares sand has a field capacity of 5%, a permanent wilting point of 1% and is 97% sand, 1% silt, and 2% clay (Carlisle et al., 1989). Further soil testing was performed on the soil at the research site to develop more appropriate values for the parameters FC and PWP.

Soil testing was performed on August 11, 2006 to develop more site specific values of FC and PWP. The values of FC in the experimental field vary across between 6% and 28% volumetric water content (VWC). Values for available water in each block, based on a 30 cm root zone, are shown in Figure 5-1. Due to variations in soil moisture across the research site treatments were arranged in a completely randomized block design.

Experimental Design

Rain sensor (RS) treatments were connected to an irrigation time clock to function in bypass mode operation so that a scheduled irrigation event would be bypassed if rainfall depth exceeded the rainfall threshold. A Mini-Clik® (Hunter Industries Inc., San Marcos, CA.) rain sensor was used to establish seven treatments. The rain sensors were set for two depths of rainfall, 6 mm and 3 mm and three different frequencies of irrigation events, 1, 2 and 7 days of irrigation per week. The same total application depth per week was divided over the possible number of days of irrigation per week. An example of the difference in irrigation depth per event for different frequencies of irrigation during the month of May is shown in Table 5-1. Additionally there were seven soil moisture sensor (SMS) controlled treatments using two brands of soil moisture sensors; the Acclima Digital TDT® RS500 (Acclima Inc., Meridian, ID.) and the LawnLogic® LL1004 (Alpine Automation, Inc., Aurora, CO.). These were attached to the irrigation timer in bypass mode similar to the rain sensors. Two ET controller treatments (ET) were also used in testing; the ET Manager™ (Rain Bird Corporation, Glendora, CA) and the Toro Intelli-sense (The Toro Company, Bloomington, MN). The ET Manager (ETM) was attached in bypass mode like the rain sensors and the Toro Intelli-Sense (TORO) was used to schedule depth and frequency of irrigation. All of the ET and SMS treatments were limited to two days of irrigation per week. Data from the SMS and ET controlled plots was used for analysis of the effect of water applied on turf quality and rooting depth along with the effect of VWC on wilting presence, treatment effects were not considered in statistical analysis. Analysis of the correlation between frequency and turf quality was performed using only rain sensor and non-irrigated treatments.

There was one control treatment in the experimental design and two time-based comparisons (Table 5-1). The control was a non-irrigated (NON) treatment. The comparison

treatments consisted of a time-based schedule without a rain sensor (WOS), time-based schedule with a rain sensor at 6 mm (WRS) and a deficit replacement schedule (DWRS) that was scheduled to apply 60% of the possible depth scheduled for WOS and the other RS treatments. Every treatment except for the DWRS and the NON treatments had the same possible total depth of irrigation application. Differences in irrigation application were due to bypassed irrigation events. Reductions in water applied by DWRS could be from bypassed irrigation events or from a shallower depth being applied during irrigation.

Data Collection

Rooting

Root samples were collected from every plot on 22 June 2006 and from the plots of nine selected treatments on 25 July 2007. Selection of treatments in 2007 was conducted to provide a range of irrigation frequencies and total depths of water applied. Samples were taken in a corner of the plots away from edges where turfgrass was well established. A sampling device was constructed out of a 5 cm diameter metal pipe (Figure 5-2). Samples were analyzed at two depths: 0 to 15 cm, and 15 to 30 cm. Samples were rinsed over an 18 gauge soil sieve to remove soil from roots, which were then placed in an oven and dried at a temp of 55°C for 48 hours. All root samples were then weighed. Statistical analyses were performed on the data using Statistical Analysis System software (SAS Institute, Inc., Cary, NC) using the General Linear Model, proc GLM comparing the mass of roots at the two sampling depths with total water applied, average weekly water applied, frequency of irrigation scheduling and year samples were collected.

Turf quality

Turfgrass quality was rated at least once every two weeks during S06 and F06 and at least once a month during S07 and F07. Quality evaluations were made using the National Turfgrass

Evaluation Program (NTEP) procedures (Shearman and Morris, 1998). The ratings were on a 1 to 9 scale, with a 1 representing dead or dormant grass and a 9 representing grass with good color and density, and without weeds (Shearman and Morris, 1998). A quality rating of 5 was considered minimally acceptable for a homeowner lawn.

Statistical analyses for turf quality data was performed with Statistical Analysis System software (SAS Institute, Inc., Cary, NC) using the General Linear Model (proc GLM) and the mixed procedure (proc MIXED). Comparisons were made between the total amounts of water applied and average weekly water applied (considering irrigation and rainfall), frequency of irrigation, and treatment period. Means separation was conducted with Duncan's Multiple Range Test.

Wilting

Measurements of the area of wilted turfgrass were taken daily during 2007 over a period from 20 May 2007 to 29 May 2007 with the exception of 21 May 2007. Measurements were taken in the afternoon when the areas with wilt were easy to distinguish. These measurements were then analyzed in comparison to volumetric water content of the soil which was recorded hourly using time domain reflectometry (TDR) sensors (CS616 Water Content Reflectometer, Campbell Scientific, Logan, UT). The TDR sensors were buried in the center of every plot with the top of the sensor at a depth of 8 cm and the bottom of the sensor at a depth of 18 cm. A two piecewise linear regression was performed on wilt data using SigmaPlot graphing software (Systat Software, Inc., San Jose, CA.).

Results

Root Sampling

Compared to 2006, root samples in 2007 on average showed increased root mass at both sampling depths. Average root mass, for all plots tested, increased by 37% from 2006 to 2007.

In 2007, root mass in the top 15 cm of soil increased by 16% and root mass from 15 to 30 cm increased by 163%. From 2006 to 2007 the root mass in the top 15 cm increased from 3.26 to 3.77 mg/cm^3 and from 0.54 to 1.43 mg/cm^3 for the 15 to 30 cm depth. In 2006, 86% of the total root mass was in the top 15 cm of the soil. In 2007, the percentage of roots in the top 15 cm was 73%.

Total and weekly water applied showed no correlation with root mass at a depth of 0 to15 cm in 2006 (P=0.270 and P=0.428) or in 2007 (P=0.219 and P=0.176; Figure 5-3). There was also no relationship between the total and weekly water applied and root mass at a depth of 15 to 30 cm in 2006 (P=0.644 and P=0.065; Figure 5-3) or in 2007 (P=0.880 and P=0.837). The root mass collected for the various irrigation frequencies is shown in Table 5-2. Root mass at both the 0 to 15 cm and 15 to 30 cm sampling depth showed no response to irrigation frequency in 2006 (P=0.138 and P=0.379) or in 2007 (P=0.254 and P=0.139; Table 5-2).

Water Applied and Turf Quality

In F06 and S07 the NON treatment was ended early by implementing a timed irrigation schedule to prevent death of the turfgrass and the need to re-sod the plots. In F06, turf quality was a 2 for plots with an irrigation frequency of 0 by the third week of testing. In S07 this treatment was ended at the end of the first week due to loss of turf quality. During both testing periods where treatments with no irrigation were continued (S06 and F07) it was seen that turf quality ratings for these plots were lower than plots in all other treatments. In F07, sufficient rainfall maintained adequate turf quality in these plots, allowing the treatment to continue throughout the testing period. The plots receiving irrigation 1 day/week had lower turf quality ratings compared to the plots receiving 2 and 7 day/week irrigation.

Analyzing total water applied and turfgrass quality data for S06 showed no relationship between the two (P=0.409; Figure 5-4), but there was a trend between weekly water applied and

turf quality (P<0.001; Figure 5-5). Between depths applied of 0 and 20 mm per week the trend in turf quality is linearly increasing and between 20 and 30 mm applied weekly the relationship becomes less apparent. Poor turf quality for plots receiving more than 30 mm of water was most likely due to factors other than the volume of water applied. While all three frequencies of irrigation (1, 2 and 7 days-per-week) had plots with turf quality ratings of 8 at some point during S06, the 7 day/week treatment never had a turf quality rating below 4 while the 1 day/week treatments had ratings as low as 2. Also, the standard deviation in turf quality for the 7 day/week plots was smaller than the other irrigation frequencies tested in S06 (Figure 5-6). Both of the one day/week treatments had similar low turf quality ratings at the end of S06 (P=0.087) but only RS1-3mm (rain sensor set at 3 mm) was below acceptable. The other one day/week treatment had a rain sensor set at 6 mm. In this example, the 3 mm threshold rain sensor bypassed 1 more irrigation event than the 6 mm setting resulting in a decrease in turf quality.

No relationship was seen between turf quality and weekly water applied (P=0.150) during F06 (Figure 5-5B) or between turf quality and total water applied (P=0.593; Figure 5-4B). Frequency of irrigation applied also had no effect on turf quality in F06 (P=0.409). Turf quality ratings in general were higher in F06 than in S06.

A correlation during S07 was seen between both total water applied and turf quality (P=0.014) and water applied weekly and turf quality (P<0.001; Figure 5-4C and 5-5C). This treatment period had the strongest relationship between total water applied and turf quality. There was an effect of frequency on turf quality during S07 (P=0.002). Plots in the 2 and 7 day/week irrigation frequency treatments tended to have higher turf quality than the 1 day/week irrigation plots (Table 5-3).

In F07, there was a relationship between turf quality and water applied weekly (P=0.027) but not between turf quality and total water applied (P=0.485). This period received more rainfall than the other treatment periods. This was the only treatment period with rainfall depths greater than historical averages for the area. It received a total of 347 mm compared to a historical average of 258 mm. This was also the only treatment period with days of rainfall exceeding the historical number of days receiving a depth of rain greater than 2.5 cm. The other three treatment periods had rainfall depths that were less than half the historical depth. The response of the turfgrass to varying frequency of irrigation was strong in F07 (P<0.001; Figure 5-6D). The effect was enhanced by the fact that the treatment NON was operated the entire time period. While turf quality ratings in these plots were high enough to allow the treatment to operate, they were lower than the plots with irrigation 1, 2 or 7 days/week.

Wilt Analysis

Analysis of data collected during S07 demonstrated the volumetric water content where different percentages of turfgrass area showed signs of wilt. Measurements of the percentage of area displaying signs of wilt along with the volumetric water content of the plot at the time of the measurement, separated by block, are shown in Figure 5-7. Soil analysis showed that the soils in these blocks had very different water holding characteristics and so were separated in this analysis.

A two piecewise linear equation was used in this analysis to show the trend of wilt with VWC (Figure 5-7). The data showed that wilt tended to increase slowly with decreasing VWC below FC but below some value of VWC the area with wilt started to increase much more rapidly. The point at which the wilt began to increase rapidly is demonstrated as the inflection point of the piecewise linear equation. The values of R^2 for these lines varied between 0.38 and 0.67. The lowest correlation (0.38) was in block 1 of the field and the highest (0.67) was in

block 2. For blocks 1, 2 and 3 the inflection point occurred at a VWC close to 7%. In Block 4 the inflection point was at 11% VWC.

Conclusions

Rooting depth was not affected by frequency of irrigation or water applied during either year of testing. Total root mass increased between the two years of testing by 35%. The largest increase was seen in the 15 to 30 cm depth, with an increase of 156% from 2006 to 2007. In both 2006 and 2007 large percentages, 87% and 75% respectively, of the total root mass were seen in the top 15 cm of the soil profile.

During the spring and summer months of testing in both years, frequency of irrigation appeared to have an effect on turf quality with 2 and 7 day/week irrigation schedules producing better turf quality than 1 day/week. In F07 there was no significant difference in turf quality between the 1, 2 or 7 day/week frequencies of irrigation. Non-irrigated plots produced turf quality significantly lower than the other plots in F07. Rain sensor setting was an important factor in turf quality for 1 day/week irrigation schedule. The threshold setting needs to ensure adequate water is applied to the turfgrass before bypassing the only irrigation event for the week.

Water applied appeared to have a correlation with turf quality in S06 and S07, as weekly water applied increased, turf quality increased. Plots receiving less than 20 mm/week during these treatment periods tended to have decreased turf quality. Testing periods F06 and F07 both had higher average turf quality ratings than S06 and S07, with no correlation between turf quality and water applied. F07 received enough rainfall that non-irrigated plots maintained adequate turf quality throughout the treatment period.

Wilting analysis data showed that, in a sandy soil, wilt tended to increase slowly with decreasing soil water content until some value of VWC (inflection point) where the wilt began to

increase rapidly. For this experiment three out of four blocks in the research site had an inflection point of 7% VWC and the fourth had an inflection point of 10%.

Table 5-1. Summary of irrigation treatment codes and descriptions along with water applied per irrigation event during the month of May.

Treatment Code	Irrigation frequency (days/week)	Depth per irrigation event (mm)	Treatment description
RS1-3mm	1	46	Rain sensor set at 3 mm rainfall threshold
RS2-3mm	2	23	Rain sensor set at 3 mm rainfall threshold
RS7-3mm	7	7	Rain sensor set at 3 mm rainfall threshold
RS1-6mm	1	46	Rain sensor set at 6 mm rainfall threshold
RS2-6mm	2	23	Rain sensor set at 6 mm rainfall threshold
RS7-6mm	7	7	Rain sensor set at 6 mm rainfall threshold
DWRS	2	14	Reduced irrigation schedule 60% of RS2-6mm
WOS	2	23	No rain sensor attached
NON	0	0	No irrigation applied

Table 5-2. Summary of the root mass collected in 2006 and 2007 at two depths, 0 to 15 cm and from 15 to 30 cm. Irrigation frequency and the year the samples were taken were both analyzed for effects on root mass at the two depths of testing.

Irrigation frequency	Root mass from 0 to 15 cm (mg/cm3)			Root mass from 15 to 30 cm (mg/cm3)		
(days/week)	2006	2007	Both	2006	2007	Both
0	2.44 ***b***	*NA*[a]	*NA*	0.2 ***a***	*NA*	*NA*
1	4.24 ***a***	3.12 ***a***	3.67 ***a***	0.81 ***a***	0.98 ***a***	0.88 ***a***
2	3.16 ***ab***	3.97 ***a***	3.40 ***a***	0.54 ***a***	1.63 ***a***	0.88 ***a***
7	3.33 ***ab***	3.16 ***a***	3.26 ***a***	0.41 ***a***	0.88 ***a***	0.58 ***a***
CV %	34.1	26.7	34.1	99.4	68.6	99.3
Year comparison						
	3.26 ***b***	3.77 ***a***		0.54 ***b***	1.43 ***a***	
CV %	31.9			85.8		

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level. *NA* indicates soil sampling analysis was not available for an irrigation frequency of 0 during 2007 because plots for the non-irrigated treatment received supplemental irrigation prior to root sampling.

Table 5-3. Summary of turf quality analysis showing average turf quality values for each of the four treatment periods S06, F06, S07 and F07. Irrigation frequency and treatment period were both analyzed for effects on average turf quality.

Irrigation frequency (days/week)	Average turf quality (1 to 9 scale)			
	S06	F06	S07	F07
0	1.4 ***c***	*NA*[a]	*NA*	5.0 ***b***
1	4.9 ***b***	*NA*	5.8 ***c***	6.2 ***a***
2	5.9 ***a***	6.7 ***a***	6.2 ***b***	6.4 ***a***
7	6.2 ***a***	6.5 ***a***	6.7 ***a***	6.8 ***a***
CV %	27.7	18.4	18.6	17.1
Treatment period comparison				
	5.5 ***c***	6.7 ***a***	6.3 ***b***	6.3 ***b***
CV %	22.4			

Different letters in columns indicate differences by Duncan's multiple range test at the 95% confidence level. [a]Treatments were ended due to poor turf quality in F06 and S07. In F06, turf quality was a 2 for plots with an irrigation frequency of 0 by the third week of testing. In S07, this treatment was ended at the end of the first week due to loss of turf quality. The 1 day/week treatments had a malfunction in the irrigation timer for a period of 20 days causing no irrigation to be applied. Therefore averages could not be analyzed for the plots receiving irrigation 1 day/week.

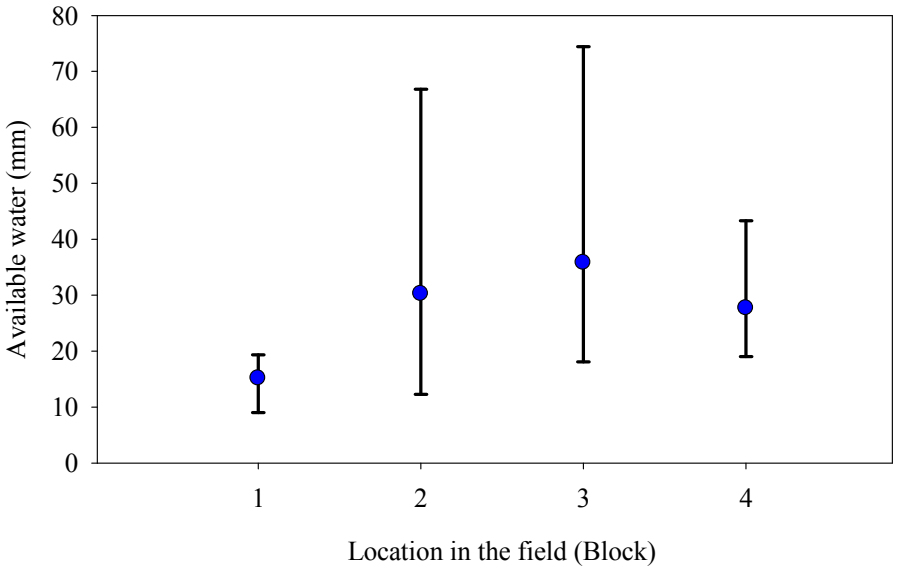

Figure 5-1. Mean values for available water are shown for each block in the field based on a 30 cm root depth. Bars show the maximum and minimum range of the values within in each block.

Figure 5-2. Sampling device used for collecting roots in turfgrass plots.

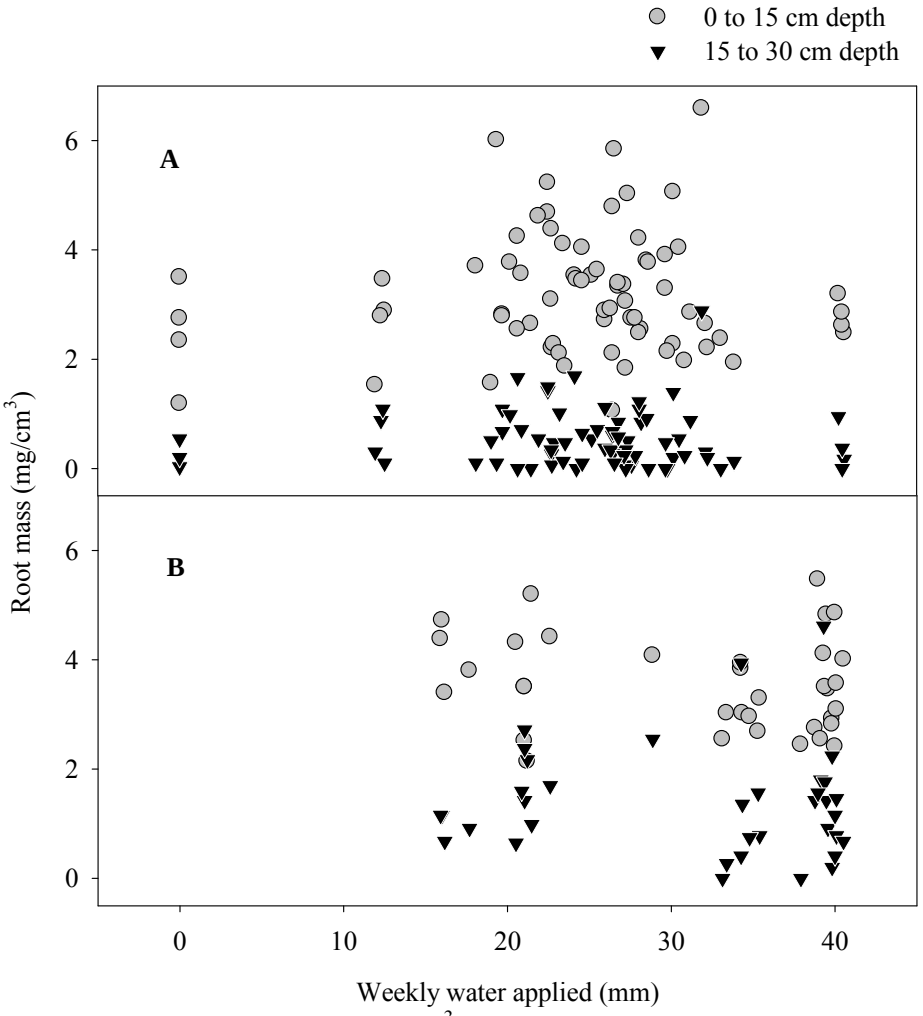

Figure 5-3. Root mass collected (mg/cm^3) at two depths in the soil profile, 0 to15 cm (circles) and 15 cm to 30 cm (triangles), along with average weekly water applied in A) 2006 and B) 2007.

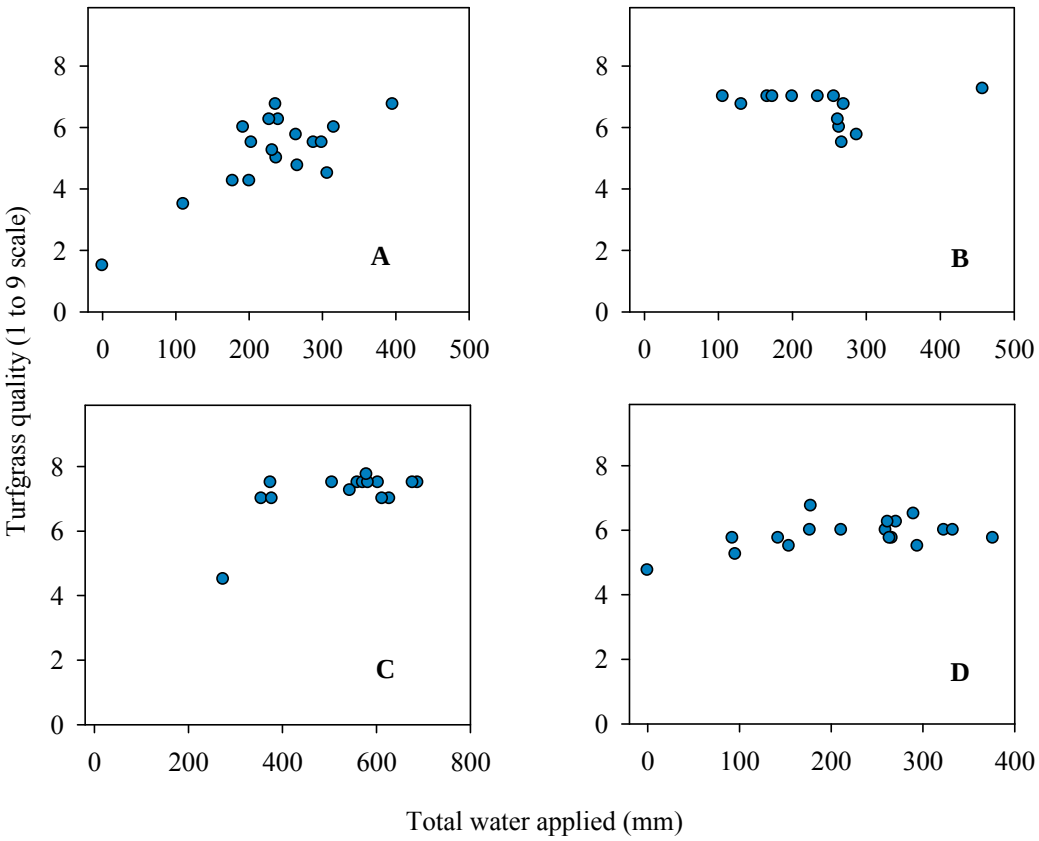

Figure 5-4. Average turfgrass quality compared to total water applied during A) S06, B) F06, C) S07 and, D) F07.

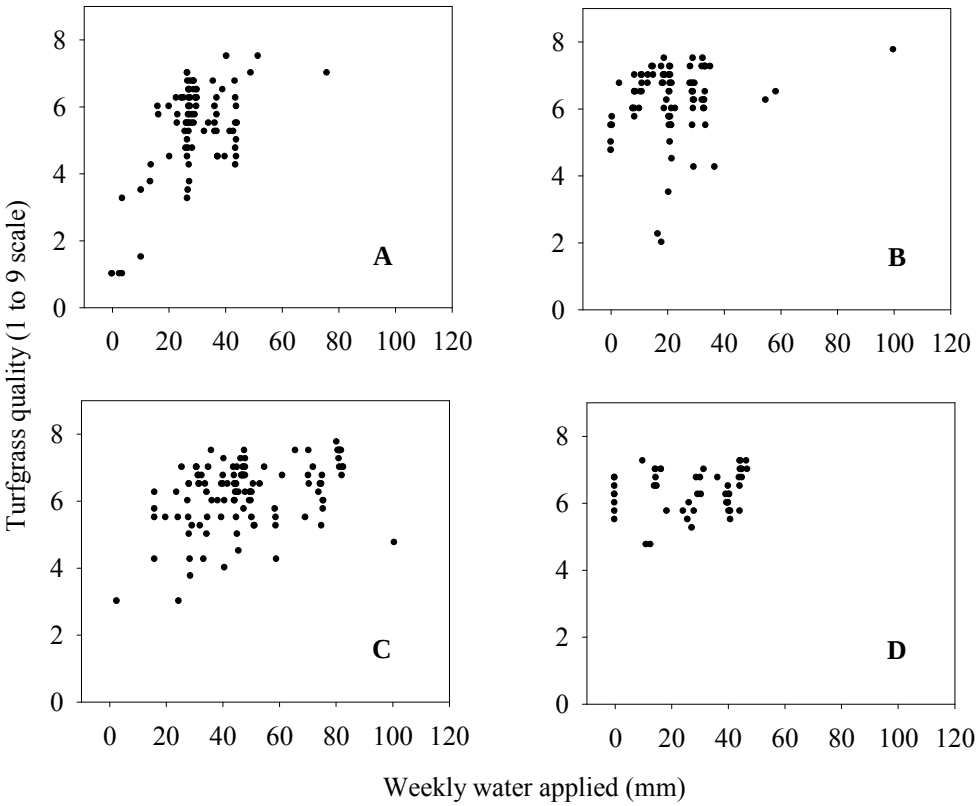

Figure 5-5. Average turfgrass quality compared to weekly water applied in (A) S06, B) F06, C) S07 and, D) F07.

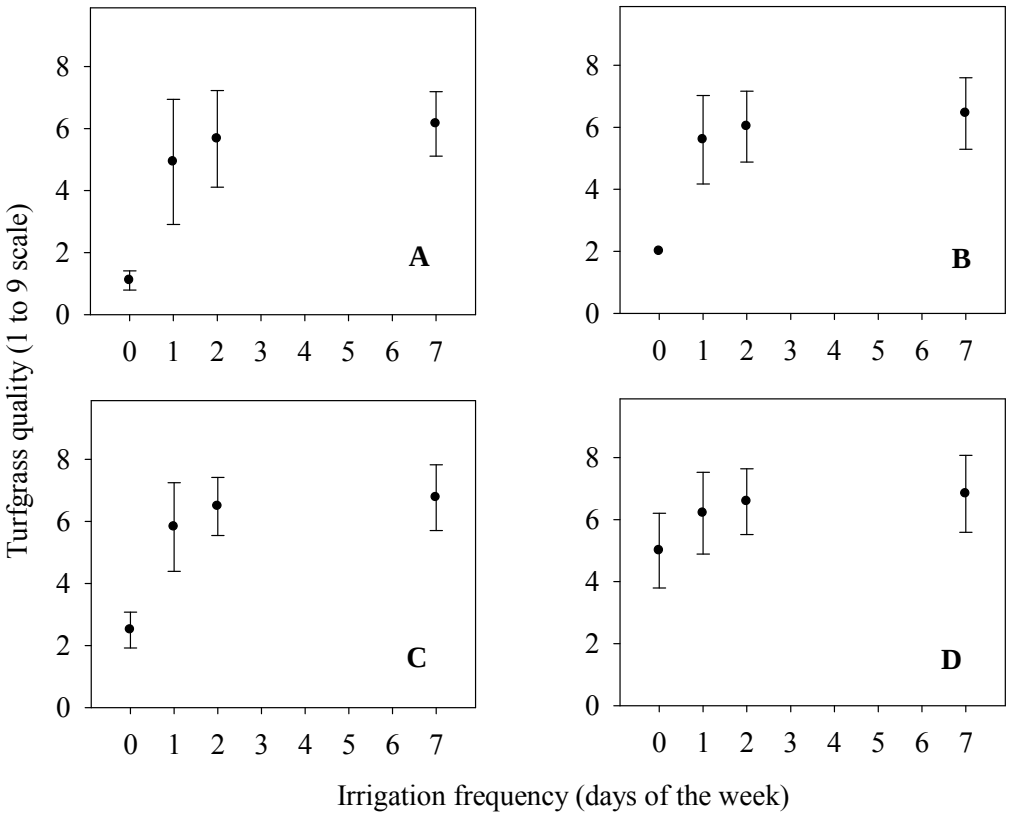

Figure 5-6. Box plots comparing frequency of irrigation and turf quality during the A) S06, B) F06, C) S07, and D) F07 treatment periods. Black dots represent the average turf quality rating. Error bars represent standard deviation. Irrigation frequency of 0 may contain fewer observations.

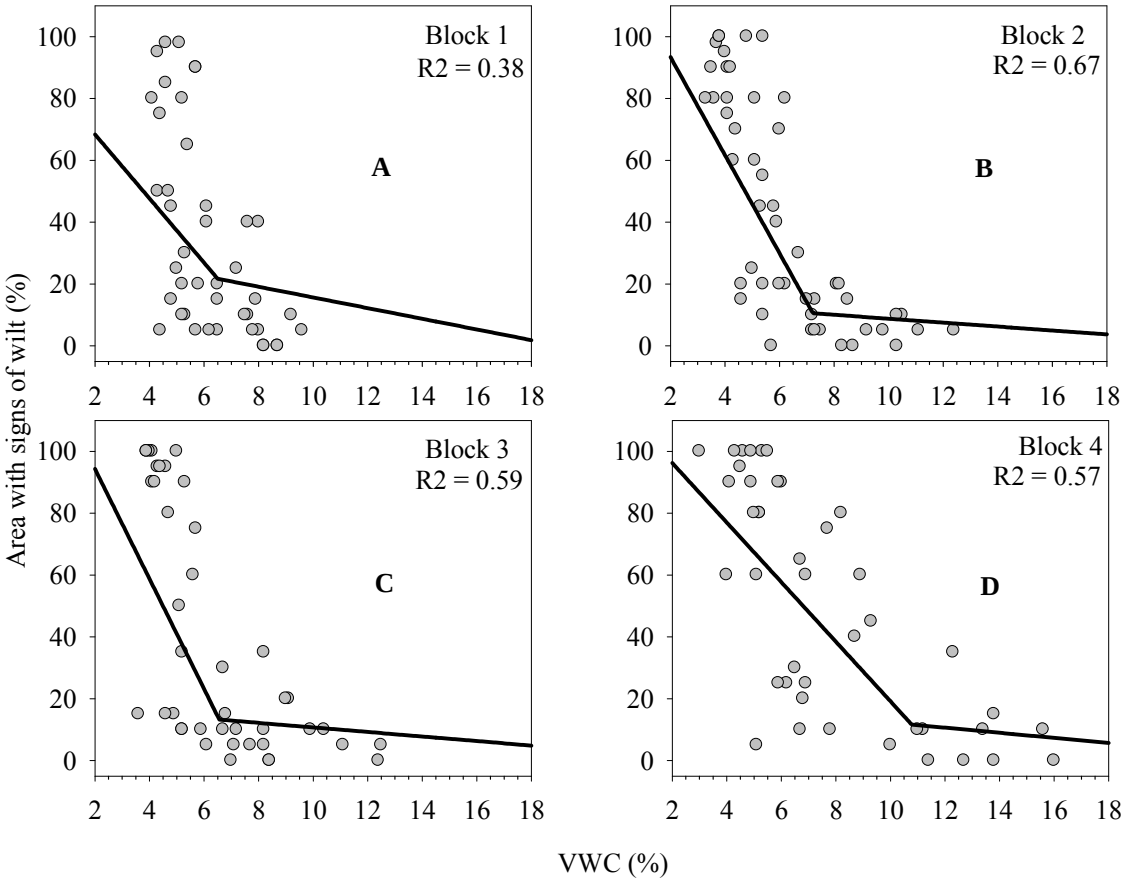

Figure 5-7. The effect of volumetric water content (VWC; %) on the presence of wilting in turfgrass. The scatter plot is the percentage area of turfgrass with the presence of wilt compared to the corresponding volumetric water content for the block the turfgrass was located in. A) Block 1. B) Block 2. C) Block 3. D) Block4.

CHAPTER 6
CONCLUSIONS

Water Applied and Turf Quality

Even though most of the testing on soil moisture sensor irrigation controllers, evapotranspiration irrigation controllers, and rain sensors was performed during relatively dry conditions, with the experimental area receiving less than half the historical rainfall depth, all of the technologies tested managed to reduce water application compared to a time clock irrigation schedule without a sensor to bypass irrigation cycles due to climatic conditions and most managed to maintain acceptable turf quality during all testing.

The medium threshold SMS-based treatments produced water savings and good quality turf during all treatment periods. Water savings for these treatments were up to 30% (AC) and 21% (LL) during dry conditions and 53% (AC) and 31% (LL) during three months with normal rainfall conditions. Low threshold sensor settings produced minimally acceptable (AC) and less than acceptable turf quality (LL) during the dry conditions of the spring of 2006. The LL Low treatment only managed to maintain acceptable turf quality during the fall of 2007, which was the only testing period where rainfall depths were greater than historical averages for the area. During October 2007, rainfall was three times the historical amount; the other fall months of testing during 2007 received rainfall depths that did not exceed historical averages. Overall the fall of 2007 was relatively wetter than the previous testing periods, but close to normal for Florida. Under the relatively wetter conditions of the fall of 2007 the low threshold SMS settings reduced water applied by 74% (AC) and 44% (LL). High threshold settings for the SMS controllers produced little or no savings (between 0 and 14%) during any of the testing.

During the dry testing periods, the weekly water applied using one SMS controller for all plots (AC 7) was similar to the weekly water applied using a separate sensor for each of the four

plots in the treatment (AC IR). The threshold settings for the two treatments were the same, but the difference was the individually monitored irrigation for each plot compared to irrigation monitored with only one sensor buried in the driest plot. There were differences in turf quality between AC IR and AC 7 during the spring testing periods. The average turf quality ratings for the AC 7 treatment were a 5.1 (2006) and a 5.8 (2007) while the AC IR plots had higher average turf quality ratings of 6.2 (2006) and 6.5 (2007). To ensure adequate water application the sensor must have the proper threshold setting for the driest plot which will need more water to be applied. Utilizing one sensor to control the irrigation for multiple areas can be effective for reducing water applied and while maintaining acceptable turf quality as long as the correct location and set point is selected for sensor installation. In this example the driest plot was selected to ensure that adequate irrigation was applied to all of the plots.

During fall 2007, which had relatively wetter conditions, the AC 7 and AC IR treatments had similar turf quality ratings. It is important to note that all of the treatments during this testing period had at least minimally acceptable turf quality, even the non-irrigated plots. Rain sensor treatments, excluding DWRS, reduced water by 7 to 24% during the dry treatment periods and by 22 to 30% during the wetter conditions in the fall of 2007.

A one-day-per-week irrigation schedule with a rain sensor set for 3 mm of rainfall resulted in less than acceptable turf quality during the spring of 2006. A similar treatment that also received irrigation only once a week but had a rainfall threshold of 6 mm had acceptable turf quality during the same season. Also, in the spring of 2007 the one-day-per-week irrigation treatment with a 3 mm rain sensor threshold had to be ended early due to loss of turf quality. The RS1-6mm treatment, which had a higher rainfall threshold setting, had acceptable turf

quality for all of the testing periods. Thus, a 6 mm rain sensor threshold should be considered the minimum for one-day-per-week irrigation frequencies.

Simply reducing the water applied per irrigation event by 40% (treatment DWRS) consistently produced higher water savings during all of the treatment periods compared to the other rain sensor treatments and the medium threshold SMS treatments. Reductions in water applied for this treatment ranged from 36 to 45% for the relatively dry conditions and 53% during wetter conditions. The turfgrass quality for the reduced irrigation schedule was always better than minimally acceptable, ranging from 6.5 to 7.1 for all testing periods.

ET controllers had water savings ranging from 25 to 63% during the fall of 2006 and the spring of 2007; both were considered dry testing periods. However in the spring of 2007 the ETM controller produced less than acceptable turf quality due to an inappropriate input parameter setting related to effective rainfall. This input resulted in a water holding capacity that was greater than actual value; therefore, the controller bypassed irrigation longer than other treatments. The controller estimated that water was still in the profile and available to the plant that was never actually in the soil profile. This shows the importance of controller set up in enabling the systems to work correctly, both reducing water applied and maintaining good quality turfgrass. During the relatively wetter conditions of the fall of 2007, ET controllers had high water savings of (59% for the ETM and 62% for the TORO and both had acceptable turf quality.

The average water savings for treatments that maintained turf quality above a rating of 6 (better than minimally acceptable) during the treatment periods when all the technologies were installed are as follows in order from greatest to least water savings produced; TORO (50%),

DWRS (47%), AC 10 (34%), LL Med (23%), RS7-3mm (26%), RS2-3mm (17%), RS7-6mm (16%), AC 13 (12%) and LL High (6%).

Overall, the proper installation and set-up of each of the technologies tested here was an important factor in determining the effectiveness to which each system could reduce water applied and maintain turfgrass quality at a level sufficient for homeowners. Volumetric moisture content threshold was an important factor in correctly establishing an irrigation schedule using an SMS system along with ensuring adequate contact between the soil and the sensor. For ET controller systems the input parameters affect the amount of water applied and the frequency with which it is applied. The input parameters determine things such as water holding capacity of the soil. Rain sensors produced water savings and only one treatment had less than acceptable quality. The water savings achieved using rain sensors was approximately half that of those achieved using soil moisture sensors (medium threshold AC sensor) and ET controllers, with the exception of DWRS. The threshold setting should be set appropriately based on local watering restrictions. With limited allowable days for irrigation the rainfall threshold needs to be set adequately to ensure that irrigation is only bypassed when a sufficient amount of water has been applied for plant needs.

Control Device Performance and Accuracy

Soil Moisture Sensors

The variability of performance of the sensors tested, or the range over which they bypassed irrigation, was smaller for the AC sensors than the LL sensors. The range is the difference between the highest VWC (i.e. wet conditions) at which the sensor allowed irrigation and the lowest VWC (i.e. dry conditions) at which the sensor bypassed irrigation. With a smaller variability of performance, the response of the controller to certain depths of soil water content becomes more predictable. The smallest error range for the AC sensors during all treatment

periods was 0% and the largest was 3.4% VWC. The LL sensors had a range of between 2.0% and 4.4% VWC. During the spring of 2006, the LL Low controller bypassed irrigation when soil VWC was as low as 4.7% (approximately 0.2 cm or 9% of total available water) and allowed irrigation when soil VWC was 8.6%. Bypassing irrigation events at low values of soil water content lead to a decrease in turf quality, with an average turf quality rating of 4.2. The same controller during the same testing period allowed irrigation when soil VWC was 8.6%.

Further testing showed that the Acclima sensors had good precision and the VWC data collected from the sensors had a good correlation compared to the data collected using TDR sensors in the experimental plots. The TDR data was used as a standard of comparison. The trend line for the data from the AC controllers and the TDR data had values of r-squared between 0.77 and 0.89 indicating that the TDR data explained most of the variability in the AC data. While there was good precision of the sensors, compared to the TDR, accuracy varied. Some of the sensors tended to read VWC higher than the correlating TDR. Seven of the 8 AC sensors tested recorded lower values for VWC than the TDR readings, with average differences with the TDR readings of between 0.1% VWC and 2.3% VWC. One sensor (AC 10) tended to record soil VWC values lower than the TDR by only 0.2%. The TDR sensors used in this testing have a published error range of +/-2.5% VWC (Campbell Scientific, Inc., 2006). This means that the AC sensors throughout the four seasons of testing had an error range that fell within the known range of accuracy of the TDR sensors used in testing.

Laboratory testing of the LawnLogic sensors showed soil water tension for the various threshold settings varied by between 0.1 kPa and 4.5 kPa. At higher LawnLogic threshold levels (9 through 6) the corresponding soil water tension values varied between sensors by only 0 to 0.7 kPa. The lower threshold settings (6 through 1), which correlate with drier soil moisture

conditions, had larger differences in compared to the soil water tension, varying by 1.4 to 4.5 kPa.

Evapotranspiration Controllers

ET_o calculations for the TORO, both supplied by the manufacturer and collected manually from the controller, tended to overestimate ET_o compared to data collected onsite. Based on manufacturer data it overestimated ET_o by 19% over a 4 month period while the ET_o data for the ETM were within 5% over the same 4 month period. Manufacturer provided monthly ET_o data for the TORO on average was within 6% of the on-site data for the months of August 2006 to April 2007, but after April 2007 the average monthly ET_o values increased to 23% greater than on-site values. This may be due to a change in weather station used to collect data or a malfunction in the weather station used by the manufacturer.

Irrigation Frequency on Turf Quality and Root Growth

Rooting depth was not affected by frequency of irrigation or water applied during 2006 or 2007. Overall total root mass increased between 2006 and 2007 by 37%. The largest increase was seen at a depth of 15 to 30 cm, with an increase of 163% in 2007 compared to 2006. In both 2006 and 2007 large percentages, 86% and 73% respectively, of the total root mass were seen in the top 15 cm of the soil profile, compared to the total sample depth of 30 cm.

During the spring and summer months of testing in both years, frequency of irrigation appeared to have an effect on turf quality with 2 and 7 day/week irrigation schedules producing better turf quality than 1 day/week. During the relatively wetter conditions in the fall of 2007, there was no significant difference in turf quality between the 1, 2 or 7 day/week irrigation frequencies. Non-irrigated plots had a minimally acceptable turf quality rating (5.0) during these wetter conditions, but the turf quality was significantly lower than any other treatments. The fall of 2007 was the only testing period where turf quality in the non-irrigated plots was acceptable.

Water applied appeared to have a correlation with turf quality in spring months of testing in both 2006 and 2007. As weekly water applied increased, turf quality increased. Plots receiving less than 20 mm/week during these treatment periods tended to have lower turf quality ratings. In general turf quality ratings were better in the fall months than the spring months for both years of testing. During the fall months there was no correlation between turf quality and water applied.

Wilting analysis data showed that, in the sandy soil present at the research site, wilt tended to increase slowly with decreasing soil water content until some value of VWC where the wilt increased rapidly. The soil water content at which the wilt began to increase rapidly was called the inflection point. For this experiment three out of four blocks in the research site had an inflection point of 7% VWC and the fourth had an inflection point of 10%. This inflection point is site and soil specific and a general recommendation for sandy soils can not be made from this study alone.

APPENDIX A
CHAPTER 2 STATISTICAL ANALYSIS.

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      Soil Moisture Sensor Treatments Water Applied and Turf Quality SMS
data SMS;
input year$ season$ month$ week$ tmt$ rep mm type$ TQ;
cards;
2006  S06   Apr06 1     NON   1     .     .     .
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2007  F07   Oct07 23    NON   1     .     .     .
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2007  F07   Oct07 25    NON   1     .     .     .
2007  F07   Oct07 26    NON   1     .     .     .
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2006	S06	June06	9	LL2	1	0	SMS	4
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2006	F06	Nov06	8	AC10	2	10	SMS	8
2006	F06	Nov06	9	AC10	2	10	SMS	.
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2006	F06	Dec06	10	AC10	3	0	SMS	7
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2006	F06	Dec06	12	AC10	3	10	SMS	.
2006	F06	Sep06	1	AC10	4	33	SMS	7
2006	F06	Oct06	2	AC10	4	33	SMS	7
2006	F06	Oct06	3	AC10	4	28	SMS	.
2006	F06	Oct06	4	AC10	4	15	SMS	7
2006	F06	Oct06	5	AC10	4	28	SMS	.
2006	F06	Nov06	6	AC10	4	10	SMS	.
2006	F06	Nov06	7	AC10	4	10	SMS	.
2006	F06	Nov06	8	AC10	4	10	SMS	7
2006	F06	Nov06	9	AC10	4	10	SMS	.
2006	F06	Dec06	10	AC10	4	0	SMS	6
2006	F06	Dec06	11	AC10	4	10	SMS	7
2006	F06	Dec06	12	AC10	4	10	SMS	.
2006	F06	Sep06	1	AC13	1	34	SMS	4
2006	F06	Oct06	2	AC13	1	34	SMS	4
2006	F06	Oct06	3	AC13	1	29	SMS	.
2006	F06	Oct06	4	AC13	1	29	SMS	4
2006	F06	Oct06	5	AC13	1	29	SMS	.
2006	F06	Nov06	6	AC13	1	10	SMS	.
2006	F06	Nov06	7	AC13	1	11	SMS	.
2006	F06	Nov06	8	AC13	1	10	SMS	6
2006	F06	Nov06	9	AC13	1	22	SMS	.
2006	F06	Dec06	10	AC13	1	10	SMS	6
2006	F06	Dec06	11	AC13	1	21	SMS	6

2006	F06	Dec06	12	AC13	1	21	SMS	.
2006	F06	Sep06	1	AC13	2	33	SMS	8
2006	F06	Oct06	2	AC13	2	33	SMS	7
2006	F06	Oct06	3	AC13	2	29	SMS	.
2006	F06	Oct06	4	AC13	2	28	SMS	8
2006	F06	Oct06	5	AC13	2	29	SMS	.
2006	F06	Nov06	6	AC13	2	10	SMS	.
2006	F06	Nov06	7	AC13	2	10	SMS	.
2006	F06	Nov06	8	AC13	2	10	SMS	8
2006	F06	Nov06	9	AC13	2	21	SMS	.
2006	F06	Dec06	10	AC13	2	10	SMS	7
2006	F06	Dec06	11	AC13	2	21	SMS	7
2006	F06	Dec06	12	AC13	2	21	SMS	.
2006	F06	Sep06	1	AC13	3	32	SMS	8
2006	F06	Oct06	2	AC13	3	32	SMS	8
2006	F06	Oct06	3	AC13	3	28	SMS	.
2006	F06	Oct06	4	AC13	3	28	SMS	8
2006	F06	Oct06	5	AC13	3	28	SMS	.
2006	F06	Nov06	6	AC13	3	10	SMS	.
2006	F06	Nov06	7	AC13	3	10	SMS	.
2006	F06	Nov06	8	AC13	3	9	SMS	7
2006	F06	Nov06	9	AC13	3	21	SMS	.
2006	F06	Dec06	10	AC13	3	9	SMS	8
2006	F06	Dec06	11	AC13	3	21	SMS	8
2006	F06	Dec06	12	AC13	3	20	SMS	.
2006	F06	Sep06	1	AC13	4	33	SMS	7
2006	F06	Oct06	2	AC13	4	33	SMS	7
2006	F06	Oct06	3	AC13	4	28	SMS	.
2006	F06	Oct06	4	AC13	4	29	SMS	7
2006	F06	Oct06	5	AC13	4	28	SMS	.
2006	F06	Nov06	6	AC13	4	10	SMS	.
2006	F06	Nov06	7	AC13	4	10	SMS	.
2006	F06	Nov06	8	AC13	4	10	SMS	7
2006	F06	Nov06	9	AC13	4	21	SMS	.
2006	F06	Dec06	10	AC13	4	10	SMS	6
2006	F06	Dec06	11	AC13	4	20	SMS	7
2006	F06	Dec06	12	AC13	4	21	SMS	.
2006	F06	Sep06	1	ACIR	1	17	SMS	8
2006	F06	Oct06	2	ACIR	1	17	SMS	7
2006	F06	Oct06	3	ACIR	1	15	SMS	.
2006	F06	Oct06	4	ACIR	1	15	SMS	7
2006	F06	Oct06	5	ACIR	1	29	SMS	.
2006	F06	Nov06	6	ACIR	1	10	SMS	.
2006	F06	Nov06	7	ACIR	1	0	SMS	.
2006	F06	Nov06	8	ACIR	1	0	SMS	7
2006	F06	Nov06	9	ACIR	1	0	SMS	.
2006	F06	Dec06	10	ACIR	1	10	SMS	6
2006	F06	Dec06	11	ACIR	1	0	SMS	7
2006	F06	Dec06	12	ACIR	1	11	SMS	.
2006	F06	Sep06	1	ACIR	2	34	SMS	5
2006	F06	Oct06	2	ACIR	2	33	SMS	5
2006	F06	Oct06	3	ACIR	2	29	SMS	.
2006	F06	Oct06	4	ACIR	2	29	SMS	5
2006	F06	Oct06	5	ACIR	2	29	SMS	.
2006	F06	Nov06	6	ACIR	2	10	SMS	.
2006	F06	Nov06	7	ACIR	2	10	SMS	.
2006	F06	Nov06	8	ACIR	2	10	SMS	5

2006	F06	Nov06	9	ACIR	2	10	SMS	.
2006	F06	Dec06	10	ACIR	2	0	SMS	4
2006	F06	Dec06	11	ACIR	2	10	SMS	5
2006	F06	Dec06	12	ACIR	2	10	SMS	.
2006	F06	Sep06	1	ACIR	3	17	SMS	7
2006	F06	Oct06	2	ACIR	3	17	SMS	6
2006	F06	Oct06	3	ACIR	3	15	SMS	.
2006	F06	Oct06	4	ACIR	3	15	SMS	7
2006	F06	Oct06	5	ACIR	3	15	SMS	.
2006	F06	Nov06	6	ACIR	3	0	SMS	.
2006	F06	Nov06	7	ACIR	3	10	SMS	.
2006	F06	Nov06	8	ACIR	3	0	SMS	8
2006	F06	Nov06	9	ACIR	3	0	SMS	.
2006	F06	Dec06	10	ACIR	3	10	SMS	7
2006	F06	Dec06	11	ACIR	3	0	SMS	8
2006	F06	Dec06	12	ACIR	3	10	SMS	.
2006	F06	Sep06	1	ACIR	4	0	SMS	8
2006	F06	Oct06	2	ACIR	4	16	SMS	7
2006	F06	Oct06	3	ACIR	4	15	SMS	.
2006	F06	Oct06	4	ACIR	4	13	SMS	7
2006	F06	Oct06	5	ACIR	4	22	SMS	.
2006	F06	Nov06	6	ACIR	4	0	SMS	.
2006	F06	Nov06	7	ACIR	4	0	SMS	.
2006	F06	Nov06	8	ACIR	4	0	SMS	8
2006	F06	Nov06	9	ACIR	4	0	SMS	.
2006	F06	Dec06	10	ACIR	4	0	SMS	7
2006	F06	Dec06	11	ACIR	4	0	SMS	7
2006	F06	Dec06	12	ACIR	4	10	SMS	.
2006	F06	Sep06	1	LL5	1	32	SMS	7
2006	F06	Oct06	2	LL5	1	33	SMS	7
2006	F06	Oct06	3	LL5	1	15	SMS	.
2006	F06	Oct06	4	LL5	1	14	SMS	7
2006	F06	Oct06	5	LL5	1	28	SMS	.
2006	F06	Nov06	6	LL5	1	10	SMS	.
2006	F06	Nov06	7	LL5	1	21	SMS	.
2006	F06	Nov06	8	LL5	1	10	SMS	7
2006	F06	Nov06	9	LL5	1	20	SMS	.
2006	F06	Dec06	10	LL5	1	10	SMS	7
2006	F06	Dec06	11	LL5	1	21	SMS	7
2006	F06	Dec06	12	LL5	1	20	SMS	.
2006	F06	Sep06	1	LL5	2	33	SMS	8
2006	F06	Oct06	2	LL5	2	33	SMS	7
2006	F06	Oct06	3	LL5	2	15	SMS	.
2006	F06	Oct06	4	LL5	2	15	SMS	7
2006	F06	Oct06	5	LL5	2	28	SMS	.
2006	F06	Nov06	6	LL5	2	9	SMS	.
2006	F06	Nov06	7	LL5	2	21	SMS	.
2006	F06	Nov06	8	LL5	2	10	SMS	8
2006	F06	Nov06	9	LL5	2	20	SMS	.
2006	F06	Dec06	10	LL5	2	10	SMS	7
2006	F06	Dec06	11	LL5	2	20	SMS	7
2006	F06	Dec06	12	LL5	2	21	SMS	.
2006	F06	Sep06	1	LL5	3	32	SMS	7
2006	F06	Oct06	2	LL5	3	33	SMS	7
2006	F06	Oct06	3	LL5	3	15	SMS	.
2006	F06	Oct06	4	LL5	3	15	SMS	7
2006	F06	Oct06	5	LL5	3	28	SMS	.

2006	F06	Nov06	6	LL5	3	10	SMS	.
2006	F06	Nov06	7	LL5	3	20	SMS	.
2006	F06	Nov06	8	LL5	3	10	SMS	7
2006	F06	Nov06	9	LL5	3	21	SMS	.
2006	F06	Dec06	10	LL5	3	10	SMS	6
2006	F06	Dec06	11	LL5	3	21	SMS	7
2006	F06	Dec06	12	LL5	3	20	SMS	.
2006	F06	Sep06	1	LL5	4	32	SMS	8
2006	F06	Oct06	2	LL5	4	32	SMS	8
2006	F06	Oct06	3	LL5	4	14	SMS	.
2006	F06	Oct06	4	LL5	4	14	SMS	8
2006	F06	Oct06	5	LL5	4	28	SMS	.
2006	F06	Nov06	6	LL5	4	10	SMS	.
2006	F06	Nov06	7	LL5	4	20	SMS	.
2006	F06	Nov06	8	LL5	4	10	SMS	8
2006	F06	Nov06	9	LL5	4	21	SMS	.
2006	F06	Dec06	10	LL5	4	10	SMS	6
2006	F06	Dec06	11	LL5	4	20	SMS	7
2006	F06	Dec06	12	LL5	4	21	SMS	.
2007	S07	May07	1	AC10	1	43	SMS	7
2007	S07	May07	2	AC10	1	42	SMS	.
2007	S07	May07	3	AC10	1	50	SMS	7
2007	S07	May07	4	AC10	1	43	SMS	7
2007	S07	Jun07	5	AC10	1	42	SMS	.
2007	S07	Jun07	6	AC10	1	39	SMS	.
2007	S07	Jun07	7	AC10	1	17	SMS	6
2007	S07	Jun07	8	AC10	1	17	SMS	.
2007	S07	Jul07	9	AC10	1	17	SMS	7
2007	S07	Jul07	10	AC10	1	16	SMS	.
2007	S07	Jul07	11	AC10	1	8	SMS	.
2007	S07	Jul07	12	AC10	1	31	SMS	6
2007	S07	Jul07	13	AC10	1	32	SMS	.
2007	S07	Aug07	14	AC10	1	20	SMS	8
2007	S07	Aug07	15	AC10	1	42	SMS	.
2007	S07	Aug07	16	AC10	1	41	SMS	.
2007	S07	Aug07	17	AC10	1	41	SMS	8
2007	F07	Sep07	18	AC10	1	21	SMS	.
2007	F07	Sep07	19	AC10	1	37	SMS	.
2007	F07	Sep07	20	AC10	1	16	SMS	7
2007	F07	Sep07	21	AC10	1	16	SMS	.
2007	F07	Oct07	22	AC10	1	31	SMS	.
2007	F07	Oct07	23	AC10	1	0	SMS	.
2007	F07	Oct07	24	AC10	1	29	SMS	7
2007	F07	Oct07	25	AC10	1	0	SMS	.
2007	F07	Oct07	26	AC10	1	0	SMS	.
2007	F07	Nov07	27	AC10	1	15	SMS	.
2007	F07	Nov07	28	AC10	1	10	SMS	6
2007	F07	Nov07	29	AC10	1	9	SMS	.
2007	F07	Nov07	30	AC10	1	0	SMS	.
2007	S07	May07	1	AC10	2	42	SMS	7
2007	S07	May07	2	AC10	2	42	SMS	.
2007	S07	May07	3	AC10	2	49	SMS	6
2007	S07	May07	4	AC10	2	43	SMS	6
2007	S07	Jun07	5	AC10	2	42	SMS	.
2007	S07	Jun07	6	AC10	2	38	SMS	.
2007	S07	Jun07	7	AC10	2	16	SMS	5
2007	S07	Jun07	8	AC10	2	17	SMS	.

2007	S07	Jul07	9	AC10	2	17	SMS	6
2007	S07	Jul07	10	AC10	2	16	SMS	.
2007	S07	Jul07	11	AC10	2	9	SMS	.
2007	S07	Jul07	12	AC10	2	31	SMS	6
2007	S07	Jul07	13	AC10	2	31	SMS	.
2007	S07	Aug07	14	AC10	2	20	SMS	7
2007	S07	Aug07	15	AC10	2	41	SMS	.
2007	S07	Aug07	16	AC10	2	41	SMS	.
2007	S07	Aug07	17	AC10	2	41	SMS	7
2007	F07	Sep07	18	AC10	2	20	SMS	.
2007	F07	Sep07	19	AC10	2	37	SMS	.
2007	F07	Sep07	20	AC10	2	16	SMS	7
2007	F07	Sep07	21	AC10	2	16	SMS	.
2007	F07	Oct07	22	AC10	2	31	SMS	.
2007	F07	Oct07	23	AC10	2	0	SMS	.
2007	F07	Oct07	24	AC10	2	28	SMS	6
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2007	S07	May07	1	AC10	3	43	SMS	6
2007	S07	May07	2	AC10	3	44	SMS	.
2007	S07	May07	3	AC10	3	50	SMS	6
2007	S07	May07	4	AC10	3	44	SMS	6
2007	S07	Jun07	5	AC10	3	43	SMS	.
2007	S07	Jun07	6	AC10	3	39	SMS	.
2007	S07	Jun07	7	AC10	3	17	SMS	6
2007	S07	Jun07	8	AC10	3	17	SMS	.
2007	S07	Jul07	9	AC10	3	18	SMS	7
2007	S07	Jul07	10	AC10	3	16	SMS	.
2007	S07	Jul07	11	AC10	3	4	SMS	.
2007	S07	Jul07	12	AC10	3	32	SMS	7
2007	S07	Jul07	13	AC10	3	31	SMS	.
2007	S07	Aug07	14	AC10	3	21	SMS	7
2007	S07	Aug07	15	AC10	3	42	SMS	.
2007	S07	Aug07	16	AC10	3	42	SMS	.
2007	S07	Aug07	17	AC10	3	42	SMS	8
2007	F07	Sep07	18	AC10	3	21	SMS	.
2007	F07	Sep07	19	AC10	3	38	SMS	.
2007	F07	Sep07	20	AC10	3	16	SMS	7
2007	F07	Sep07	21	AC10	3	17	SMS	.
2007	F07	Oct07	22	AC10	3	33	SMS	.
2007	F07	Oct07	23	AC10	3	0	SMS	.
2007	F07	Oct07	24	AC10	3	31	SMS	7
2007	F07	Oct07	25	AC10	3	0	SMS	.
2007	F07	Oct07	26	AC10	3	0	SMS	.
2007	F07	Nov07	27	AC10	3	16	SMS	.
2007	F07	Nov07	28	AC10	3	14	SMS	7
2007	F07	Nov07	29	AC10	3	10	SMS	.
2007	F07	Nov07	30	AC10	3	0	SMS	.
2007	S07	May07	1	AC10	4	43	SMS	6
2007	S07	May07	2	AC10	4	43	SMS	.
2007	S07	May07	3	AC10	4	49	SMS	6
2007	S07	May07	4	AC10	4	43	SMS	6
2007	S07	Jun07	5	AC10	4	43	SMS	.

2007	S07	Jun07	6	AC10	4	39	SMS	.
2007	S07	Jun07	7	AC10	4	17	SMS	6
2007	S07	Jun07	8	AC10	4	17	SMS	.
2007	S07	Jul07	9	AC10	4	17	SMS	6
2007	S07	Jul07	10	AC10	4	16	SMS	.
2007	S07	Jul07	11	AC10	4	10	SMS	.
2007	S07	Jul07	12	AC10	4	32	SMS	6
2007	S07	Jul07	13	AC10	4	32	SMS	.
2007	S07	Aug07	14	AC10	4	21	SMS	7
2007	S07	Aug07	15	AC10	4	42	SMS	.
2007	S07	Aug07	16	AC10	4	42	SMS	.
2007	S07	Aug07	17	AC10	4	42	SMS	7
2007	F07	Sep07	18	AC10	4	20	SMS	.
2007	F07	Sep07	19	AC10	4	38	SMS	.
2007	F07	Sep07	20	AC10	4	16	SMS	7
2007	F07	Sep07	21	AC10	4	17	SMS	.
2007	F07	Oct07	22	AC10	4	32	SMS	.
2007	F07	Oct07	23	AC10	4	0	SMS	.
2007	F07	Oct07	24	AC10	4	28	SMS	7
2007	F07	Oct07	25	AC10	4	0	SMS	.
2007	F07	Oct07	26	AC10	4	0	SMS	.
2007	F07	Nov07	27	AC10	4	16	SMS	.
2007	F07	Nov07	28	AC10	4	10	SMS	6
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2007	F07	Nov07	30	AC10	4	0	SMS	.
2007	S07	May07	1	AC13	1	44	SMS	6
2007	S07	May07	2	AC13	1	44	SMS	.
2007	S07	May07	3	AC13	1	51	SMS	6
2007	S07	May07	4	AC13	1	44	SMS	7
2007	S07	Jun07	5	AC13	1	44	SMS	.
2007	S07	Jun07	6	AC13	1	40	SMS	.
2007	S07	Jun07	7	AC13	1	33	SMS	7
2007	S07	Jun07	8	AC13	1	17	SMS	.
2007	S07	Jul07	9	AC13	1	18	SMS	6
2007	S07	Jul07	10	AC13	1	32	SMS	.
2007	S07	Jul07	11	AC13	1	26	SMS	.
2007	S07	Jul07	12	AC13	1	33	SMS	7
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2007	S07	Aug07	14	AC13	1	22	SMS	7
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2007	S07	Aug07	17	AC13	1	43	SMS	7
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2007	F07	Sep07	19	AC13	1	38	SMS	.
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2007	F07	Sep07	21	AC13	1	17	SMS	.
2007	F07	Oct07	22	AC13	1	33	SMS	.
2007	F07	Oct07	23	AC13	1	15	SMS	.
2007	F07	Oct07	24	AC13	1	29	SMS	6
2007	F07	Oct07	25	AC13	1	30	SMS	.
2007	F07	Oct07	26	AC13	1	0	SMS	.
2007	F07	Nov07	27	AC13	1	29	SMS	.
2007	F07	Nov07	28	AC13	1	26	SMS	6
2007	F07	Nov07	29	AC13	1	22	SMS	.
2007	F07	Nov07	30	AC13	1	10	SMS	.
2007	S07	May07	1	AC13	2	43	SMS	6
2007	S07	May07	2	AC13	2	43	SMS	.

2007	S07	May07	3	AC13	2	51	SMS	6
2007	S07	May07	4	AC13	2	43	SMS	7
2007	S07	Jun07	5	AC13	2	43	SMS	.
2007	S07	Jun07	6	AC13	2	38	SMS	.
2007	S07	Jun07	7	AC13	2	33	SMS	6
2007	S07	Jun07	8	AC13	2	17	SMS	.
2007	S07	Jul07	9	AC13	2	17	SMS	7
2007	S07	Jul07	10	AC13	2	31	SMS	.
2007	S07	Jul07	11	AC13	2	24	SMS	.
2007	S07	Jul07	12	AC13	2	32	SMS	7
2007	S07	Jul07	13	AC13	2	31	SMS	.
2007	S07	Aug07	14	AC13	2	21	SMS	7
2007	S07	Aug07	15	AC13	2	41	SMS	.
2007	S07	Aug07	16	AC13	2	42	SMS	.
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2007	F07	Sep07	19	AC13	2	35	SMS	.
2007	F07	Sep07	20	AC13	2	30	SMS	7
2007	F07	Sep07	21	AC13	2	16	SMS	.
2007	F07	Oct07	22	AC13	2	30	SMS	.
2007	F07	Oct07	23	AC13	2	15	SMS	.
2007	F07	Oct07	24	AC13	2	27	SMS	7
2007	F07	Oct07	25	AC13	2	27	SMS	.
2007	F07	Oct07	26	AC13	2	0	SMS	.
2007	F07	Nov07	27	AC13	2	28	SMS	.
2007	F07	Nov07	28	AC13	2	24	SMS	6
2007	F07	Nov07	29	AC13	2	19	SMS	.
2007	F07	Nov07	30	AC13	2	10	SMS	.
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2007	S07	Jun07	5	AC13	3	41	SMS	.
2007	S07	Jun07	6	AC13	3	35	SMS	.
2007	S07	Jun07	7	AC13	3	31	SMS	7
2007	S07	Jun07	8	AC13	3	16	SMS	.
2007	S07	Jul07	9	AC13	3	16	SMS	6
2007	S07	Jul07	10	AC13	3	29	SMS	.
2007	S07	Jul07	11	AC13	3	21	SMS	.
2007	S07	Jul07	12	AC13	3	28	SMS	7
2007	S07	Jul07	13	AC13	3	28	SMS	.
2007	S07	Aug07	14	AC13	3	19	SMS	7
2007	S07	Aug07	15	AC13	3	35	SMS	.
2007	S07	Aug07	16	AC13	3	35	SMS	.
2007	S07	Aug07	17	AC13	3	42	SMS	8
2007	F07	Sep07	18	AC13	3	40	SMS	.
2007	F07	Sep07	19	AC13	3	35	SMS	.
2007	F07	Sep07	20	AC13	3	31	SMS	7
2007	F07	Sep07	21	AC13	3	16	SMS	.
2007	F07	Oct07	22	AC13	3	30	SMS	.
2007	F07	Oct07	23	AC13	3	15	SMS	.
2007	F07	Oct07	24	AC13	3	63	SMS	7
2007	F07	Oct07	25	AC13	3	62	SMS	.
2007	F07	Oct07	26	AC13	3	0	SMS	.
2007	F07	Nov07	27	AC13	3	45	SMS	.
2007	F07	Nov07	28	AC13	3	25	SMS	6
2007	F07	Nov07	29	AC13	3	20	SMS	.

2007	F07	Nov07	30	AC13	3	10	SMS	.
2007	S07	May07	1	AC13	4	43	SMS	7
2007	S07	May07	2	AC13	4	43	SMS	.
2007	S07	May07	3	AC13	4	50	SMS	6
2007	S07	May07	4	AC13	4	43	SMS	7
2007	S07	Jun07	5	AC13	4	42	SMS	.
2007	S07	Jun07	6	AC13	4	39	SMS	.
2007	S07	Jun07	7	AC13	4	32	SMS	6
2007	S07	Jun07	8	AC13	4	17	SMS	.
2007	S07	Jul07	9	AC13	4	17	SMS	7
2007	S07	Jul07	10	AC13	4	31	SMS	.
2007	S07	Jul07	11	AC13	4	26	SMS	.
2007	S07	Jul07	12	AC13	4	31	SMS	6
2007	S07	Jul07	13	AC13	4	31	SMS	.
2007	S07	Aug07	14	AC13	4	21	SMS	7
2007	S07	Aug07	15	AC13	4	41	SMS	.
2007	S07	Aug07	16	AC13	4	41	SMS	.
2007	S07	Aug07	17	AC13	4	41	SMS	7
2007	F07	Sep07	18	AC13	4	41	SMS	.
2007	F07	Sep07	19	AC13	4	37	SMS	.
2007	F07	Sep07	20	AC13	4	31	SMS	7
2007	F07	Sep07	21	AC13	4	16	SMS	.
2007	F07	Oct07	22	AC13	4	31	SMS	.
2007	F07	Oct07	23	AC13	4	15	SMS	.
2007	F07	Oct07	24	AC13	4	28	SMS	7
2007	F07	Oct07	25	AC13	4	28	SMS	.
2007	F07	Oct07	26	AC13	4	0	SMS	.
2007	F07	Nov07	27	AC13	4	29	SMS	.
2007	F07	Nov07	28	AC13	4	25	SMS	6
2007	F07	Nov07	29	AC13	4	22	SMS	.
2007	F07	Nov07	30	AC13	4	10	SMS	.
2007	S07	May07	1	ACIR	1	42	SMS	6
2007	S07	May07	2	ACIR	1	22	SMS	.
2007	S07	May07	3	ACIR	1	50	SMS	6
2007	S07	May07	4	ACIR	1	21	SMS	6
2007	S07	Jun07	5	ACIR	1	21	SMS	.
2007	S07	Jun07	6	ACIR	1	39	SMS	.
2007	S07	Jun07	7	ACIR	1	16	SMS	5
2007	S07	Jun07	8	ACIR	1	0	SMS	.
2007	S07	Jul07	9	ACIR	1	17	SMS	6
2007	S07	Jul07	10	ACIR	1	16	SMS	.
2007	S07	Jul07	11	ACIR	1	3	SMS	.
2007	S07	Jul07	12	ACIR	1	16	SMS	6
2007	S07	Jul07	13	ACIR	1	16	SMS	.
2007	S07	Aug07	14	ACIR	1	20	SMS	7
2007	S07	Aug07	15	ACIR	1	20	SMS	.
2007	S07	Aug07	16	ACIR	1	21	SMS	.
2007	S07	Aug07	17	ACIR	1	0	SMS	7
2007	F07	Sep07	18	ACIR	1	20	SMS	.
2007	F07	Sep07	19	ACIR	1	16	SMS	.
2007	F07	Sep07	20	ACIR	1	15	SMS	6
2007	F07	Sep07	21	ACIR	1	0	SMS	.
2007	F07	Oct07	22	ACIR	1	16	SMS	.
2007	F07	Oct07	23	ACIR	1	0	SMS	.
2007	F07	Oct07	24	ACIR	1	14	SMS	6
2007	F07	Oct07	25	ACIR	1	0	SMS	.
2007	F07	Oct07	26	ACIR	1	0	SMS	.

2007	F07	Nov07	27	ACIR	1	0	SMS	.
2007	F07	Nov07	28	ACIR	1	10	SMS	5
2007	F07	Nov07	29	ACIR	1	0	SMS	.
2007	F07	Nov07	30	ACIR	1	0	SMS	.
2007	S07	May07	1	ACIR	2	44	SMS	4
2007	S07	May07	2	ACIR	2	22	SMS	.
2007	S07	May07	3	ACIR	2	29	SMS	4
2007	S07	May07	4	ACIR	2	43	SMS	4
2007	S07	Jun07	5	ACIR	2	44	SMS	.
2007	S07	Jun07	6	ACIR	2	39	SMS	.
2007	S07	Jun07	7	ACIR	2	17	SMS	4
2007	S07	Jun07	8	ACIR	2	0	SMS	.
2007	S07	Jul07	9	ACIR	2	17	SMS	4
2007	S07	Jul07	10	ACIR	2	17	SMS	.
2007	S07	Jul07	11	ACIR	2	8	SMS	.
2007	S07	Jul07	12	ACIR	2	17	SMS	4
2007	S07	Jul07	13	ACIR	2	16	SMS	.
2007	S07	Aug07	14	ACIR	2	21	SMS	6
2007	S07	Aug07	15	ACIR	2	43	SMS	.
2007	S07	Aug07	16	ACIR	2	42	SMS	.
2007	S07	Aug07	17	ACIR	2	22	SMS	7
2007	F07	Sep07	18	ACIR	2	21	SMS	.
2007	F07	Sep07	19	ACIR	2	37	SMS	.
2007	F07	Sep07	20	ACIR	2	17	SMS	6
2007	F07	Sep07	21	ACIR	2	0	SMS	.
2007	F07	Oct07	22	ACIR	2	16	SMS	.
2007	F07	Oct07	23	ACIR	2	0	SMS	.
2007	F07	Oct07	24	ACIR	2	15	SMS	6
2007	F07	Oct07	25	ACIR	2	16	SMS	.
2007	F07	Oct07	26	ACIR	2	0	SMS	.
2007	F07	Nov07	27	ACIR	2	15	SMS	.
2007	F07	Nov07	28	ACIR	2	10	SMS	4
2007	F07	Nov07	29	ACIR	2	10	SMS	.
2007	F07	Nov07	30	ACIR	2	0	SMS	.
2007	S07	May07	1	ACIR	3	22	SMS	6
2007	S07	May07	2	ACIR	3	22	SMS	.
2007	S07	May07	3	ACIR	3	28	SMS	4
2007	S07	May07	4	ACIR	3	44	SMS	6
2007	S07	Jun07	5	ACIR	3	21	SMS	.
2007	S07	Jun07	6	ACIR	3	39	SMS	.
2007	S07	Jun07	7	ACIR	3	17	SMS	6
2007	S07	Jun07	8	ACIR	3	0	SMS	.
2007	S07	Jul07	9	ACIR	3	17	SMS	6
2007	S07	Jul07	10	ACIR	3	16	SMS	.
2007	S07	Jul07	11	ACIR	3	3	SMS	.
2007	S07	Jul07	12	ACIR	3	16	SMS	6
2007	S07	Jul07	13	ACIR	3	17	SMS	.
2007	S07	Aug07	14	ACIR	3	0	SMS	7
2007	S07	Aug07	15	ACIR	3	41	SMS	.
2007	S07	Aug07	16	ACIR	3	21	SMS	.
2007	S07	Aug07	17	ACIR	3	21	SMS	7
2007	F07	Sep07	18	ACIR	3	0	SMS	.
2007	F07	Sep07	19	ACIR	3	17	SMS	.
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2007	F07	Sep07	21	ACIR	3	0	SMS	.
2007	F07	Oct07	22	ACIR	3	16	SMS	.
2007	F07	Oct07	23	ACIR	3	0	SMS	.

2007	F07	Oct07	24	ACIR	3	15	SMS	7
2007	F07	Oct07	25	ACIR	3	0	SMS	.
2007	F07	Oct07	26	ACIR	3	0	SMS	.
2007	F07	Nov07	27	ACIR	3	0	SMS	.
2007	F07	Nov07	28	ACIR	3	15	SMS	7
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2007	S07	May07	1	ACIR	4	11	SMS	6
2007	S07	May07	2	ACIR	4	33	SMS	.
2007	S07	May07	3	ACIR	4	29	SMS	6
2007	S07	May07	4	ACIR	4	21	SMS	6
2007	S07	Jun07	5	ACIR	4	22	SMS	.
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2007	S07	Jun07	7	ACIR	4	17	SMS	6
2007	S07	Jun07	8	ACIR	4	0	SMS	.
2007	S07	Jul07	9	ACIR	4	17	SMS	6
2007	S07	Jul07	10	ACIR	4	17	SMS	.
2007	S07	Jul07	11	ACIR	4	30	SMS	.
2007	S07	Jul07	12	ACIR	4	17	SMS	6
2007	S07	Jul07	13	ACIR	4	0	SMS	.
2007	S07	Aug07	14	ACIR	4	0	SMS	6
2007	S07	Aug07	15	ACIR	4	41	SMS	.
2007	S07	Aug07	16	ACIR	4	21	SMS	.
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2007	F07	Oct07	26	ACIR	4	0	SMS	.
2007	F07	Nov07	27	ACIR	4	0	SMS	.
2007	F07	Nov07	28	ACIR	4	10	SMS	7
2007	F07	Nov07	29	ACIR	4	21	SMS	.
2007	F07	Nov07	30	ACIR	4	0	SMS	.
2007	S07	May07	1	AC7	1	28	SMS	7
2007	S07	May07	2	AC7	1	43	SMS	.
2007	S07	May07	3	AC7	1	28	SMS	6
2007	S07	May07	4	AC7	1	21	SMS	6
2007	S07	Jun07	5	AC7	1	21	SMS	.
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2007	S07	Jun07	7	AC7	1	17	SMS	6
2007	S07	Jun07	8	AC7	1	0	SMS	.
2007	S07	Jul07	9	AC7	1	17	SMS	7
2007	S07	Jul07	10	AC7	1	16	SMS	.
2007	S07	Jul07	11	AC7	1	8	SMS	.
2007	S07	Jul07	12	AC7	1	16	SMS	6
2007	S07	Jul07	13	AC7	1	16	SMS	.
2007	S07	Aug07	14	AC7	1	0	SMS	8
2007	S07	Aug07	15	AC7	1	21	SMS	.
2007	S07	Aug07	16	AC7	1	21	SMS	.
2007	S07	Aug07	17	AC7	1	21	SMS	8
2007	F07	Sep07	18	AC7	1	20	SMS	.
2007	F07	Sep07	19	AC7	1	21	SMS	.
2007	F07	Sep07	20	AC7	1	17	SMS	7

2007	F07	Sep07	21	AC7	1	0	SMS	.
2007	F07	Oct07	22	AC7	1	16	SMS	.
2007	F07	Oct07	23	AC7	1	0	SMS	.
2007	F07	Oct07	24	AC7	1	15	SMS	7
2007	F07	Oct07	25	AC7	1	0	SMS	.
2007	F07	Oct07	26	AC7	1	0	SMS	.
2007	F07	Nov07	27	AC7	1	0	SMS	.
2007	F07	Nov07	28	AC7	1	15	SMS	6
2007	F07	Nov07	29	AC7	1	10	SMS	.
2007	F07	Nov07	30	AC7	1	0	SMS	.
2007	S07	May07	1	AC7	2	29	SMS	5
2007	S07	May07	2	AC7	2	43	SMS	.
2007	S07	May07	3	AC7	2	28	SMS	5
2007	S07	May07	4	AC7	2	22	SMS	5
2007	S07	Jun07	5	AC7	2	21	SMS	.
2007	S07	Jun07	6	AC7	2	39	SMS	.
2007	S07	Jun07	7	AC7	2	16	SMS	5
2007	S07	Jun07	8	AC7	2	0	SMS	.
2007	S07	Jul07	9	AC7	2	17	SMS	4
2007	S07	Jul07	10	AC7	2	16	SMS	.
2007	S07	Jul07	11	AC7	2	9	SMS	.
2007	S07	Jul07	12	AC7	2	16	SMS	5
2007	S07	Jul07	13	AC7	2	16	SMS	.
2007	S07	Aug07	14	AC7	2	0	SMS	7
2007	S07	Aug07	15	AC7	2	21	SMS	.
2007	S07	Aug07	16	AC7	2	21	SMS	.
2007	S07	Aug07	17	AC7	2	20	SMS	7
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2007	F07	Sep07	19	AC7	2	20	SMS	.
2007	F07	Sep07	20	AC7	2	16	SMS	6
2007	F07	Sep07	21	AC7	2	0	SMS	.
2007	F07	Oct07	22	AC7	2	17	SMS	.
2007	F07	Oct07	23	AC7	2	0	SMS	.
2007	F07	Oct07	24	AC7	2	14	SMS	7
2007	F07	Oct07	25	AC7	2	0	SMS	.
2007	F07	Oct07	26	AC7	2	0	SMS	.
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2007	S07	May07	1	AC7	3	31	SMS	5
2007	S07	May07	2	AC7	3	44	SMS	.
2007	S07	May07	3	AC7	3	31	SMS	5
2007	S07	May07	4	AC7	3	23	SMS	5
2007	S07	Jun07	5	AC7	3	25	SMS	.
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2007	S07	Jun07	7	AC7	3	17	SMS	5
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2007	S07	Jul07	9	AC7	3	19	SMS	4
2007	S07	Jul07	10	AC7	3	17	SMS	.
2007	S07	Jul07	11	AC7	3	8	SMS	.
2007	S07	Jul07	12	AC7	3	17	SMS	5
2007	S07	Jul07	13	AC7	3	19	SMS	.
2007	S07	Aug07	14	AC7	3	0	SMS	6
2007	S07	Aug07	15	AC7	3	21	SMS	.
2007	S07	Aug07	16	AC7	3	21	SMS	.
2007	S07	Aug07	17	AC7	3	23	SMS	6

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2007	F07	Sep07	19	AC7	3	23	SMS	.
2007	F07	Sep07	20	AC7	3	19	SMS	6
2007	F07	Sep07	21	AC7	3	0	SMS	.
2007	F07	Oct07	22	AC7	3	19	SMS	.
2007	F07	Oct07	23	AC7	3	0	SMS	.
2007	F07	Oct07	24	AC7	3	17	SMS	5
2007	F07	Oct07	25	AC7	3	0	SMS	.
2007	F07	Oct07	26	AC7	3	0	SMS	.
2007	F07	Nov07	27	AC7	3	0	SMS	.
2007	F07	Nov07	28	AC7	3	21	SMS	5
2007	F07	Nov07	29	AC7	3	13	SMS	.
2007	F07	Nov07	30	AC7	3	0	SMS	.
2007	S07	May07	1	AC7	4	27	SMS	5
2007	S07	May07	2	AC7	4	42	SMS	.
2007	S07	May07	3	AC7	4	28	SMS	5
2007	S07	May07	4	AC7	4	21	SMS	6
2007	S07	Jun07	5	AC7	4	21	SMS	.
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2007	S07	Jun07	7	AC7	4	17	SMS	6
2007	S07	Jun07	8	AC7	4	0	SMS	.
2007	S07	Jul07	9	AC7	4	16	SMS	5
2007	S07	Jul07	10	AC7	4	16	SMS	.
2007	S07	Jul07	11	AC7	4	7	SMS	.
2007	S07	Jul07	12	AC7	4	16	SMS	6
2007	S07	Jul07	13	AC7	4	16	SMS	.
2007	S07	Aug07	14	AC7	4	0	SMS	6
2007	S07	Aug07	15	AC7	4	20	SMS	.
2007	S07	Aug07	16	AC7	4	21	SMS	.
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2007	F07	Sep07	21	AC7	4	0	SMS	.
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2007	F07	Oct07	24	AC7	4	15	SMS	6
2007	F07	Oct07	25	AC7	4	0	SMS	.
2007	F07	Oct07	26	AC7	4	0	SMS	.
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2007	S07	May07	1	LL5	1	67	SMS	6
2007	S07	May07	2	LL5	1	44	SMS	.
2007	S07	May07	3	LL5	1	50	SMS	6
2007	S07	May07	4	LL5	1	43	SMS	6
2007	S07	Jun07	5	LL5	1	44	SMS	.
2007	S07	Jun07	6	LL5	1	38	SMS	.
2007	S07	Jun07	7	LL5	1	33	SMS	6
2007	S07	Jun07	8	LL5	1	17	SMS	.
2007	S07	Jul07	9	LL5	1	17	SMS	6
2007	S07	Jul07	10	LL5	1	17	SMS	.
2007	S07	Jul07	11	LL5	1	40	SMS	.
2007	S07	Jul07	12	LL5	1	0	SMS	6
2007	S07	Jul07	13	LL5	1	33	SMS	.
2007	S07	Aug07	14	LL5	1	21	SMS	6

2007	S07	Aug07	15	LL5	1	42	SMS	.
2007	S07	Aug07	16	LL5	1	41	SMS	.
2007	S07	Aug07	17	LL5	1	42	SMS	7
2007	F07	Sep07	18	LL5	1	0	SMS	.
2007	F07	Sep07	19	LL5	1	37	SMS	.
2007	F07	Sep07	20	LL5	1	33	SMS	6
2007	F07	Sep07	21	LL5	1	17	SMS	.
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2007	S07	May07	1	LL5	2	66	SMS	6
2007	S07	May07	2	LL5	2	42	SMS	.
2007	S07	May07	3	LL5	2	50	SMS	7
2007	S07	May07	4	LL5	2	42	SMS	6
2007	S07	Jun07	5	LL5	2	42	SMS	.
2007	S07	Jun07	6	LL5	2	37	SMS	.
2007	S07	Jun07	7	LL5	2	32	SMS	7
2007	S07	Jun07	8	LL5	2	17	SMS	.
2007	S07	Jul07	9	LL5	2	17	SMS	7
2007	S07	Jul07	10	LL5	2	15	SMS	.
2007	S07	Jul07	11	LL5	2	33	SMS	.
2007	S07	Jul07	12	LL5	2	0	SMS	7
2007	S07	Jul07	13	LL5	2	31	SMS	.
2007	S07	Aug07	14	LL5	2	19	SMS	7
2007	S07	Aug07	15	LL5	2	40	SMS	.
2007	S07	Aug07	16	LL5	2	40	SMS	.
2007	S07	Aug07	17	LL5	2	40	SMS	8
2007	F07	Sep07	18	LL5	2	0	SMS	.
2007	F07	Sep07	19	LL5	2	34	SMS	.
2007	F07	Sep07	20	LL5	2	30	SMS	7
2007	F07	Sep07	21	LL5	2	15	SMS	.
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2007	S07	May07	1	LL5	3	67	SMS	6
2007	S07	May07	2	LL5	3	42	SMS	.
2007	S07	May07	3	LL5	3	50	SMS	5
2007	S07	May07	4	LL5	3	42	SMS	6
2007	S07	Jun07	5	LL5	3	43	SMS	.
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2007	S07	Jun07	7	LL5	3	32	SMS	6
2007	S07	Jun07	8	LL5	3	17	SMS	.
2007	S07	Jul07	9	LL5	3	17	SMS	6
2007	S07	Jul07	10	LL5	3	16	SMS	.
2007	S07	Jul07	11	LL5	3	41	SMS	.

2007	S07	Jul07	12	LL5	3	0	SMS	7
2007	S07	Jul07	13	LL5	3	30	SMS	.
2007	S07	Aug07	14	LL5	3	20	SMS	7
2007	S07	Aug07	15	LL5	3	41	SMS	.
2007	S07	Aug07	16	LL5	3	41	SMS	.
2007	S07	Aug07	17	LL5	3	41	SMS	7
2007	F07	Sep07	18	LL5	3	0	SMS	.
2007	F07	Sep07	19	LL5	3	35	SMS	.
2007	F07	Sep07	20	LL5	3	31	SMS	7
2007	F07	Sep07	21	LL5	3	16	SMS	.
2007	F07	Oct07	22	LL5	3	31	SMS	.
2007	F07	Oct07	23	LL5	3	14	SMS	.
2007	F07	Oct07	24	LL5	3	28	SMS	7
2007	F07	Oct07	25	LL5	3	29	SMS	.
2007	F07	Oct07	26	LL5	3	0	SMS	.
2007	F07	Nov07	27	LL5	3	29	SMS	.
2007	F07	Nov07	28	LL5	3	25	SMS	7
2007	F07	Nov07	29	LL5	3	21	SMS	.
2007	F07	Nov07	30	LL5	3	0	SMS	.
2007	S07	May07	1	LL5	4	65	SMS	6
2007	S07	May07	2	LL5	4	43	SMS	.
2007	S07	May07	3	LL5	4	49	SMS	6
2007	S07	May07	4	LL5	4	42	SMS	7
2007	S07	Jun07	5	LL5	4	43	SMS	.
2007	S07	Jun07	6	LL5	4	37	SMS	.
2007	S07	Jun07	7	LL5	4	33	SMS	7
2007	S07	Jun07	8	LL5	4	17	SMS	.
2007	S07	Jul07	9	LL5	4	16	SMS	7
2007	S07	Jul07	10	LL5	4	16	SMS	.
2007	S07	Jul07	11	LL5	4	33	SMS	.
2007	S07	Jul07	12	LL5	4	0	SMS	7
2007	S07	Jul07	13	LL5	4	31	SMS	.
2007	S07	Aug07	14	LL5	4	20	SMS	7
2007	S07	Aug07	15	LL5	4	41	SMS	.
2007	S07	Aug07	16	LL5	4	41	SMS	.
2007	S07	Aug07	17	LL5	4	41	SMS	8
2007	F07	Sep07	18	LL5	4	0	SMS	.
2007	F07	Sep07	19	LL5	4	35	SMS	.
2007	F07	Sep07	20	LL5	4	30	SMS	6
2007	F07	Sep07	21	LL5	4	15	SMS	.
2007	F07	Oct07	22	LL5	4	31	SMS	.
2007	F07	Oct07	23	LL5	4	15	SMS	.
2007	F07	Oct07	24	LL5	4	27	SMS	7
2007	F07	Oct07	25	LL5	4	28	SMS	.
2007	F07	Oct07	26	LL5	4	0	SMS	.
2007	F07	Nov07	27	LL5	4	28	SMS	.
2007	F07	Nov07	28	LL5	4	24	SMS	6
2007	F07	Nov07	29	LL5	4	21	SMS	.
2007	F07	Nov07	30	LL5	4	0	SMS	.
2007	S07	May07	1	LL6	1	66	SMS	6
2007	S07	May07	2	LL6	1	43	SMS	.
2007	S07	May07	3	LL6	1	50	SMS	6
2007	S07	May07	4	LL6	1	42	SMS	6
2007	S07	Jun07	5	LL6	1	43	SMS	.
2007	S07	Jun07	6	LL6	1	38	SMS	.
2007	S07	Jun07	7	LL6	1	33	SMS	6
2007	S07	Jun07	8	LL6	1	32	SMS	.

2007	S07	Jul07	9	LL6	1	32	SMS	7
2007	S07	Jul07	10	LL6	1	30	SMS	.
2007	S07	Jul07	11	LL6	1	33	SMS	.
2007	S07	Jul07	12	LL6	1	31	SMS	6
2007	S07	Jul07	13	LL6	1	30	SMS	.
2007	S07	Aug07	14	LL6	1	40	SMS	7
2007	S07	Aug07	15	LL6	1	41	SMS	.
2007	S07	Aug07	16	LL6	1	40	SMS	.
2007	S07	Aug07	17	LL6	1	41	SMS	7
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2007	F07	Sep07	19	LL6	1	35	SMS	.
2007	F07	Sep07	20	LL6	1	31	SMS	7
2007	F07	Sep07	21	LL6	1	16	SMS	.
2007	F07	Oct07	22	LL6	1	31	SMS	.
2007	F07	Oct07	23	LL6	1	14	SMS	.
2007	F07	Oct07	24	LL6	1	29	SMS	6
2007	F07	Oct07	25	LL6	1	28	SMS	.
2007	F07	Oct07	26	LL6	1	28	SMS	.
2007	F07	Nov07	27	LL6	1	28	SMS	.
2007	F07	Nov07	28	LL6	1	24	SMS	5
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2007	F07	Nov07	30	LL6	1	9	SMS	.
2007	S07	May07	1	LL6	2	66	SMS	6
2007	S07	May07	2	LL6	2	42	SMS	.
2007	S07	May07	3	LL6	2	49	SMS	6
2007	S07	May07	4	LL6	2	43	SMS	7
2007	S07	Jun07	5	LL6	2	43	SMS	.
2007	S07	Jun07	6	LL6	2	38	SMS	.
2007	S07	Jun07	7	LL6	2	33	SMS	7
2007	S07	Jun07	8	LL6	2	33	SMS	.
2007	S07	Jul07	9	LL6	2	31	SMS	7
2007	S07	Jul07	10	LL6	2	31	SMS	.
2007	S07	Jul07	11	LL6	2	34	SMS	.
2007	S07	Jul07	12	LL6	2	28	SMS	7
2007	S07	Jul07	13	LL6	2	28	SMS	.
2007	S07	Aug07	14	LL6	2	35	SMS	7
2007	S07	Aug07	15	LL6	2	35	SMS	.
2007	S07	Aug07	16	LL6	2	37	SMS	.
2007	S07	Aug07	17	LL6	2	43	SMS	8
2007	F07	Sep07	18	LL6	2	41	SMS	.
2007	F07	Sep07	19	LL6	2	38	SMS	.
2007	F07	Sep07	20	LL6	2	32	SMS	7
2007	F07	Sep07	21	LL6	2	16	SMS	.
2007	F07	Oct07	22	LL6	2	33	SMS	.
2007	F07	Oct07	23	LL6	2	16	SMS	.
2007	F07	Oct07	24	LL6	2	30	SMS	7
2007	F07	Oct07	25	LL6	2	30	SMS	.
2007	F07	Oct07	26	LL6	2	29	SMS	.
2007	F07	Nov07	27	LL6	2	30	SMS	.
2007	F07	Nov07	28	LL6	2	26	SMS	6
2007	F07	Nov07	29	LL6	2	21	SMS	.
2007	F07	Nov07	30	LL6	2	11	SMS	.
2007	S07	May07	1	LL6	3	67	SMS	7
2007	S07	May07	2	LL6	3	43	SMS	.
2007	S07	May07	3	LL6	3	50	SMS	6
2007	S07	May07	4	LL6	3	43	SMS	7
2007	S07	Jun07	5	LL6	3	43	SMS	.

2007	S07	Jun07	6	LL6	3	38	SMS	.
2007	S07	Jun07	7	LL6	3	33	SMS	7
2007	S07	Jun07	8	LL6	3	33	SMS	.
2007	S07	Jul07	9	LL6	3	32	SMS	7
2007	S07	Jul07	10	LL6	3	31	SMS	.
2007	S07	Jul07	11	LL6	3	42	SMS	.
2007	S07	Jul07	12	LL6	3	31	SMS	7
2007	S07	Jul07	13	LL6	3	31	SMS	.
2007	S07	Aug07	14	LL6	3	42	SMS	8
2007	S07	Aug07	15	LL6	3	41	SMS	.
2007	S07	Aug07	16	LL6	3	41	SMS	.
2007	S07	Aug07	17	LL6	3	42	SMS	8
2007	F07	Sep07	18	LL6	3	41	SMS	.
2007	F07	Sep07	19	LL6	3	37	SMS	.
2007	F07	Sep07	20	LL6	3	32	SMS	8
2007	F07	Sep07	21	LL6	3	17	SMS	.
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2007	F07	Oct07	23	LL6	3	15	SMS	.
2007	F07	Oct07	24	LL6	3	29	SMS	8
2007	F07	Oct07	25	LL6	3	28	SMS	.
2007	F07	Oct07	26	LL6	3	29	SMS	.
2007	F07	Nov07	27	LL6	3	29	SMS	.
2007	F07	Nov07	28	LL6	3	24	SMS	7
2007	F07	Nov07	29	LL6	3	21	SMS	.
2007	F07	Nov07	30	LL6	3	10	SMS	.
2007	S07	May07	1	LL6	4	66	SMS	6
2007	S07	May07	2	LL6	4	43	SMS	.
2007	S07	May07	3	LL6	4	49	SMS	7
2007	S07	May07	4	LL6	4	42	SMS	6
2007	S07	Jun07	5	LL6	4	43	SMS	.
2007	S07	Jun07	6	LL6	4	38	SMS	.
2007	S07	Jun07	7	LL6	4	33	SMS	7
2007	S07	Jun07	8	LL6	4	32	SMS	.
2007	S07	Jul07	9	LL6	4	31	SMS	7
2007	S07	Jul07	10	LL6	4	31	SMS	.
2007	S07	Jul07	11	LL6	4	42	SMS	.
2007	S07	Jul07	12	LL6	4	31	SMS	7
2007	S07	Jul07	13	LL6	4	31	SMS	.
2007	S07	Aug07	14	LL6	4	41	SMS	7
2007	S07	Aug07	15	LL6	4	41	SMS	.
2007	S07	Aug07	16	LL6	4	41	SMS	.
2007	S07	Aug07	17	LL6	4	41	SMS	7
2007	F07	Sep07	18	LL6	4	40	SMS	.
2007	F07	Sep07	19	LL6	4	37	SMS	.
2007	F07	Sep07	20	LL6	4	31	SMS	7
2007	F07	Sep07	21	LL6	4	15	SMS	.
2007	F07	Oct07	22	LL6	4	32	SMS	.
2007	F07	Oct07	23	LL6	4	15	SMS	.
2007	F07	Oct07	24	LL6	4	28	SMS	7
2007	F07	Oct07	25	LL6	4	28	SMS	.
2007	F07	Oct07	26	LL6	4	29	SMS	.
2007	F07	Nov07	27	LL6	4	28	SMS	.
2007	F07	Nov07	28	LL6	4	25	SMS	6
2007	F07	Nov07	29	LL6	4	20	SMS	.
2007	F07	Nov07	30	LL6	4	10	SMS	.
2007	F07	Sep07	18	LL4	1	0	SMS	.
2007	F07	Sep07	19	LL4	1	17	SMS	.

2007	F07	Sep07	20	LL4	1	32	SMS	5
2007	F07	Sep07	21	LL4	1	32	SMS	.
2007	F07	Oct07	22	LL4	1	16	SMS	.
2007	F07	Oct07	23	LL4	1	31	SMS	.
2007	F07	Oct07	24	LL4	1	29	SMS	7
2007	F07	Oct07	25	LL4	1	0	SMS	.
2007	F07	Oct07	26	LL4	1	0	SMS	.
2007	F07	Nov07	27	LL4	1	15	SMS	.
2007	F07	Nov07	28	LL4	1	26	SMS	6
2007	F07	Nov07	29	LL4	1	23	SMS	.
2007	F07	Nov07	30	LL4	1	0	SMS	.
2007	F07	Sep07	18	LL4	2	0	SMS	.
2007	F07	Sep07	19	LL4	2	16	SMS	.
2007	F07	Sep07	20	LL4	2	31	SMS	5
2007	F07	Sep07	21	LL4	2	31	SMS	.
2007	F07	Oct07	22	LL4	2	16	SMS	.
2007	F07	Oct07	23	LL4	2	30	SMS	.
2007	F07	Oct07	24	LL4	2	27	SMS	6
2007	F07	Oct07	25	LL4	2	0	SMS	.
2007	F07	Oct07	26	LL4	2	0	SMS	.
2007	F07	Nov07	27	LL4	2	15	SMS	.
2007	F07	Nov07	28	LL4	2	22	SMS	5
2007	F07	Nov07	29	LL4	2	18	SMS	.
2007	F07	Nov07	30	LL4	2	0	SMS	.
2007	F07	Sep07	18	LL4	3	0	SMS	.
2007	F07	Sep07	19	LL4	3	16	SMS	.
2007	F07	Sep07	20	LL4	3	31	SMS	7
2007	F07	Sep07	21	LL4	3	30	SMS	.
2007	F07	Oct07	22	LL4	3	16	SMS	.
2007	F07	Oct07	23	LL4	3	29	SMS	.
2007	F07	Oct07	24	LL4	3	28	SMS	7
2007	F07	Oct07	25	LL4	3	0	SMS	.
2007	F07	Oct07	26	LL4	3	0	SMS	.
2007	F07	Nov07	27	LL4	3	15	SMS	.
2007	F07	Nov07	28	LL4	3	24	SMS	7
2007	F07	Nov07	29	LL4	3	21	SMS	.
2007	F07	Nov07	30	LL4	3	0	SMS	.
2007	F07	Sep07	18	LL4	4	0	SMS	.
2007	F07	Sep07	19	LL4	4	16	SMS	.
2007	F07	Sep07	20	LL4	4	31	SMS	6
2007	F07	Sep07	21	LL4	4	30	SMS	.
2007	F07	Oct07	22	LL4	4	16	SMS	.
2007	F07	Oct07	23	LL4	4	30	SMS	.
2007	F07	Oct07	24	LL4	4	27	SMS	7
2007	F07	Oct07	25	LL4	4	0	SMS	.
2007	F07	Oct07	26	LL4	4	0	SMS	.
2007	F07	Nov07	27	LL4	4	14	SMS	.
2007	F07	Nov07	28	LL4	4	24	SMS	6
2007	F07	Nov07	29	LL4	4	21	SMS	.
2007	F07	Nov07	30	LL4	4	0	SMS	.
2006	S06	Apr06	1	WOS	1	29	WOS	.
2006	S06	May06	2	WOS	1	27	WOS	.
2006	S06	May06	3	WOS	1	27	WOS	4
2006	S06	May06	4	WOS	1	29	WOS	3
2006	S06	May06	5	WOS	1	27	WOS	3
2006	S06	June06	6	WOS	1	35	WOS	.
2006	S06	June06	7	WOS	1	33	WOS	3

2006	S06	June06	8	WOS	1	35	WOS	.
2006	S06	June06	9	WOS	1	33	WOS	3
2006	S06	June06	10	WOS	1	33	WOS	.
2006	S06	Apr06 1	WOS	2	28	WOS	.	
2006	S06	May06 2	WOS	2	26	WOS	.	
2006	S06	May06 3	WOS	2	27	WOS	6	
2006	S06	May06 4	WOS	2	25	WOS	5	
2006	S06	May06 5	WOS	2	27	WOS	4	
2006	S06	June06	6	WOS	2	33	WOS	.
2006	S06	June06	7	WOS	2	33	WOS	4
2006	S06	June06	8	WOS	2	33	WOS	.
2006	S06	June06	9	WOS	2	33	WOS	5
2006	S06	June06	10	WOS	2	33	WOS	.
2006	S06	Apr06 1	WOS	3	27	WOS	.	
2006	S06	May06 2	WOS	3	26	WOS	.	
2006	S06	May06 3	WOS	3	27	WOS	8	
2006	S06	May06 4	WOS	3	25	WOS	8	
2006	S06	May06 5	WOS	3	26	WOS	7	
2006	S06	June06	6	WOS	3	32	WOS	.
2006	S06	June06	7	WOS	3	31	WOS	8
2006	S06	June06	8	WOS	3	31	WOS	.
2006	S06	June06	9	WOS	3	31	WOS	8
2006	S06	June06	10	WOS	3	29	WOS	.
2006	S06	Apr06 1	WOS	4	27	WOS	.	
2006	S06	May06 2	WOS	4	26	WOS	.	
2006	S06	May06 3	WOS	4	27	WOS	8	
2006	S06	May06 4	WOS	4	27	WOS	7	
2006	S06	May06 5	WOS	4	27	WOS	6	
2006	S06	June06	6	WOS	4	33	WOS	.
2006	S06	June06	7	WOS	4	32	WOS	6
2006	S06	June06	8	WOS	4	33	WOS	.
2006	S06	June06	9	WOS	4	33	WOS	6
2006	S06	June06	10	WOS	4	32	WOS	.
2006	F06	Sep06 1	WOS	1	33	WOS	4	
2006	F06	Oct06 2	WOS	1	33	WOS	4	
2006	F06	Oct06 3	WOS	1	29	WOS	.	
2006	F06	Oct06 4	WOS	1	29	WOS	4	
2006	F06	Oct06 5	WOS	1	29	WOS	.	
2006	F06	Nov06 6	WOS	1	13	WOS	.	
2006	F06	Nov06 7	WOS	1	21	WOS	.	
2006	F06	Nov06 8	WOS	1	23	WOS	4	
2006	F06	Nov06 9	WOS	1	23	WOS	.	
2006	F06	Dec06 10	WOS	1	21	WOS	3	
2006	F06	Dec06 11	WOS	1	21	WOS	4	
2006	F06	Dec06 12	WOS	1	21	WOS	.	
2006	F06	Sep06 1	WOS	2	31	WOS	6	
2006	F06	Oct06 2	WOS	2	33	WOS	7	
2006	F06	Oct06 3	WOS	2	28	WOS	.	
2006	F06	Oct06 4	WOS	2	28	WOS	7	
2006	F06	Oct06 5	WOS	2	29	WOS	.	
2006	F06	Nov06 6	WOS	2	10	WOS	.	
2006	F06	Nov06 7	WOS	2	22	WOS	.	
2006	F06	Nov06 8	WOS	2	21	WOS	6	
2006	F06	Nov06 9	WOS	2	21	WOS	.	
2006	F06	Dec06 10	WOS	2	20	WOS	5	
2006	F06	Dec06 11	WOS	2	21	WOS	5	
2006	F06	Dec06 12	WOS	2	21	WOS	.	

2006	F06	Sep06	1	WOS	3	32	WOS	8
2006	F06	Oct06	2	WOS	3	32	WOS	8
2006	F06	Oct06	3	WOS	3	28	WOS	.
2006	F06	Oct06	4	WOS	3	28	WOS	8
2006	F06	Oct06	5	WOS	3	28	WOS	.
2006	F06	Nov06	6	WOS	3	10	WOS	.
2006	F06	Nov06	7	WOS	3	21	WOS	.
2006	F06	Nov06	8	WOS	3	20	WOS	8
2006	F06	Nov06	9	WOS	3	21	WOS	.
2006	F06	Dec06	10	WOS	3	21	WOS	8
2006	F06	Dec06	11	WOS	3	20	WOS	8
2006	F06	Dec06	12	WOS	3	21	WOS	.
2006	F06	Sep06	1	WOS	4	32	WOS	7
2006	F06	Oct06	2	WOS	4	33	WOS	6
2006	F06	Oct06	3	WOS	4	28	WOS	.
2006	F06	Oct06	4	WOS	4	28	WOS	7
2006	F06	Oct06	5	WOS	4	29	WOS	.
2006	F06	Nov06	6	WOS	4	9	WOS	.
2006	F06	Nov06	7	WOS	4	21	WOS	.
2006	F06	Nov06	8	WOS	4	21	WOS	7
2006	F06	Nov06	9	WOS	4	21	WOS	.
2006	F06	Dec06	10	WOS	4	20	WOS	6
2006	F06	Dec06	11	WOS	4	21	WOS	6
2006	F06	Dec06	12	WOS	4	21	WOS	.
2007	S07	May07	1	WOS	1	42	WOS	4
2007	S07	May07	2	WOS	1	44	WOS	.
2007	S07	May07	3	WOS	1	52	WOS	4
2007	S07	May07	4	WOS	1	44	WOS	5
2007	S07	Jun07	5	WOS	1	44	WOS	.
2007	S07	Jun07	6	WOS	1	38	WOS	.
2007	S07	Jun07	7	WOS	1	33	WOS	5
2007	S07	Jun07	8	WOS	1	19	WOS	.
2007	S07	Jul07	9	WOS	1	40	WOS	5
2007	S07	Jul07	10	WOS	1	52	WOS	.
2007	S07	Jul07	11	WOS	1	40	WOS	.
2007	S07	Jul07	12	WOS	1	33	WOS	6
2007	S07	Jul07	13	WOS	1	31	WOS	.
2007	S07	Aug07	14	WOS	1	42	WOS	6
2007	S07	Aug07	15	WOS	1	44	WOS	.
2007	S07	Aug07	16	WOS	1	42	WOS	.
2007	S07	Aug07	17	WOS	1	44	WOS	7
2007	F07	Sep07	18	WOS	1	42	WOS	.
2007	F07	Sep07	19	WOS	1	38	WOS	.
2007	F07	Sep07	20	WOS	1	33	WOS	6
2007	F07	Sep07	21	WOS	1	33	WOS	.
2007	F07	Oct07	22	WOS	1	31	WOS	.
2007	F07	Oct07	23	WOS	1	31	WOS	.
2007	F07	Oct07	24	WOS	1	31	WOS	5
2007	F07	Oct07	25	WOS	1	29	WOS	.
2007	F07	Oct07	26	WOS	1	29	WOS	.
2007	F07	Nov07	27	WOS	1	29	WOS	.
2007	F07	Nov07	28	WOS	1	25	WOS	4
2007	F07	Nov07	29	WOS	1	23	WOS	.
2007	F07	Nov07	30	WOS	1	21	WOS	.
2007	S07	May07	1	WOS	2	43	WOS	6
2007	S07	May07	2	WOS	2	46	WOS	.
2007	S07	May07	3	WOS	2	50	WOS	6

2007	S07	May07	4	WOS	2	43	WOS	7
2007	S07	Jun07	5	WOS	2	42	WOS	.
2007	S07	Jun07	6	WOS	2	39	WOS	.
2007	S07	Jun07	7	WOS	2	32	WOS	6
2007	S07	Jun07	8	WOS	2	18	WOS	.
2007	S07	Jul07	9	WOS	2	40	WOS	6
2007	S07	Jul07	10	WOS	2	55	WOS	.
2007	S07	Jul07	11	WOS	2	39	WOS	.
2007	S07	Jul07	12	WOS	2	32	WOS	7
2007	S07	Jul07	13	WOS	2	34	WOS	.
2007	S07	Aug07	14	WOS	2	41	WOS	7
2007	S07	Aug07	15	WOS	2	44	WOS	.
2007	S07	Aug07	16	WOS	2	44	WOS	.
2007	S07	Aug07	17	WOS	2	42	WOS	7
2007	F07	Sep07	18	WOS	2	41	WOS	.
2007	F07	Sep07	19	WOS	2	37	WOS	.
2007	F07	Sep07	20	WOS	2	33	WOS	7
2007	F07	Sep07	21	WOS	2	34	WOS	.
2007	F07	Oct07	22	WOS	2	31	WOS	.
2007	F07	Oct07	23	WOS	2	30	WOS	.
2007	F07	Oct07	24	WOS	2	29	WOS	6
2007	F07	Oct07	25	WOS	2	30	WOS	.
2007	F07	Oct07	26	WOS	2	31	WOS	.
2007	F07	Nov07	27	WOS	2	29	WOS	.
2007	F07	Nov07	28	WOS	2	25	WOS	5
2007	F07	Nov07	29	WOS	2	21	WOS	.
2007	F07	Nov07	30	WOS	2	21	WOS	.
2007	S07	May07	1	WOS	3	40	WOS	8
2007	S07	May07	2	WOS	3	37	WOS	.
2007	S07	May07	3	WOS	3	45	WOS	8
2007	S07	May07	4	WOS	3	38	WOS	8
2007	S07	Jun07	5	WOS	3	38	WOS	.
2007	S07	Jun07	6	WOS	3	34	WOS	.
2007	S07	Jun07	7	WOS	3	30	WOS	8
2007	S07	Jun07	8	WOS	3	15	WOS	.
2007	S07	Jul07	9	WOS	3	35	WOS	8
2007	S07	Jul07	10	WOS	3	47	WOS	.
2007	S07	Jul07	11	WOS	3	37	WOS	.
2007	S07	Jul07	12	WOS	3	29	WOS	7
2007	S07	Jul07	13	WOS	3	28	WOS	.
2007	S07	Aug07	14	WOS	3	39	WOS	8
2007	S07	Aug07	15	WOS	3	38	WOS	.
2007	S07	Aug07	16	WOS	3	38	WOS	.
2007	S07	Aug07	17	WOS	3	38	WOS	9
2007	F07	Sep07	18	WOS	3	38	WOS	.
2007	F07	Sep07	19	WOS	3	32	WOS	.
2007	F07	Sep07	20	WOS	3	28	WOS	8
2007	F07	Sep07	21	WOS	3	29	WOS	.
2007	F07	Oct07	22	WOS	3	31	WOS	.
2007	F07	Oct07	23	WOS	3	30	WOS	.
2007	F07	Oct07	24	WOS	3	28	WOS	8
2007	F07	Oct07	25	WOS	3	29	WOS	.
2007	F07	Oct07	26	WOS	3	28	WOS	.
2007	F07	Nov07	27	WOS	3	29	WOS	.
2007	F07	Nov07	28	WOS	3	25	WOS	8
2007	F07	Nov07	29	WOS	3	22	WOS	.
2007	F07	Nov07	30	WOS	3	21	WOS	.

```
2007  S07   May07 1     WOS   4     43    WOS   6
2007  S07   May07 2     WOS   4     42    WOS   .
2007  S07   May07 3     WOS   4     50    WOS   6
2007  S07   May07 4     WOS   4     43    WOS   6
2007  S07   Jun07 5     WOS   4     42    WOS   .
2007  S07   Jun07 6     WOS   4     38    WOS   .
2007  S07   Jun07 7     WOS   4     33    WOS   6
2007  S07   Jun07 8     WOS   4     16    WOS   .
2007  S07   Jul07 9     WOS   4     40    WOS   6
2007  S07   Jul07 10    WOS   4     51    WOS   .
2007  S07   Jul07 11    WOS   4     39    WOS   .
2007  S07   Jul07 12    WOS   4     32    WOS   7
2007  S07   Jul07 13    WOS   4     31    WOS   .
2007  S07   Aug07 14    WOS   4     41    WOS   7
2007  S07   Aug07 15    WOS   4     41    WOS   .
2007  S07   Aug07 16    WOS   4     42    WOS   .
2007  S07   Aug07 17    WOS   4     41    WOS   7
2007  F07   Sep07 18    WOS   4     41    WOS   .
2007  F07   Sep07 19    WOS   4     37    WOS   .
2007  F07   Sep07 20    WOS   4     31    WOS   7
2007  F07   Sep07 21    WOS   4     31    WOS   .
2007  F07   Oct07 22    WOS   4     31    WOS   .
2007  F07   Oct07 23    WOS   4     30    WOS   .
2007  F07   Oct07 24    WOS   4     28    WOS   6
2007  F07   Oct07 25    WOS   4     29    WOS   .
2007  F07   Oct07 26    WOS   4     28    WOS   .
2007  F07   Nov07 27    WOS   4     29    WOS   .
2007  F07   Nov07 28    WOS   4     26    WOS   6
2007  F07   Nov07 29    WOS   4     21    WOS   .
2007  F07   Nov07 30    WOS   4     21    WOS   .
run;
proc sort;
      by season;
      run;
proc glm; by season;
      title 'Turf Quality';
      class tmt rep week;
      model TQ = tmt rep week/ss3;
      means tmt/duncan;
      run;
proc mixed; by season;
      title 'Turf Quality';
      class tmt rep week ;
      model TQ = tmt; random week rep;
      lsmeans tmt/pdiff;
      run;
proc glm; by season;
      title 'Water Applied';
      class tmt rep week;
      model mm = tmt rep week/ss3;
      means tmt/duncan;
      run;
proc mixed; by season;
      title 'Water Applied';
      class tmt rep week ;
      model mm = tmt; random week rep;
      lsmeans tmt/pdiff;
```

```
run;
```

Rain Sensor Treatments Water Applied and Turf Quality

```
options nodate nonumber center formdlim="*" linesize=88;
data RS;
input year$ season$ month$ week$ tmt$ rep mm freq$ depth$ TQ;
cards;
2006  S06   Apr06 1     RS1-3mm     1     27    1     3     .
2006  S06   May06 2     RS1-3mm     1     27    1     3     .
2006  S06   May06 3     RS1-3mm     1     27    1     3     4
2006  S06   May06 4     RS1-3mm     1     27    1     3     6
2006  S06   May06 5     RS1-3mm     1     27    1     3     6
2006  S06   June06      6     RS1-3mm     1     0     1     3     .
2006  S06   June06      7     RS1-3mm     1     33    1     3     4
2006  S06   June06      8     RS1-3mm     1     0     1     3     .
2006  S06   June06      9     RS1-3mm     1     33    1     3     4
2006  S06   June06      10    RS1-3mm     1     0     1     3     .
2006  S06   Apr06 1     RS1-3mm     2     27    1     3     .
2006  S06   May06 2     RS1-3mm     2     27    1     3     .
2006  S06   May06 3     RS1-3mm     2     27    1     3     5
2006  S06   May06 4     RS1-3mm     2     27    1     3     8
2006  S06   May06 5     RS1-3mm     2     27    1     3     8
2006  S06   June06      6     RS1-3mm     2     0     1     3     .
2006  S06   June06      7     RS1-3mm     2     33    1     3     8
2006  S06   June06      8     RS1-3mm     2     0     1     3     .
2006  S06   June06      9     RS1-3mm     2     33    1     3     8
2006  S06   June06      10    RS1-3mm     2     0     1     3     .
2006  S06   Apr06 1     RS1-3mm     3     25    1     3     .
2006  S06   May06 2     RS1-3mm     3     25    1     3     .
2006  S06   May06 3     RS1-3mm     3     24    1     3     2
2006  S06   May06 4     RS1-3mm     3     24    1     3     4
2006  S06   May06 5     RS1-3mm     3     27    1     3     4
2006  S06   June06      6     RS1-3mm     3     0     1     3     .
2006  S06   June06      7     RS1-3mm     3     34    1     3     3
2006  S06   June06      8     RS1-3mm     3     0     1     3     .
2006  S06   June06      9     RS1-3mm     3     33    1     3     2
2006  S06   June06      10    RS1-3mm     3     0     1     3     .
2006  S06   Apr06 1     RS1-3mm     4     27    1     3     .
2006  S06   May06 2     RS1-3mm     4     27    1     3     .
2006  S06   May06 3     RS1-3mm     4     29    1     3     2
2006  S06   May06 4     RS1-3mm     4     27    1     3     4
2006  S06   May06 5     RS1-3mm     4     27    1     3     3
2006  S06   June06      6     RS1-3mm     4     0     1     3     .
2006  S06   June06      7     RS1-3mm     4     33    1     3     3
2006  S06   June06      8     RS1-3mm     4     0     1     3     .
2006  S06   June06      9     RS1-3mm     4     33    1     3     3
2006  S06   June06      10    RS1-3mm     4     0     1     3     .
2006  S06   Apr06 1     RS2-3mm     1     14    2     3     .
2006  S06   May06 2     RS2-3mm     1     27    2     3     .
2006  S06   May06 3     RS2-3mm     1     26    2     3     7
2006  S06   May06 4     RS2-3mm     1     27    2     3     5
2006  S06   May06 5     RS2-3mm     1     26    2     3     4
2006  S06   June06      6     RS2-3mm     1     17    2     3     .
2006  S06   June06      7     RS2-3mm     1     32    2     3     4
2006  S06   June06      8     RS2-3mm     1     17    2     3     .
2006  S06   June06      9     RS2-3mm     1     32    2     3     4
2006  S06   June06      10    RS2-3mm     1     17    2     3     .
```

2006	S06	Apr06	1	RS2-3mm	2	14	2	3	.
2006	S06	May06	2	RS2-3mm	2	27	2	3	.
2006	S06	May06	3	RS2-3mm	2	27	2	3	7
2006	S06	May06	4	RS2-3mm	2	27	2	3	7
2006	S06	May06	5	RS2-3mm	2	26	2	3	6
2006	S06	June06	6	RS2-3mm	2	17	2	3	.
2006	S06	June06	7	RS2-3mm	2	33	2	3	6
2006	S06	June06	8	RS2-3mm	2	17	2	3	.
2006	S06	June06	9	RS2-3mm	2	33	2	3	6
2006	S06	June06	10	RS2-3mm	2	16	2	3	.
2006	S06	Apr06	1	RS2-3mm	3	13	2	3	.
2006	S06	May06	2	RS2-3mm	3	26	2	3	.
2006	S06	May06	3	RS2-3mm	3	25	2	3	6
2006	S06	May06	4	RS2-3mm	3	25	2	3	7
2006	S06	May06	5	RS2-3mm	3	25	2	3	6
2006	S06	June06	6	RS2-3mm	3	16	2	3	.
2006	S06	June06	7	RS2-3mm	3	31	2	3	6
2006	S06	June06	8	RS2-3mm	3	15	2	3	.
2006	S06	June06	9	RS2-3mm	3	30	2	3	6
2006	S06	June06	10	RS2-3mm	3	15	2	3	.
2006	S06	Apr06	1	RS2-3mm	4	14	2	3	.
2006	S06	May06	2	RS2-3mm	4	27	2	3	.
2006	S06	May06	3	RS2-3mm	4	26	2	3	8
2006	S06	May06	4	RS2-3mm	4	27	2	3	7
2006	S06	May06	5	RS2-3mm	4	27	2	3	6
2006	S06	June06	6	RS2-3mm	4	17	2	3	.
2006	S06	June06	7	RS2-3mm	4	33	2	3	6
2006	S06	June06	8	RS2-3mm	4	17	2	3	.
2006	S06	June06	9	RS2-3mm	4	33	2	3	5
2006	S06	June06	10	RS2-3mm	4	16	2	3	.
2006	S06	Apr06	1	RS7-3mm	1	17	7	3	.
2006	S06	May06	2	RS7-3mm	1	28	7	3	.
2006	S06	May06	3	RS7-3mm	1	17	7	3	7
2006	S06	May06	4	RS7-3mm	1	28	7	3	6
2006	S06	May06	5	RS7-3mm	1	28	7	3	6
2006	S06	June06	6	RS7-3mm	1	29	7	3	.
2006	S06	June06	7	RS7-3mm	1	25	7	3	5
2006	S06	June06	8	RS7-3mm	1	19	7	3	.
2006	S06	June06	9	RS7-3mm	1	20	7	3	6
2006	S06	June06	10	RS7-3mm	1	20	7	3	.
2006	S06	Apr06	1	RS7-3mm	2	14	7	3	.
2006	S06	May06	2	RS7-3mm	2	27	7	3	.
2006	S06	May06	3	RS7-3mm	2	17	7	3	8
2006	S06	May06	4	RS7-3mm	2	27	7	3	7
2006	S06	May06	5	RS7-3mm	2	29	7	3	7
2006	S06	June06	6	RS7-3mm	2	27	7	3	.
2006	S06	June06	7	RS7-3mm	2	23	7	3	7
2006	S06	June06	8	RS7-3mm	2	21	7	3	.
2006	S06	June06	9	RS7-3mm	2	19	7	3	8
2006	S06	June06	10	RS7-3mm	2	19	7	3	.
2006	S06	Apr06	1	RS7-3mm	3	16	7	3	.
2006	S06	May06	2	RS7-3mm	3	29	7	3	.
2006	S06	May06	3	RS7-3mm	3	16	7	3	6
2006	S06	May06	4	RS7-3mm	3	29	7	3	6
2006	S06	May06	5	RS7-3mm	3	28	7	3	5
2006	S06	June06	6	RS7-3mm	3	30	7	3	.
2006	S06	June06	7	RS7-3mm	3	24	7	3	4

2006	S06	June06	8	RS7-3mm	3	20	7	3	.
2006	S06	June06	9	RS7-3mm	3	20	7	3	5
2006	S06	June06	10	RS7-3mm	3	19	7	3	.
2006	S06	Apr06 1	RS7-3mm	4	16	7	3	.	
2006	S06	May06 2	RS7-3mm	4	29	7	3	.	
2006	S06	May06 3	RS7-3mm	4	16	7	3	6	
2006	S06	May06 4	RS7-3mm	4	28	7	3	6	
2006	S06	May06 5	RS7-3mm	4	28	7	3	5	
2006	S06	June06	6	RS7-3mm	4	30	7	3	.
2006	S06	June06	7	RS7-3mm	4	23	7	3	7
2006	S06	June06	8	RS7-3mm	4	20	7	3	.
2006	S06	June06	9	RS7-3mm	4	19	7	3	6
2006	S06	June06	10	RS7-3mm	4	19	7	3	.
2006	S06	Apr06 1	RS1-6mm	1	28	1	6	.	
2006	S06	May06 2	RS1-6mm	1	28	1	6	.	
2006	S06	May06 3	RS1-6mm	1	28	1	6	2	
2006	S06	May06 4	RS1-6mm	1	28	1	6	4	
2006	S06	May06 5	RS1-6mm	1	28	1	6	3	
2006	S06	June06	6	RS1-6mm	1	0	1	6	.
2006	S06	June06	7	RS1-6mm	1	34	1	6	3
2006	S06	June06	8	RS1-6mm	1	34	1	6	.
2006	S06	June06	9	RS1-6mm	1	34	1	6	3
2006	S06	June06	10	RS1-6mm	1	0	1	6	.
2006	S06	Apr06 1	RS1-6mm	2	27	1	6	.	
2006	S06	May06 2	RS1-6mm	2	27	1	6	.	
2006	S06	May06 3	RS1-6mm	2	27	1	6	5	
2006	S06	May06 4	RS1-6mm	2	27	1	6	7	
2006	S06	May06 5	RS1-6mm	2	28	1	6	7	
2006	S06	June06	6	RS1-6mm	2	0	1	6	.
2006	S06	June06	7	RS1-6mm	2	33	1	6	6
2006	S06	June06	8	RS1-6mm	2	34	1	6	.
2006	S06	June06	9	RS1-6mm	2	33	1	6	6
2006	S06	June06	10	RS1-6mm	2	0	1	6	.
2006	S06	Apr06 1	RS1-6mm	3	27	1	6	.	
2006	S06	May06 2	RS1-6mm	3	27	1	6	.	
2006	S06	May06 3	RS1-6mm	3	27	1	6	4	
2006	S06	May06 4	RS1-6mm	3	26	1	6	8	
2006	S06	May06 5	RS1-6mm	3	27	1	6	8	
2006	S06	June06	6	RS1-6mm	3	0	1	6	.
2006	S06	June06	7	RS1-6mm	3	33	1	6	8
2006	S06	June06	8	RS1-6mm	3	32	1	6	.
2006	S06	June06	9	RS1-6mm	3	33	1	6	7
2006	S06	June06	10	RS1-6mm	3	0	1	6	.
2006	S06	Apr06 1	RS1-6mm	4	27	1	6	.	
2006	S06	May06 2	RS1-6mm	4	27	1	6	.	
2006	S06	May06 3	RS1-6mm	4	26	1	6	4	
2006	S06	May06 4	RS1-6mm	4	27	1	6	7	
2006	S06	May06 5	RS1-6mm	4	27	1	6	6	
2006	S06	June06	6	RS1-6mm	4	0	1	6	.
2006	S06	June06	7	RS1-6mm	4	32	1	6	4
2006	S06	June06	8	RS1-6mm	4	33	1	6	.
2006	S06	June06	9	RS1-6mm	4	33	1	6	4
2006	S06	June06	10	RS1-6mm	4	0	1	6	.
2006	S06	Apr06 1	RS2-6mm	1	14	2	6	.	
2006	S06	May06 2	RS2-6mm	1	27	2	6	.	
2006	S06	May06 3	RS2-6mm	1	27	2	6	7	
2006	S06	May06 4	RS2-6mm	1	27	2	6	7	

2006	S06	May06	5	RS2-6mm	1	27	2	6	6
2006	S06	June06	6	RS2-6mm	1	17	2	6	.
2006	S06	June06	7	RS2-6mm	1	33	2	6	5
2006	S06	June06	8	RS2-6mm	1	33	2	6	.
2006	S06	June06	9	RS2-6mm	1	33	2	6	6
2006	S06	June06	10	RS2-6mm	1	0	2	6	.
2006	S06	Apr06	1	RS2-6mm	2	14	2	6	.
2006	S06	May06	2	RS2-6mm	2	27	2	6	.
2006	S06	May06	3	RS2-6mm	2	28	2	6	8
2006	S06	May06	4	RS2-6mm	2	27	2	6	7
2006	S06	May06	5	RS2-6mm	2	28	2	6	7
2006	S06	June06	6	RS2-6mm	2	17	2	6	.
2006	S06	June06	7	RS2-6mm	2	34	2	6	7
2006	S06	June06	8	RS2-6mm	2	34	2	6	.
2006	S06	June06	9	RS2-6mm	2	34	2	6	8
2006	S06	June06	10	RS2-6mm	2	0	2	6	.
2006	S06	Apr06	1	RS2-6mm	3	15	2	6	.
2006	S06	May06	2	RS2-6mm	3	27	2	6	.
2006	S06	May06	3	RS2-6mm	3	27	2	6	3
2006	S06	May06	4	RS2-6mm	3	27	2	6	4
2006	S06	May06	5	RS2-6mm	3	27	2	6	3
2006	S06	June06	6	RS2-6mm	3	17	2	6	.
2006	S06	June06	7	RS2-6mm	3	33	2	6	3
2006	S06	June06	8	RS2-6mm	3	34	2	6	.
2006	S06	June06	9	RS2-6mm	3	33	2	6	3
2006	S06	June06	10	RS2-6mm	3	0	2	6	.
2006	S06	Apr06	1	RS2-6mm	4	14	2	6	.
2006	S06	May06	2	RS2-6mm	4	27	2	6	.
2006	S06	May06	3	RS2-6mm	4	26	2	6	8
2006	S06	May06	4	RS2-6mm	4	27	2	6	7
2006	S06	May06	5	RS2-6mm	4	27	2	6	6
2006	S06	June06	6	RS2-6mm	4	17	2	6	.
2006	S06	June06	7	RS2-6mm	4	32	2	6	8
2006	S06	June06	8	RS2-6mm	4	33	2	6	.
2006	S06	June06	9	RS2-6mm	4	33	2	6	8
2006	S06	June06	10	RS2-6mm	4	0	2	6	.
2006	S06	Apr06	1	DWRS	1	15	2	6	.
2006	S06	May06	2	DWRS	1	28	2	6	.
2006	S06	May06	3	DWRS	1	27	2	6	5
2006	S06	May06	4	DWRS	1	28	2	6	6
2006	S06	May06	5	DWRS	1	22	2	6	5
2006	S06	June06	6	DWRS	1	9	2	6	.
2006	S06	June06	7	DWRS	1	20	2	6	5
2006	S06	June06	8	DWRS	1	19	2	6	.
2006	S06	June06	9	DWRS	1	20	2	6	5
2006	S06	June06	10	DWRS	1	10	2	6	.
2006	S06	Apr06	1	DWRS	2	15	2	6	.
2006	S06	May06	2	DWRS	2	27	2	6	.
2006	S06	May06	3	DWRS	2	27	2	6	8
2006	S06	May06	4	DWRS	2	27	2	6	6
2006	S06	May06	5	DWRS	2	23	2	6	7
2006	S06	June06	6	DWRS	2	8	2	6	.
2006	S06	June06	7	DWRS	2	21	2	6	5
2006	S06	June06	8	DWRS	2	19	2	6	.
2006	S06	June06	9	DWRS	2	19	2	6	5
2006	S06	June06	10	DWRS	2	10	2	6	.
2006	S06	Apr06	1	DWRS	3	14	2	6	.

2006	S06	May06	2	DWRS	3	27	2	6	.
2006	S06	May06	3	DWRS	3	27	2	6	8
2006	S06	May06	4	DWRS	3	27	2	6	8
2006	S06	May06	5	DWRS	3	22	2	6	8
2006	S06	June06	6	DWRS	3	9	2	6	.
2006	S06	June06	7	DWRS	3	19	2	6	7
2006	S06	June06	8	DWRS	3	19	2	6	.
2006	S06	June06	9	DWRS	3	18	2	6	7
2006	S06	June06	10	DWRS	3	9	2	6	.
2006	S06	Apr06	1	DWRS	4	13	2	6	.
2006	S06	May06	2	DWRS	4	24	2	6	.
2006	S06	May06	3	DWRS	4	25	2	6	7
2006	S06	May06	4	DWRS	4	24	2	6	7
2006	S06	May06	5	DWRS	4	22	2	6	7
2006	S06	June06	6	DWRS	4	9	2	6	.
2006	S06	June06	7	DWRS	4	19	2	6	6
2006	S06	June06	8	DWRS	4	19	2	6	.
2006	S06	June06	9	DWRS	4	20	2	6	7
2006	S06	June06	10	DWRS	4	9	2	6	.
2006	F06	Sep06	1	RS2-3mm	1	32	2	3	6
2006	F06	Oct06	2	RS2-3mm	1	33	2	3	7
2006	F06	Oct06	3	RS2-3mm	1	28	2	3	.
2006	F06	Oct06	4	RS2-3mm	1	28	2	3	7
2006	F06	Oct06	5	RS2-3mm	1	28	2	3	.
2006	F06	Nov06	6	RS2-3mm	1	10	2	3	.
2006	F06	Nov06	7	RS2-3mm	1	21	2	3	.
2006	F06	Nov06	8	RS2-3mm	1	9	2	3	5
2006	F06	Nov06	9	RS2-3mm	1	21	2	3	.
2006	F06	Dec06	10	RS2-3mm	1	10	2	3	5
2006	F06	Dec06	11	RS2-3mm	1	21	2	3	5
2006	F06	Dec06	12	RS2-3mm	1	21	2	3	.
2006	F06	Sep06	1	RS2-3mm	2	33	2	3	8
2006	F06	Oct06	2	RS2-3mm	2	33	2	3	8
2006	F06	Oct06	3	RS2-3mm	2	29	2	3	.
2006	F06	Oct06	4	RS2-3mm	2	28	2	3	8
2006	F06	Oct06	5	RS2-3mm	2	28	2	3	.
2006	F06	Nov06	6	RS2-3mm	2	10	2	3	.
2006	F06	Nov06	7	RS2-3mm	2	21	2	3	.
2006	F06	Nov06	8	RS2-3mm	2	10	2	3	8
2006	F06	Nov06	9	RS2-3mm	2	21	2	3	.
2006	F06	Dec06	10	RS2-3mm	2	10	2	3	6
2006	F06	Dec06	11	RS2-3mm	2	21	2	3	7
2006	F06	Dec06	12	RS2-3mm	2	21	2	3	.
2006	F06	Sep06	1	RS2-3mm	3	32	2	3	7
2006	F06	Oct06	2	RS2-3mm	3	29	2	3	7
2006	F06	Oct06	3	RS2-3mm	3	27	2	3	.
2006	F06	Oct06	4	RS2-3mm	3	29	2	3	7
2006	F06	Oct06	5	RS2-3mm	3	28	2	3	.
2006	F06	Nov06	6	RS2-3mm	3	9	2	3	.
2006	F06	Nov06	7	RS2-3mm	3	21	2	3	.
2006	F06	Nov06	8	RS2-3mm	3	10	2	3	7
2006	F06	Nov06	9	RS2-3mm	3	21	2	3	.
2006	F06	Dec06	10	RS2-3mm	3	9	2	3	6
2006	F06	Dec06	11	RS2-3mm	3	21	2	3	7
2006	F06	Dec06	12	RS2-3mm	3	21	2	3	.
2006	F06	Sep06	1	RS2-3mm	4	33	2	3	7
2006	F06	Oct06	2	RS2-3mm	4	33	2	3	7

2006	F06	Oct06	3	RS2-3mm	4	28	2	3	.
2006	F06	Oct06	4	RS2-3mm	4	28	2	3	7
2006	F06	Oct06	5	RS2-3mm	4	28	2	3	.
2006	F06	Nov06	6	RS2-3mm	4	10	2	3	.
2006	F06	Nov06	7	RS2-3mm	4	21	2	3	.
2006	F06	Nov06	8	RS2-3mm	4	10	2	3	6
2006	F06	Nov06	9	RS2-3mm	4	21	2	3	.
2006	F06	Dec06	10	RS2-3mm	4	10	2	3	5
2006	F06	Dec06	11	RS2-3mm	4	21	2	3	5
2006	F06	Dec06	12	RS2-3mm	4	20	2	3	.
2006	F06	Sep06	1	RS2-6mm	1	33	2	6	8
2006	F06	Oct06	2	RS2-6mm	1	33	2	6	8
2006	F06	Oct06	3	RS2-6mm	1	28	2	6	.
2006	F06	Oct06	4	RS2-6mm	1	28	2	6	7
2006	F06	Oct06	5	RS2-6mm	1	29	2	6	.
2006	F06	Nov06	6	RS2-6mm	1	10	2	6	.
2006	F06	Nov06	7	RS2-6mm	1	20	2	6	.
2006	F06	Nov06	8	RS2-6mm	1	10	2	6	7
2006	F06	Nov06	9	RS2-6mm	1	21	2	6	.
2006	F06	Dec06	10	RS2-6mm	1	10	2	6	6
2006	F06	Dec06	11	RS2-6mm	1	21	2	6	6
2006	F06	Dec06	12	RS2-6mm	1	21	2	6	.
2006	F06	Sep06	1	RS2-6mm	2	33	2	6	5
2006	F06	Oct06	2	RS2-6mm	2	32	2	6	5
2006	F06	Oct06	3	RS2-6mm	2	29	2	6	.
2006	F06	Oct06	4	RS2-6mm	2	28	2	6	5
2006	F06	Oct06	5	RS2-6mm	2	29	2	6	.
2006	F06	Nov06	6	RS2-6mm	2	9	2	6	.
2006	F06	Nov06	7	RS2-6mm	2	21	2	6	.
2006	F06	Nov06	8	RS2-6mm	2	10	2	6	5
2006	F06	Nov06	9	RS2-6mm	2	21	2	6	.
2006	F06	Dec06	10	RS2-6mm	2	10	2	6	4
2006	F06	Dec06	11	RS2-6mm	2	21	2	6	4
2006	F06	Dec06	12	RS2-6mm	2	21	2	6	.
2006	F06	Sep06	1	RS2-6mm	3	34	2	6	4
2006	F06	Oct06	2	RS2-6mm	3	33	2	6	4
2006	F06	Oct06	3	RS2-6mm	3	29	2	6	.
2006	F06	Oct06	4	RS2-6mm	3	29	2	6	4
2006	F06	Oct06	5	RS2-6mm	3	29	2	6	.
2006	F06	Nov06	6	RS2-6mm	3	10	2	6	.
2006	F06	Nov06	7	RS2-6mm	3	21	2	6	.
2006	F06	Nov06	8	RS2-6mm	3	10	2	6	5
2006	F06	Nov06	9	RS2-6mm	3	22	2	6	.
2006	F06	Dec06	10	RS2-6mm	3	10	2	6	4
2006	F06	Dec06	11	RS2-6mm	3	21	2	6	5
2006	F06	Dec06	12	RS2-6mm	3	21	2	6	.
2006	F06	Sep06	1	RS2-6mm	4	33	2	6	7
2006	F06	Oct06	2	RS2-6mm	4	32	2	6	7
2006	F06	Oct06	3	RS2-6mm	4	28	2	6	.
2006	F06	Oct06	4	RS2-6mm	4	29	2	6	8
2006	F06	Oct06	5	RS2-6mm	4	28	2	6	.
2006	F06	Nov06	6	RS2-6mm	4	10	2	6	.
2006	F06	Nov06	7	RS2-6mm	4	21	2	6	.
2006	F06	Nov06	8	RS2-6mm	4	10	2	6	7
2006	F06	Nov06	9	RS2-6mm	4	21	2	6	.
2006	F06	Dec06	10	RS2-6mm	4	10	2	6	6
2006	F06	Dec06	11	RS2-6mm	4	21	2	6	7

2006	F06	Dec06	12	RS2-6mm	4	21	2	6	.
2006	F06	Sep06	1	RS7-6mm	1	3	1	6	8
2006	F06	Oct06	2	RS7-6mm	1	51	1	6	7
2006	F06	Oct06	3	RS7-6mm	1	28	1	6	.
2006	F06	Oct06	4	RS7-6mm	1	28	1	6	7
2006	F06	Oct06	5	RS7-6mm	1	28	1	6	.
2006	F06	Nov06	6	RS7-6mm	1	13	1	6	.
2006	F06	Nov06	7	RS7-6mm	1	19	1	6	.
2006	F06	Nov06	8	RS7-6mm	1	20	1	6	7
2006	F06	Nov06	9	RS7-6mm	1	22	1	6	.
2006	F06	Dec06	10	RS7-6mm	1	17	1	6	6
2006	F06	Dec06	11	RS7-6mm	1	19	1	6	6
2006	F06	Dec06	12	RS7-6mm	1	14	1	6	.
2006	F06	Sep06	1	RS7-6mm	2	3	1	6	8
2006	F06	Oct06	2	RS7-6mm	2	52	1	6	8
2006	F06	Oct06	3	RS7-6mm	2	28	1	6	.
2006	F06	Oct06	4	RS7-6mm	2	28	1	6	8
2006	F06	Oct06	5	RS7-6mm	2	29	1	6	.
2006	F06	Nov06	6	RS7-6mm	2	13	1	6	.
2006	F06	Nov06	7	RS7-6mm	2	20	1	6	.
2006	F06	Nov06	8	RS7-6mm	2	20	1	6	8
2006	F06	Nov06	9	RS7-6mm	2	23	1	6	.
2006	F06	Dec06	10	RS7-6mm	2	16	1	6	8
2006	F06	Dec06	11	RS7-6mm	2	20	1	6	8
2006	F06	Dec06	12	RS7-6mm	2	13	1	6	.
2006	F06	Sep06	1	RS7-6mm	3	3	1	6	5
2006	F06	Oct06	2	RS7-6mm	3	52	1	6	4
2006	F06	Oct06	3	RS7-6mm	3	29	1	6	.
2006	F06	Oct06	4	RS7-6mm	3	28	1	6	6
2006	F06	Oct06	5	RS7-6mm	3	28	1	6	.
2006	F06	Nov06	6	RS7-6mm	3	13	1	6	.
2006	F06	Nov06	7	RS7-6mm	3	20	1	6	.
2006	F06	Nov06	8	RS7-6mm	3	20	1	6	5
2006	F06	Nov06	9	RS7-6mm	3	22	1	6	.
2006	F06	Dec06	10	RS7-6mm	3	17	1	6	4
2006	F06	Dec06	11	RS7-6mm	3	20	1	6	5
2006	F06	Dec06	12	RS7-6mm	3	13	1	6	.
2006	F06	Sep06	1	RS7-6mm	4	3	1	6	6
2006	F06	Oct06	2	RS7-6mm	4	51	1	6	6
2006	F06	Oct06	3	RS7-6mm	4	28	1	6	.
2006	F06	Oct06	4	RS7-6mm	4	28	1	6	6
2006	F06	Oct06	5	RS7-6mm	4	28	1	6	.
2006	F06	Nov06	6	RS7-6mm	4	13	1	6	.
2006	F06	Nov06	7	RS7-6mm	4	19	1	6	.
2006	F06	Nov06	8	RS7-6mm	4	19	1	6	7
2006	F06	Nov06	9	RS7-6mm	4	23	1	6	.
2006	F06	Dec06	10	RS7-6mm	4	16	1	6	6
2006	F06	Dec06	11	RS7-6mm	4	19	1	6	6
2006	F06	Dec06	12	RS7-6mm	4	13	1	6	.
2006	F06	Sep06	1	DWRS	1	21	2	6	7
2006	F06	Oct06	2	DWRS	1	21	2	6	7
2006	F06	Oct06	3	DWRS	1	18	2	6	.
2006	F06	Oct06	4	DWRS	1	18	2	6	7
2006	F06	Oct06	5	DWRS	1	18	2	6	.
2006	F06	Nov06	6	DWRS	1	7	2	6	.
2006	F06	Nov06	7	DWRS	1	13	2	6	.
2006	F06	Nov06	8	DWRS	1	7	2	6	7

2006	F06	Nov06	9	DWRS	1	13	2	6	.
2006	F06	Dec06	10	DWRS	1	7	2	6	7
2006	F06	Dec06	11	DWRS	1	13	2	6	7
2006	F06	Dec06	12	DWRS	1	14	2	6	.
2006	F06	Sep06	1	DWRS	2	21	2	6	7
2006	F06	Oct06	2	DWRS	2	21	2	6	7
2006	F06	Oct06	3	DWRS	2	17	2	6	.
2006	F06	Oct06	4	DWRS	2	17	2	6	7
2006	F06	Oct06	5	DWRS	2	19	2	6	.
2006	F06	Nov06	6	DWRS	2	6	2	6	.
2006	F06	Nov06	7	DWRS	2	13	2	6	.
2006	F06	Nov06	8	DWRS	2	6	2	6	7
2006	F06	Nov06	9	DWRS	2	15	2	6	.
2006	F06	Dec06	10	DWRS	2	6	2	6	6
2006	F06	Dec06	11	DWRS	2	13	2	6	7
2006	F06	Dec06	12	DWRS	2	13	2	6	.
2006	F06	Sep06	1	DWRS	3	22	2	6	8
2006	F06	Oct06	2	DWRS	3	21	2	6	8
2006	F06	Oct06	3	DWRS	3	18	2	6	.
2006	F06	Oct06	4	DWRS	3	18	2	6	8
2006	F06	Oct06	5	DWRS	3	18	2	6	.
2006	F06	Nov06	6	DWRS	3	6	2	6	.
2006	F06	Nov06	7	DWRS	3	14	2	6	.
2006	F06	Nov06	8	DWRS	3	6	2	6	8
2006	F06	Nov06	9	DWRS	3	13	2	6	.
2006	F06	Dec06	10	DWRS	3	7	2	6	8
2006	F06	Dec06	11	DWRS	3	13	2	6	8
2006	F06	Dec06	12	DWRS	3	13	2	6	.
2006	F06	Sep06	1	DWRS	4	21	2	6	7
2006	F06	Oct06	2	DWRS	4	21	2	6	7
2006	F06	Oct06	3	DWRS	4	18	2	6	.
2006	F06	Oct06	4	DWRS	4	18	2	6	7
2006	F06	Oct06	5	DWRS	4	17	2	6	.
2006	F06	Nov06	6	DWRS	4	7	2	6	.
2006	F06	Nov06	7	DWRS	4	13	2	6	.
2006	F06	Nov06	8	DWRS	4	6	2	6	7
2006	F06	Nov06	9	DWRS	4	14	2	6	.
2006	F06	Dec06	10	DWRS	4	6	2	6	6
2006	F06	Dec06	11	DWRS	4	14	2	6	6
2006	F06	Dec06	12	DWRS	4	13	2	6	.
2007	S07	May07	1	RS2-3mm	1	43	2	3	6
2007	S07	May07	2	RS2-3mm	1	42	2	3	.
2007	S07	May07	3	RS2-3mm	1	51	2	3	7
2007	S07	May07	4	RS2-3mm	1	21	2	3	7
2007	S07	Jun07	5	RS2-3mm	1	42	2	3	.
2007	S07	Jun07	6	RS2-3mm	1	38	2	3	.
2007	S07	Jun07	7	RS2-3mm	1	33	2	3	7
2007	S07	Jun07	8	RS2-3mm	1	17	2	3	.
2007	S07	Jul07	9	RS2-3mm	1	16	2	3	7
2007	S07	Jul07	10	RS2-3mm	1	32	2	3	.
2007	S07	Jul07	11	RS2-3mm	1	22	2	3	.
2007	S07	Jul07	12	RS2-3mm	1	31	2	3	7
2007	S07	Jul07	13	RS2-3mm	1	31	2	3	.
2007	S07	Aug07	14	RS2-3mm	1	20	2	3	8
2007	S07	Aug07	15	RS2-3mm	1	41	2	3	.
2007	S07	Aug07	16	RS2-3mm	1	41	2	3	.
2007	S07	Aug07	17	RS2-3mm	1	40	2	3	8

2007	F07	Sep07	18	RS2-3mm	1	41	2	3	.
2007	F07	Sep07	19	RS2-3mm	1	37	2	3	.
2007	F07	Sep07	20	RS2-3mm	1	31	2	3	7
2007	F07	Sep07	21	RS2-3mm	1	16	2	3	.
2007	F07	Oct07	22	RS2-3mm	1	16	2	3	.
2007	F07	Oct07	23	RS2-3mm	1	15	2	3	.
2007	F07	Oct07	24	RS2-3mm	1	28	2	3	7
2007	F07	Oct07	25	RS2-3mm	1	15	2	3	.
2007	F07	Oct07	26	RS2-3mm	1	0	2	3	.
2007	F07	Nov07	27	RS2-3mm	1	28	2	3	.
2007	F07	Nov07	28	RS2-3mm	1	25	2	3	6
2007	F07	Nov07	29	RS2-3mm	1	22	2	3	.
2007	F07	Nov07	30	RS2-3mm	1	10	2	3	.
2007	S07	May07	1	RS2-3mm	2	43	2	3	7
2007	S07	May07	2	RS2-3mm	2	42	2	3	.
2007	S07	May07	3	RS2-3mm	2	51	2	3	7
2007	S07	May07	4	RS2-3mm	2	22	2	3	6
2007	S07	Jun07	5	RS2-3mm	2	43	2	3	.
2007	S07	Jun07	6	RS2-3mm	2	39	2	3	.
2007	S07	Jun07	7	RS2-3mm	2	33	2	3	7
2007	S07	Jun07	8	RS2-3mm	2	17	2	3	.
2007	S07	Jul07	9	RS2-3mm	2	18	2	3	7
2007	S07	Jul07	10	RS2-3mm	2	31	2	3	.
2007	S07	Jul07	11	RS2-3mm	2	24	2	3	.
2007	S07	Jul07	12	RS2-3mm	2	31	2	3	7
2007	S07	Jul07	13	RS2-3mm	2	32	2	3	.
2007	S07	Aug07	14	RS2-3mm	2	20	2	3	8
2007	S07	Aug07	15	RS2-3mm	2	42	2	3	.
2007	S07	Aug07	16	RS2-3mm	2	42	2	3	.
2007	S07	Aug07	17	RS2-3mm	2	42	2	3	8
2007	F07	Sep07	18	RS2-3mm	2	41	2	3	.
2007	F07	Sep07	19	RS2-3mm	2	37	2	3	.
2007	F07	Sep07	20	RS2-3mm	2	32	2	3	8
2007	F07	Sep07	21	RS2-3mm	2	16	2	3	.
2007	F07	Oct07	22	RS2-3mm	2	16	2	3	.
2007	F07	Oct07	23	RS2-3mm	2	15	2	3	.
2007	F07	Oct07	24	RS2-3mm	2	29	2	3	8
2007	F07	Oct07	25	RS2-3mm	2	15	2	3	.
2007	F07	Oct07	26	RS2-3mm	2	0	2	3	.
2007	F07	Nov07	27	RS2-3mm	2	28	2	3	.
2007	F07	Nov07	28	RS2-3mm	2	25	2	3	8
2007	F07	Nov07	29	RS2-3mm	2	21	2	3	.
2007	F07	Nov07	30	RS2-3mm	2	10	2	3	.
2007	S07	May07	1	RS2-3mm	3	43	2	3	5
2007	S07	May07	2	RS2-3mm	3	42	2	3	.
2007	S07	May07	3	RS2-3mm	3	50	2	3	6
2007	S07	May07	4	RS2-3mm	3	21	2	3	6
2007	S07	Jun07	5	RS2-3mm	3	43	2	3	.
2007	S07	Jun07	6	RS2-3mm	3	38	2	3	.
2007	S07	Jun07	7	RS2-3mm	3	32	2	3	6
2007	S07	Jun07	8	RS2-3mm	3	17	2	3	.
2007	S07	Jul07	9	RS2-3mm	3	16	2	3	6
2007	S07	Jul07	10	RS2-3mm	3	31	2	3	.
2007	S07	Jul07	11	RS2-3mm	3	23	2	3	.
2007	S07	Jul07	12	RS2-3mm	3	31	2	3	7
2007	S07	Jul07	13	RS2-3mm	3	31	2	3	.
2007	S07	Aug07	14	RS2-3mm	3	20	2	3	7

2007	S07	Aug07	15	RS2-3mm	3	41	2	3	.
2007	S07	Aug07	16	RS2-3mm	3	41	2	3	.
2007	S07	Aug07	17	RS2-3mm	3	41	2	3	7
2007	F07	Sep07	18	RS2-3mm	3	41	2	3	.
2007	F07	Sep07	19	RS2-3mm	3	35	2	3	.
2007	F07	Sep07	20	RS2-3mm	3	31	2	3	7
2007	F07	Sep07	21	RS2-3mm	3	16	2	3	.
2007	F07	Oct07	22	RS2-3mm	3	16	2	3	.
2007	F07	Oct07	23	RS2-3mm	3	14	2	3	.
2007	F07	Oct07	24	RS2-3mm	3	28	2	3	7
2007	F07	Oct07	25	RS2-3mm	3	15	2	3	.
2007	F07	Oct07	26	RS2-3mm	3	0	2	3	.
2007	F07	Nov07	27	RS2-3mm	3	28	2	3	.
2007	F07	Nov07	28	RS2-3mm	3	24	2	3	6
2007	F07	Nov07	29	RS2-3mm	3	21	2	3	.
2007	F07	Nov07	30	RS2-3mm	3	10	2	3	.
2007	S07	May07	1	RS2-3mm	4	42	2	3	6
2007	S07	May07	2	RS2-3mm	4	43	2	3	.
2007	S07	May07	3	RS2-3mm	4	50	2	3	6
2007	S07	May07	4	RS2-3mm	4	21	2	3	6
2007	S07	Jun07	5	RS2-3mm	4	43	2	3	.
2007	S07	Jun07	6	RS2-3mm	4	38	2	3	.
2007	S07	Jun07	7	RS2-3mm	4	33	2	3	6
2007	S07	Jun07	8	RS2-3mm	4	16	2	3	.
2007	S07	Jul07	9	RS2-3mm	4	17	2	3	7
2007	S07	Jul07	10	RS2-3mm	4	31	2	3	.
2007	S07	Jul07	11	RS2-3mm	4	23	2	3	.
2007	S07	Jul07	12	RS2-3mm	4	31	2	3	6
2007	S07	Jul07	13	RS2-3mm	4	31	2	3	.
2007	S07	Aug07	14	RS2-3mm	4	21	2	3	7
2007	S07	Aug07	15	RS2-3mm	4	40	2	3	.
2007	S07	Aug07	16	RS2-3mm	4	41	2	3	.
2007	S07	Aug07	17	RS2-3mm	4	41	2	3	7
2007	F07	Sep07	18	RS2-3mm	4	41	2	3	.
2007	F07	Sep07	19	RS2-3mm	4	37	2	3	.
2007	F07	Sep07	20	RS2-3mm	4	31	2	3	7
2007	F07	Sep07	21	RS2-3mm	4	16	2	3	.
2007	F07	Oct07	22	RS2-3mm	4	16	2	3	.
2007	F07	Oct07	23	RS2-3mm	4	15	2	3	.
2007	F07	Oct07	24	RS2-3mm	4	28	2	3	6
2007	F07	Oct07	25	RS2-3mm	4	14	2	3	.
2007	F07	Oct07	26	RS2-3mm	4	0	2	3	.
2007	F07	Nov07	27	RS2-3mm	4	29	2	3	.
2007	F07	Nov07	28	RS2-3mm	4	24	2	3	5
2007	F07	Nov07	29	RS2-3mm	4	21	2	3	.
2007	F07	Nov07	30	RS2-3mm	4	10	2	3	.
2007	S07	May07	1	RS7-3mm	1	46	7	3	6
2007	S07	May07	2	RS7-3mm	1	45	7	3	.
2007	S07	May07	3	RS7-3mm	1	53	7	3	6
2007	S07	May07	4	RS7-3mm	1	39	7	3	7
2007	S07	Jun07	5	RS7-3mm	1	32	7	3	.
2007	S07	Jun07	6	RS7-3mm	1	39	7	3	.
2007	S07	Jun07	7	RS7-3mm	1	28	7	3	8
2007	S07	Jun07	8	RS7-3mm	1	20	7	3	.
2007	S07	Jul07	9	RS7-3mm	1	24	7	3	7
2007	S07	Jul07	10	RS7-3mm	1	24	7	3	.
2007	S07	Jul07	11	RS7-3mm	1	27	7	3	.

2007	S07	Jul07	12	RS7-3mm	1	24	7	3	8
2007	S07	Jul07	13	RS7-3mm	1	29	7	3	.
2007	S07	Aug07	14	RS7-3mm	1	17	7	3	8
2007	S07	Aug07	15	RS7-3mm	1	33	7	3	.
2007	S07	Aug07	16	RS7-3mm	1	34	7	3	.
2007	S07	Aug07	17	RS7-3mm	1	28	7	3	8
2007	F07	Sep07	18	RS7-3mm	1	22	7	3	.
2007	F07	Sep07	19	RS7-3mm	1	37	7	3	.
2007	F07	Sep07	20	RS7-3mm	1	29	7	3	8
2007	F07	Sep07	21	RS7-3mm	1	9	7	3	.
2007	F07	Oct07	22	RS7-3mm	1	29	7	3	.
2007	F07	Oct07	23	RS7-3mm	1	8	7	3	.
2007	F07	Oct07	24	RS7-3mm	1	29	7	3	8
2007	F07	Oct07	25	RS7-3mm	1	16	7	3	.
2007	F07	Oct07	26	RS7-3mm	1	4	7	3	.
2007	F07	Nov07	27	RS7-3mm	1	25	7	3	.
2007	F07	Nov07	28	RS7-3mm	1	25	7	3	8
2007	F07	Nov07	29	RS7-3mm	1	14	7	3	.
2007	F07	Nov07	30	RS7-3mm	1	17	7	3	.
2007	S07	May07	1	RS7-3mm	2	33	7	3	7
2007	S07	May07	2	RS7-3mm	2	27	7	3	.
2007	S07	May07	3	RS7-3mm	2	42	7	3	7
2007	S07	May07	4	RS7-3mm	2	35	7	3	6
2007	S07	Jun07	5	RS7-3mm	2	31	7	3	.
2007	S07	Jun07	6	RS7-3mm	2	38	7	3	.
2007	S07	Jun07	7	RS7-3mm	2	27	7	3	7
2007	S07	Jun07	8	RS7-3mm	2	19	7	3	.
2007	S07	Jul07	9	RS7-3mm	2	23	7	3	7
2007	S07	Jul07	10	RS7-3mm	2	23	7	3	.
2007	S07	Jul07	11	RS7-3mm	2	25	7	3	.
2007	S07	Jul07	12	RS7-3mm	2	23	7	3	8
2007	S07	Jul07	13	RS7-3mm	2	29	7	3	.
2007	S07	Aug07	14	RS7-3mm	2	17	7	3	6
2007	S07	Aug07	15	RS7-3mm	2	31	7	3	.
2007	S07	Aug07	16	RS7-3mm	2	33	7	3	.
2007	S07	Aug07	17	RS7-3mm	2	27	7	3	8
2007	F07	Sep07	18	RS7-3mm	2	21	7	3	.
2007	F07	Sep07	19	RS7-3mm	2	35	7	3	.
2007	F07	Sep07	20	RS7-3mm	2	29	7	3	7
2007	F07	Sep07	21	RS7-3mm	2	8	7	3	.
2007	F07	Oct07	22	RS7-3mm	2	29	7	3	.
2007	F07	Oct07	23	RS7-3mm	2	6	7	3	.
2007	F07	Oct07	24	RS7-3mm	2	27	7	3	8
2007	F07	Oct07	25	RS7-3mm	2	17	7	3	.
2007	F07	Oct07	26	RS7-3mm	2	4	7	3	.
2007	F07	Nov07	27	RS7-3mm	2	23	7	3	.
2007	F07	Nov07	28	RS7-3mm	2	25	7	3	7
2007	F07	Nov07	29	RS7-3mm	2	13	7	3	.
2007	F07	Nov07	30	RS7-3mm	2	17	7	3	.
2007	S07	May07	1	RS7-3mm	3	48	7	3	6
2007	S07	May07	2	RS7-3mm	3	47	7	3	.
2007	S07	May07	3	RS7-3mm	3	55	7	3	7
2007	S07	May07	4	RS7-3mm	3	40	7	3	7
2007	S07	Jun07	5	RS7-3mm	3	33	7	3	.
2007	S07	Jun07	6	RS7-3mm	3	40	7	3	.
2007	S07	Jun07	7	RS7-3mm	3	30	7	3	6
2007	S07	Jun07	8	RS7-3mm	3	20	7	3	.

2007	S07	Jul07	9	RS7-3mm	3	26	7	3	7
2007	S07	Jul07	10	RS7-3mm	3	25	7	3	.
2007	S07	Jul07	11	RS7-3mm	3	28	7	3	.
2007	S07	Jul07	12	RS7-3mm	3	25	7	3	7
2007	S07	Jul07	13	RS7-3mm	3	26	7	3	.
2007	S07	Aug07	14	RS7-3mm	3	18	7	3	7
2007	S07	Aug07	15	RS7-3mm	3	35	7	3	.
2007	S07	Aug07	16	RS7-3mm	3	37	7	3	.
2007	S07	Aug07	17	RS7-3mm	3	30	7	3	7
2007	F07	Sep07	18	RS7-3mm	3	24	7	3	.
2007	F07	Sep07	19	RS7-3mm	3	32	7	3	.
2007	F07	Sep07	20	RS7-3mm	3	31	7	3	7
2007	F07	Sep07	21	RS7-3mm	3	10	7	3	.
2007	F07	Oct07	22	RS7-3mm	3	29	7	3	.
2007	F07	Oct07	23	RS7-3mm	3	8	7	3	.
2007	F07	Oct07	24	RS7-3mm	3	30	7	3	7
2007	F07	Oct07	25	RS7-3mm	3	18	7	3	.
2007	F07	Oct07	26	RS7-3mm	3	0	7	3	.
2007	F07	Nov07	27	RS7-3mm	3	22	7	3	.
2007	F07	Nov07	28	RS7-3mm	3	27	7	3	6
2007	F07	Nov07	29	RS7-3mm	3	15	7	3	.
2007	F07	Nov07	30	RS7-3mm	3	18	7	3	.
2007	S07	May07	1	RS7-3mm	4	45	7	3	4
2007	S07	May07	2	RS7-3mm	4	46	7	3	.
2007	S07	May07	3	RS7-3mm	4	49	7	3	5
2007	S07	May07	4	RS7-3mm	4	39	7	3	4
2007	S07	Jun07	5	RS7-3mm	4	32	7	3	.
2007	S07	Jun07	6	RS7-3mm	4	39	7	3	.
2007	S07	Jun07	7	RS7-3mm	4	29	7	3	5
2007	S07	Jun07	8	RS7-3mm	4	19	7	3	.
2007	S07	Jul07	9	RS7-3mm	4	25	7	3	5
2007	S07	Jul07	10	RS7-3mm	4	24	7	3	.
2007	S07	Jul07	11	RS7-3mm	4	26	7	3	.
2007	S07	Jul07	12	RS7-3mm	4	25	7	3	5
2007	S07	Jul07	13	RS7-3mm	4	29	7	3	.
2007	S07	Aug07	14	RS7-3mm	4	17	7	3	5
2007	S07	Aug07	15	RS7-3mm	4	34	7	3	.
2007	S07	Aug07	16	RS7-3mm	4	34	7	3	.
2007	S07	Aug07	17	RS7-3mm	4	29	7	3	6
2007	F07	Sep07	18	RS7-3mm	4	23	7	3	.
2007	F07	Sep07	19	RS7-3mm	4	37	7	3	.
2007	F07	Sep07	20	RS7-3mm	4	29	7	3	6
2007	F07	Sep07	21	RS7-3mm	4	10	7	3	.
2007	F07	Oct07	22	RS7-3mm	4	29	7	3	.
2007	F07	Oct07	23	RS7-3mm	4	8	7	3	.
2007	F07	Oct07	24	RS7-3mm	4	29	7	3	5
2007	F07	Oct07	25	RS7-3mm	4	16	7	3	.
2007	F07	Oct07	26	RS7-3mm	4	4	7	3	.
2007	F07	Nov07	27	RS7-3mm	4	25	7	3	.
2007	F07	Nov07	28	RS7-3mm	4	27	7	3	4
2007	F07	Nov07	29	RS7-3mm	4	14	7	3	.
2007	F07	Nov07	30	RS7-3mm	4	17	7	3	.
2007	S07	May07	1	RS1-6mm	1	44	1	6	7
2007	S07	May07	2	RS1-6mm	1	44	1	6	.
2007	S07	May07	3	RS1-6mm	1	52	1	6	6
2007	S07	May07	4	RS1-6mm	1	44	1	6	7
2007	S07	Jun07	5	RS1-6mm	1	45	1	6	.

2007	S07	Jun07	6	RS1-6mm	1	44	1	6	.
2007	S07	Jun07	7	RS1-6mm	1	34	1	6	8
2007	S07	Jun07	8	RS1-6mm	1	0	1	6	.
2007	S07	Jul07	9	RS1-6mm	1	33	1	6	8
2007	S07	Jul07	10	RS1-6mm	1	33	1	6	.
2007	S07	Jul07	11	RS1-6mm	1	40	1	6	.
2007	S07	Jul07	12	RS1-6mm	1	33	1	6	7
2007	S07	Jul07	13	RS1-6mm	1	32	1	6	.
2007	S07	Aug07	14	RS1-6mm	1	0	1	6	8
2007	S07	Aug07	15	RS1-6mm	1	43	1	6	.
2007	S07	Aug07	16	RS1-6mm	1	43	1	6	.
2007	S07	Aug07	17	RS1-6mm	1	42	1	6	8
2007	F07	Sep07	18	RS1-6mm	1	43	1	6	.
2007	F07	Sep07	19	RS1-6mm	1	43	1	6	.
2007	F07	Sep07	20	RS1-6mm	1	32	1	6	8
2007	F07	Sep07	21	RS1-6mm	1	0	1	6	.
2007	F07	Oct07	22	RS1-6mm	1	33	1	6	.
2007	F07	Oct07	23	RS1-6mm	1	0	1	6	.
2007	F07	Oct07	24	RS1-6mm	1	29	1	6	8
2007	F07	Oct07	25	RS1-6mm	1	29	1	6	.
2007	F07	Oct07	26	RS1-6mm	1	0	1	6	.
2007	F07	Nov07	27	RS1-6mm	1	30	1	6	.
2007	F07	Nov07	28	RS1-6mm	1	29	1	6	8
2007	F07	Nov07	29	RS1-6mm	1	22	1	6	.
2007	F07	Nov07	30	RS1-6mm	1	0	1	6	.
2007	S07	May07	1	RS1-6mm	2	43	1	6	4
2007	S07	May07	2	RS1-6mm	2	43	1	6	.
2007	S07	May07	3	RS1-6mm	2	51	1	6	5
2007	S07	May07	4	RS1-6mm	2	43	1	6	4
2007	S07	Jun07	5	RS1-6mm	2	43	1	6	.
2007	S07	Jun07	6	RS1-6mm	2	43	1	6	.
2007	S07	Jun07	7	RS1-6mm	2	33	1	6	5
2007	S07	Jun07	8	RS1-6mm	2	0	1	6	.
2007	S07	Jul07	9	RS1-6mm	2	33	1	6	5
2007	S07	Jul07	10	RS1-6mm	2	32	1	6	.
2007	S07	Jul07	11	RS1-6mm	2	39	1	6	.
2007	S07	Jul07	12	RS1-6mm	2	32	1	6	6
2007	S07	Jul07	13	RS1-6mm	2	31	1	6	.
2007	S07	Aug07	14	RS1-6mm	2	0	1	6	6
2007	S07	Aug07	15	RS1-6mm	2	42	1	6	.
2007	S07	Aug07	16	RS1-6mm	2	42	1	6	.
2007	S07	Aug07	17	RS1-6mm	2	41	1	6	7
2007	F07	Sep07	18	RS1-6mm	2	42	1	6	.
2007	F07	Sep07	19	RS1-6mm	2	42	1	6	.
2007	F07	Sep07	20	RS1-6mm	2	31	1	6	6
2007	F07	Sep07	21	RS1-6mm	2	0	1	6	.
2007	F07	Oct07	22	RS1-6mm	2	32	1	6	.
2007	F07	Oct07	23	RS1-6mm	2	0	1	6	.
2007	F07	Oct07	24	RS1-6mm	2	31	1	6	6
2007	F07	Oct07	25	RS1-6mm	2	28	1	6	.
2007	F07	Oct07	26	RS1-6mm	2	0	1	6	.
2007	F07	Nov07	27	RS1-6mm	2	30	1	6	.
2007	F07	Nov07	28	RS1-6mm	2	32	1	6	5
2007	F07	Nov07	29	RS1-6mm	2	23	1	6	.
2007	F07	Nov07	30	RS1-6mm	2	0	1	6	.
2007	S07	May07	1	RS1-6mm	3	42	1	6	4
2007	S07	May07	2	RS1-6mm	3	42	1	6	.

2007	S07	May07	3	RS1-6mm	3	50	1	6	4
2007	S07	May07	4	RS1-6mm	3	42	1	6	4
2007	S07	Jun07	5	RS1-6mm	3	43	1	6	.
2007	S07	Jun07	6	RS1-6mm	3	42	1	6	.
2007	S07	Jun07	7	RS1-6mm	3	33	1	6	4
2007	S07	Jun07	8	RS1-6mm	3	0	1	6	.
2007	S07	Jul07	9	RS1-6mm	3	32	1	6	5
2007	S07	Jul07	10	RS1-6mm	3	31	1	6	.
2007	S07	Jul07	11	RS1-6mm	3	33	1	6	.
2007	S07	Jul07	12	RS1-6mm	3	31	1	6	4
2007	S07	Jul07	13	RS1-6mm	3	30	1	6	.
2007	S07	Aug07	14	RS1-6mm	3	0	1	6	6
2007	S07	Aug07	15	RS1-6mm	3	41	1	6	.
2007	S07	Aug07	16	RS1-6mm	3	40	1	6	.
2007	S07	Aug07	17	RS1-6mm	3	40	1	6	6
2007	F07	Sep07	18	RS1-6mm	3	41	1	6	.
2007	F07	Sep07	19	RS1-6mm	3	41	1	6	.
2007	F07	Sep07	20	RS1-6mm	3	30	1	6	6
2007	F07	Sep07	21	RS1-6mm	3	0	1	6	.
2007	F07	Oct07	22	RS1-6mm	3	31	1	6	.
2007	F07	Oct07	23	RS1-6mm	3	0	1	6	.
2007	F07	Oct07	24	RS1-6mm	3	27	1	6	4
2007	F07	Oct07	25	RS1-6mm	3	28	1	6	.
2007	F07	Oct07	26	RS1-6mm	3	0	1	6	.
2007	F07	Nov07	27	RS1-6mm	3	28	1	6	.
2007	F07	Nov07	28	RS1-6mm	3	28	1	6	4
2007	F07	Nov07	29	RS1-6mm	3	21	1	6	.
2007	F07	Nov07	30	RS1-6mm	3	0	1	6	.
2007	S07	May07	1	RS1-6mm	4	42	1	6	5
2007	S07	May07	2	RS1-6mm	4	43	1	6	.
2007	S07	May07	3	RS1-6mm	4	50	1	6	6
2007	S07	May07	4	RS1-6mm	4	42	1	6	5
2007	S07	Jun07	5	RS1-6mm	4	43	1	6	.
2007	S07	Jun07	6	RS1-6mm	4	42	1	6	.
2007	S07	Jun07	7	RS1-6mm	4	33	1	6	6
2007	S07	Jun07	8	RS1-6mm	4	0	1	6	.
2007	S07	Jul07	9	RS1-6mm	4	32	1	6	6
2007	S07	Jul07	10	RS1-6mm	4	31	1	6	.
2007	S07	Jul07	11	RS1-6mm	4	34	1	6	.
2007	S07	Jul07	12	RS1-6mm	4	32	1	6	6
2007	S07	Jul07	13	RS1-6mm	4	31	1	6	.
2007	S07	Aug07	14	RS1-6mm	4	0	1	6	7
2007	S07	Aug07	15	RS1-6mm	4	41	1	6	.
2007	S07	Aug07	16	RS1-6mm	4	41	1	6	.
2007	S07	Aug07	17	RS1-6mm	4	41	1	6	7
2007	F07	Sep07	18	RS1-6mm	4	41	1	6	.
2007	F07	Sep07	19	RS1-6mm	4	42	1	6	.
2007	F07	Sep07	20	RS1-6mm	4	31	1	6	7
2007	F07	Sep07	21	RS1-6mm	4	0	1	6	.
2007	F07	Oct07	22	RS1-6mm	4	31	1	6	.
2007	F07	Oct07	23	RS1-6mm	4	0	1	6	.
2007	F07	Oct07	24	RS1-6mm	4	29	1	6	6
2007	F07	Oct07	25	RS1-6mm	4	28	1	6	.
2007	F07	Oct07	26	RS1-6mm	4	0	1	6	.
2007	F07	Nov07	27	RS1-6mm	4	28	1	6	.
2007	F07	Nov07	28	RS1-6mm	4	29	1	6	6
2007	F07	Nov07	29	RS1-6mm	4	20	1	6	.

2007	F07	Nov07	30	RS1-6mm	4	0	1	6	.
2007	S07	May07	1	RS2-6mm	1	43	2	6	5
2007	S07	May07	2	RS2-6mm	1	43	2	6	.
2007	S07	May07	3	RS2-6mm	1	50	2	6	6
2007	S07	May07	4	RS2-6mm	1	43	2	6	5
2007	S07	Jun07	5	RS2-6mm	1	43	2	6	.
2007	S07	Jun07	6	RS2-6mm	1	38	2	6	.
2007	S07	Jun07	7	RS2-6mm	1	32	2	6	5
2007	S07	Jun07	8	RS2-6mm	1	17	2	6	.
2007	S07	Jul07	9	RS2-6mm	1	17	2	6	6
2007	S07	Jul07	10	RS2-6mm	1	31	2	6	.
2007	S07	Jul07	11	RS2-6mm	1	23	2	6	.
2007	S07	Jul07	12	RS2-6mm	1	32	2	6	5
2007	S07	Jul07	13	RS2-6mm	1	31	2	6	.
2007	S07	Aug07	14	RS2-6mm	1	20	2	6	6
2007	S07	Aug07	15	RS2-6mm	1	42	2	6	.
2007	S07	Aug07	16	RS2-6mm	1	41	2	6	.
2007	S07	Aug07	17	RS2-6mm	1	42	2	6	7
2007	F07	Sep07	18	RS2-6mm	1	41	2	6	.
2007	F07	Sep07	19	RS2-6mm	1	37	2	6	.
2007	F07	Sep07	20	RS2-6mm	1	31	2	6	6
2007	F07	Sep07	21	RS2-6mm	1	16	2	6	.
2007	F07	Oct07	22	RS2-6mm	1	17	2	6	.
2007	F07	Oct07	23	RS2-6mm	1	15	2	6	.
2007	F07	Oct07	24	RS2-6mm	1	30	2	6	6
2007	F07	Oct07	25	RS2-6mm	1	29	2	6	.
2007	F07	Oct07	26	RS2-6mm	1	0	2	6	.
2007	F07	Nov07	27	RS2-6mm	1	30	2	6	.
2007	F07	Nov07	28	RS2-6mm	1	27	2	6	4
2007	F07	Nov07	29	RS2-6mm	1	22	2	6	.
2007	F07	Nov07	30	RS2-6mm	1	10	2	6	.
2007	S07	May07	1	RS2-6mm	2	43	2	6	4
2007	S07	May07	2	RS2-6mm	2	43	2	6	.
2007	S07	May07	3	RS2-6mm	2	50	2	6	5
2007	S07	May07	4	RS2-6mm	2	43	2	6	5
2007	S07	Jun07	5	RS2-6mm	2	43	2	6	.
2007	S07	Jun07	6	RS2-6mm	2	38	2	6	.
2007	S07	Jun07	7	RS2-6mm	2	33	2	6	4
2007	S07	Jun07	8	RS2-6mm	2	17	2	6	.
2007	S07	Jul07	9	RS2-6mm	2	17	2	6	6
2007	S07	Jul07	10	RS2-6mm	2	31	2	6	.
2007	S07	Jul07	11	RS2-6mm	2	24	2	6	.
2007	S07	Jul07	12	RS2-6mm	2	31	2	6	7
2007	S07	Jul07	13	RS2-6mm	2	32	2	6	.
2007	S07	Aug07	14	RS2-6mm	2	20	2	6	7
2007	S07	Aug07	15	RS2-6mm	2	42	2	6	.
2007	S07	Aug07	16	RS2-6mm	2	41	2	6	.
2007	S07	Aug07	17	RS2-6mm	2	41	2	6	7
2007	F07	Sep07	18	RS2-6mm	2	42	2	6	.
2007	F07	Sep07	19	RS2-6mm	2	35	2	6	.
2007	F07	Sep07	20	RS2-6mm	2	32	2	6	7
2007	F07	Sep07	21	RS2-6mm	2	16	2	6	.
2007	F07	Oct07	22	RS2-6mm	2	16	2	6	.
2007	F07	Oct07	23	RS2-6mm	2	15	2	6	.
2007	F07	Oct07	24	RS2-6mm	2	28	2	6	6
2007	F07	Oct07	25	RS2-6mm	2	29	2	6	.
2007	F07	Oct07	26	RS2-6mm	2	0	2	6	.

2007	F07	Nov07	27	RS2-6mm	2	28	2	6	.
2007	F07	Nov07	28	RS2-6mm	2	25	2	6	5
2007	F07	Nov07	29	RS2-6mm	2	22	2	6	.
2007	F07	Nov07	30	RS2-6mm	2	10	2	6	.
2007	S07	May07	1	RS2-6mm	3	44	2	6	4
2007	S07	May07	2	RS2-6mm	3	43	2	6	.
2007	S07	May07	3	RS2-6mm	3	50	2	6	5
2007	S07	May07	4	RS2-6mm	3	42	2	6	5
2007	S07	Jun07	5	RS2-6mm	3	43	2	6	.
2007	S07	Jun07	6	RS2-6mm	3	48	2	6	.
2007	S07	Jun07	7	RS2-6mm	3	33	2	6	5
2007	S07	Jun07	8	RS2-6mm	3	18	2	6	.
2007	S07	Jul07	9	RS2-6mm	3	17	2	6	6
2007	S07	Jul07	10	RS2-6mm	3	32	2	6	.
2007	S07	Jul07	11	RS2-6mm	3	23	2	6	.
2007	S07	Jul07	12	RS2-6mm	3	32	2	6	7
2007	S07	Jul07	13	RS2-6mm	3	32	2	6	.
2007	S07	Aug07	14	RS2-6mm	3	22	2	6	8
2007	S07	Aug07	15	RS2-6mm	3	43	2	6	.
2007	S07	Aug07	16	RS2-6mm	3	43	2	6	.
2007	S07	Aug07	17	RS2-6mm	3	43	2	6	8
2007	F07	Sep07	18	RS2-6mm	3	43	2	6	.
2007	F07	Sep07	19	RS2-6mm	3	39	2	6	.
2007	F07	Sep07	20	RS2-6mm	3	33	2	6	8
2007	F07	Sep07	21	RS2-6mm	3	17	2	6	.
2007	F07	Oct07	22	RS2-6mm	3	17	2	6	.
2007	F07	Oct07	23	RS2-6mm	3	16	2	6	.
2007	F07	Oct07	24	RS2-6mm	3	30	2	6	8
2007	F07	Oct07	25	RS2-6mm	3	29	2	6	.
2007	F07	Oct07	26	RS2-6mm	3	0	2	6	.
2007	F07	Nov07	27	RS2-6mm	3	30	2	6	.
2007	F07	Nov07	28	RS2-6mm	3	26	2	6	7
2007	F07	Nov07	29	RS2-6mm	3	23	2	6	.
2007	F07	Nov07	30	RS2-6mm	3	10	2	6	.
2007	S07	May07	1	RS2-6mm	4	43	2	6	7
2007	S07	May07	2	RS2-6mm	4	43	2	6	.
2007	S07	May07	3	RS2-6mm	4	50	2	6	6
2007	S07	May07	4	RS2-6mm	4	42	2	6	7
2007	S07	Jun07	5	RS2-6mm	4	43	2	6	.
2007	S07	Jun07	6	RS2-6mm	4	38	2	6	.
2007	S07	Jun07	7	RS2-6mm	4	33	2	6	7
2007	S07	Jun07	8	RS2-6mm	4	17	2	6	.
2007	S07	Jul07	9	RS2-6mm	4	17	2	6	7
2007	S07	Jul07	10	RS2-6mm	4	31	2	6	.
2007	S07	Jul07	11	RS2-6mm	4	23	2	6	.
2007	S07	Jul07	12	RS2-6mm	4	32	2	6	7
2007	S07	Jul07	13	RS2-6mm	4	31	2	6	.
2007	S07	Aug07	14	RS2-6mm	4	21	2	6	7
2007	S07	Aug07	15	RS2-6mm	4	41	2	6	.
2007	S07	Aug07	16	RS2-6mm	4	42	2	6	.
2007	S07	Aug07	17	RS2-6mm	4	42	2	6	6
2007	F07	Sep07	18	RS2-6mm	4	41	2	6	.
2007	F07	Sep07	19	RS2-6mm	4	38	2	6	.
2007	F07	Sep07	20	RS2-6mm	4	31	2	6	7
2007	F07	Sep07	21	RS2-6mm	4	16	2	6	.
2007	F07	Oct07	22	RS2-6mm	4	17	2	6	.
2007	F07	Oct07	23	RS2-6mm	4	15	2	6	.

2007	F07	Oct07	24	RS2-6mm	4	28	2	6	6
2007	F07	Oct07	25	RS2-6mm	4	29	2	6	.
2007	F07	Oct07	26	RS2-6mm	4	0	2	6	.
2007	F07	Nov07	27	RS2-6mm	4	29	2	6	.
2007	F07	Nov07	28	RS2-6mm	4	26	2	6	6
2007	F07	Nov07	29	RS2-6mm	4	21	2	6	.
2007	F07	Nov07	30	RS2-6mm	4	10	2	6	.
2007	S07	May07	1	RS7-6mm	1	45	7	6	6
2007	S07	May07	2	RS7-6mm	1	45	7	6	.
2007	S07	May07	3	RS7-6mm	1	51	7	6	6
2007	S07	May07	4	RS7-6mm	1	44	7	6	6
2007	S07	Jun07	5	RS7-6mm	1	32	7	6	.
2007	S07	Jun07	6	RS7-6mm	1	38	7	6	.
2007	S07	Jun07	7	RS7-6mm	1	28	7	6	6
2007	S07	Jun07	8	RS7-6mm	1	19	7	6	.
2007	S07	Jul07	9	RS7-6mm	1	24	7	6	6
2007	S07	Jul07	10	RS7-6mm	1	24	7	6	.
2007	S07	Jul07	11	RS7-6mm	1	31	7	6	.
2007	S07	Jul07	12	RS7-6mm	1	24	7	6	6
2007	S07	Jul07	13	RS7-6mm	1	28	7	6	.
2007	S07	Aug07	14	RS7-6mm	1	17	7	6	6
2007	S07	Aug07	15	RS7-6mm	1	39	7	6	.
2007	S07	Aug07	16	RS7-6mm	1	33	7	6	.
2007	S07	Aug07	17	RS7-6mm	1	33	7	6	7
2007	F07	Sep07	18	RS7-6mm	1	22	7	6	.
2007	F07	Sep07	19	RS7-6mm	1	35	7	6	.
2007	F07	Sep07	20	RS7-6mm	1	28	7	6	6
2007	F07	Sep07	21	RS7-6mm	1	15	7	6	.
2007	F07	Oct07	22	RS7-6mm	1	28	7	6	.
2007	F07	Oct07	23	RS7-6mm	1	14	7	6	.
2007	F07	Oct07	24	RS7-6mm	1	27	7	6	6
2007	F07	Oct07	25	RS7-6mm	1	24	7	6	.
2007	F07	Oct07	26	RS7-6mm	1	13	7	6	.
2007	F07	Nov07	27	RS7-6mm	1	28	7	6	.
2007	F07	Nov07	28	RS7-6mm	1	25	7	6	5
2007	F07	Nov07	29	RS7-6mm	1	13	7	6	.
2007	F07	Nov07	30	RS7-6mm	1	20	7	6	.
2007	S07	May07	1	RS7-6mm	2	46	7	6	8
2007	S07	May07	2	RS7-6mm	2	46	7	6	.
2007	S07	May07	3	RS7-6mm	2	55	7	6	8
2007	S07	May07	4	RS7-6mm	2	46	7	6	8
2007	S07	Jun07	5	RS7-6mm	2	33	7	6	.
2007	S07	Jun07	6	RS7-6mm	2	40	7	6	.
2007	S07	Jun07	7	RS7-6mm	2	29	7	6	8
2007	S07	Jun07	8	RS7-6mm	2	20	7	6	.
2007	S07	Jul07	9	RS7-6mm	2	25	7	6	8
2007	S07	Jul07	10	RS7-6mm	2	24	7	6	.
2007	S07	Jul07	11	RS7-6mm	2	32	7	6	.
2007	S07	Jul07	12	RS7-6mm	2	25	7	6	8
2007	S07	Jul07	13	RS7-6mm	2	30	7	6	.
2007	S07	Aug07	14	RS7-6mm	2	17	7	6	8
2007	S07	Aug07	15	RS7-6mm	2	41	7	6	.
2007	S07	Aug07	16	RS7-6mm	2	35	7	6	.
2007	S07	Aug07	17	RS7-6mm	2	35	7	6	9
2007	F07	Sep07	18	RS7-6mm	2	23	7	6	.
2007	F07	Sep07	19	RS7-6mm	2	37	7	6	.
2007	F07	Sep07	20	RS7-6mm	2	30	7	6	8

2007	F07	Sep07	21	RS7-6mm	2	15	7	6	.
2007	F07	Oct07	22	RS7-6mm	2	29	7	6	.
2007	F07	Oct07	23	RS7-6mm	2	14	7	6	.
2007	F07	Oct07	24	RS7-6mm	2	29	7	6	8
2007	F07	Oct07	25	RS7-6mm	2	25	7	6	.
2007	F07	Oct07	26	RS7-6mm	2	13	7	6	.
2007	F07	Nov07	27	RS7-6mm	2	29	7	6	.
2007	F07	Nov07	28	RS7-6mm	2	26	7	6	9
2007	F07	Nov07	29	RS7-6mm	2	14	7	6	.
2007	F07	Nov07	30	RS7-6mm	2	20	7	6	.
2007	S07	May07	1	RS7-6mm	3	45	7	6	5
2007	S07	May07	2	RS7-6mm	3	45	7	6	.
2007	S07	May07	3	RS7-6mm	3	53	7	6	7
2007	S07	May07	4	RS7-6mm	3	45	7	6	7
2007	S07	Jun07	5	RS7-6mm	3	31	7	6	.
2007	S07	Jun07	6	RS7-6mm	3	39	7	6	.
2007	S07	Jun07	7	RS7-6mm	3	29	7	6	7
2007	S07	Jun07	8	RS7-6mm	3	19	7	6	.
2007	S07	Jul07	9	RS7-6mm	3	24	7	6	7
2007	S07	Jul07	10	RS7-6mm	3	25	7	6	.
2007	S07	Jul07	11	RS7-6mm	3	31	7	6	.
2007	S07	Jul07	12	RS7-6mm	3	24	7	6	7
2007	S07	Jul07	13	RS7-6mm	3	29	7	6	.
2007	S07	Aug07	14	RS7-6mm	3	17	7	6	8
2007	S07	Aug07	15	RS7-6mm	3	39	7	6	.
2007	S07	Aug07	16	RS7-6mm	3	34	7	6	.
2007	S07	Aug07	17	RS7-6mm	3	33	7	6	8
2007	F07	Sep07	18	RS7-6mm	3	22	7	6	.
2007	F07	Sep07	19	RS7-6mm	3	37	7	6	.
2007	F07	Sep07	20	RS7-6mm	3	29	7	6	8
2007	F07	Sep07	21	RS7-6mm	3	15	7	6	.
2007	F07	Oct07	22	RS7-6mm	3	28	7	6	.
2007	F07	Oct07	23	RS7-6mm	3	14	7	6	.
2007	F07	Oct07	24	RS7-6mm	3	28	7	6	8
2007	F07	Oct07	25	RS7-6mm	3	24	7	6	.
2007	F07	Oct07	26	RS7-6mm	3	13	7	6	.
2007	F07	Nov07	27	RS7-6mm	3	29	7	6	.
2007	F07	Nov07	28	RS7-6mm	3	25	7	6	6
2007	F07	Nov07	29	RS7-6mm	3	14	7	6	.
2007	F07	Nov07	30	RS7-6mm	3	20	7	6	.
2007	S07	May07	1	RS7-6mm	4	45	7	6	5
2007	S07	May07	2	RS7-6mm	4	45	7	6	.
2007	S07	May07	3	RS7-6mm	4	52	7	6	5
2007	S07	May07	4	RS7-6mm	4	44	7	6	6
2007	S07	Jun07	5	RS7-6mm	4	32	7	6	.
2007	S07	Jun07	6	RS7-6mm	4	38	7	6	.
2007	S07	Jun07	7	RS7-6mm	4	29	7	6	6
2007	S07	Jun07	8	RS7-6mm	4	19	7	6	.
2007	S07	Jul07	9	RS7-6mm	4	24	7	6	6
2007	S07	Jul07	10	RS7-6mm	4	24	7	6	.
2007	S07	Jul07	11	RS7-6mm	4	31	7	6	.
2007	S07	Jul07	12	RS7-6mm	4	23	7	6	7
2007	S07	Jul07	13	RS7-6mm	4	28	7	6	.
2007	S07	Aug07	14	RS7-6mm	4	17	7	6	7
2007	S07	Aug07	15	RS7-6mm	4	39	7	6	.
2007	S07	Aug07	16	RS7-6mm	4	32	7	6	.
2007	S07	Aug07	17	RS7-6mm	4	33	7	6	7

2007	F07	Sep07	18	RS7-6mm		4	22	7	6	.
2007	F07	Sep07	19	RS7-6mm		4	37	7	6	.
2007	F07	Sep07	20	RS7-6mm		4	30	7	6	7
2007	F07	Sep07	21	RS7-6mm		4	15	7	6	.
2007	F07	Oct07	22	RS7-6mm		4	29	7	6	.
2007	F07	Oct07	23	RS7-6mm		4	13	7	6	.
2007	F07	Oct07	24	RS7-6mm		4	28	7	6	6
2007	F07	Oct07	25	RS7-6mm		4	25	7	6	.
2007	F07	Oct07	26	RS7-6mm		4	13	7	6	.
2007	F07	Nov07	27	RS7-6mm		4	28	7	6	.
2007	F07	Nov07	28	RS7-6mm		4	25	7	6	6
2007	F07	Nov07	29	RS7-6mm		4	14	7	6	.
2007	F07	Nov07	30	RS7-6mm		4	20	7	6	.
2007	S07	May07	1	DWRS	1	26	2	6	6	
2007	S07	May07	2	DWRS	1	26	2	6	.	
2007	S07	May07	3	DWRS	1	34	2	6	6	
2007	S07	May07	4	DWRS	1	26	2	6	7	
2007	S07	Jun07	5	DWRS	1	26	2	6	.	
2007	S07	Jun07	6	DWRS	1	23	2	6	.	
2007	S07	Jun07	7	DWRS	1	20	2	6	7	
2007	S07	Jun07	8	DWRS	1	9	2	6	.	
2007	S07	Jul07	9	DWRS	1	10	2	6	6	
2007	S07	Jul07	10	DWRS	1	19	2	6	.	
2007	S07	Jul07	11	DWRS	1	18	2	6	.	
2007	S07	Jul07	12	DWRS	1	20	2	6	6	
2007	S07	Jul07	13	DWRS	1	20	2	6	.	
2007	S07	Aug07	14	DWRS	1	14	2	6	7	
2007	S07	Aug07	15	DWRS	1	27	2	6	.	
2007	S07	Aug07	16	DWRS	1	27	2	6	.	
2007	S07	Aug07	17	DWRS	1	26	2	6	7	
2007	F07	Sep07	18	DWRS	1	27	2	6	.	
2007	F07	Sep07	19	DWRS	1	24	2	6	.	
2007	F07	Sep07	20	DWRS	1	20	2	6	6	
2007	F07	Sep07	21	DWRS	1	10	2	6	.	
2007	F07	Oct07	22	DWRS	1	9	2	6	.	
2007	F07	Oct07	23	DWRS	1	10	2	6	.	
2007	F07	Oct07	24	DWRS	1	19	2	6	7	
2007	F07	Oct07	25	DWRS	1	19	2	6	.	
2007	F07	Oct07	26	DWRS	1	0	2	6	.	
2007	F07	Nov07	27	DWRS	1	19	2	6	.	
2007	F07	Nov07	28	DWRS	1	17	2	6	5	
2007	F07	Nov07	29	DWRS	1	14	2	6	.	
2007	F07	Nov07	30	DWRS	1	6	2	6	.	
2007	S07	May07	1	DWRS	2	25	2	6	7	
2007	S07	May07	2	DWRS	2	25	2	6	.	
2007	S07	May07	3	DWRS	2	33	2	6	7	
2007	S07	May07	4	DWRS	2	25	2	6	7	
2007	S07	Jun07	5	DWRS	2	27	2	6	.	
2007	S07	Jun07	6	DWRS	2	23	2	6	.	
2007	S07	Jun07	7	DWRS	2	19	2	6	7	
2007	S07	Jun07	8	DWRS	2	8	2	6	.	
2007	S07	Jul07	9	DWRS	2	10	2	6	8	
2007	S07	Jul07	10	DWRS	2	19	2	6	.	
2007	S07	Jul07	11	DWRS	2	19	2	6	.	
2007	S07	Jul07	12	DWRS	2	19	2	6	8	
2007	S07	Jul07	13	DWRS	2	21	2	6	.	
2007	S07	Aug07	14	DWRS	2	13	2	6	8	

2007	S07	Aug07	15	DWRS	2	25	2	6	.
2007	S07	Aug07	16	DWRS	2	27	2	6	.
2007	S07	Aug07	17	DWRS	2	25	2	6	8
2007	F07	Sep07	18	DWRS	2	25	2	6	.
2007	F07	Sep07	19	DWRS	2	23	2	6	.
2007	F07	Sep07	20	DWRS	2	21	2	6	8
2007	F07	Sep07	21	DWRS	2	8	2	6	.
2007	F07	Oct07	22	DWRS	2	10	2	6	.
2007	F07	Oct07	23	DWRS	2	10	2	6	.
2007	F07	Oct07	24	DWRS	2	17	2	6	8
2007	F07	Oct07	25	DWRS	2	19	2	6	.
2007	F07	Oct07	26	DWRS	2	0	2	6	.
2007	F07	Nov07	27	DWRS	2	19	2	6	.
2007	F07	Nov07	28	DWRS	2	17	2	6	8
2007	F07	Nov07	29	DWRS	2	15	2	6	.
2007	F07	Nov07	30	DWRS	2	6	2	6	.
2007	S07	May07	1	DWRS	3	26	2	6	6
2007	S07	May07	2	DWRS	3	25	2	6	.
2007	S07	May07	3	DWRS	3	33	2	6	7
2007	S07	May07	4	DWRS	3	26	2	6	6
2007	S07	Jun07	5	DWRS	3	25	2	6	.
2007	S07	Jun07	6	DWRS	3	23	2	6	.
2007	S07	Jun07	7	DWRS	3	19	2	6	7
2007	S07	Jun07	8	DWRS	3	9	2	6	.
2007	S07	Jul07	9	DWRS	3	10	2	6	8
2007	S07	Jul07	10	DWRS	3	19	2	6	.
2007	S07	Jul07	11	DWRS	3	17	2	6	.
2007	S07	Jul07	12	DWRS	3	20	2	6	8
2007	S07	Jul07	13	DWRS	3	19	2	6	.
2007	S07	Aug07	14	DWRS	3	13	2	6	8
2007	S07	Aug07	15	DWRS	3	25	2	6	.
2007	S07	Aug07	16	DWRS	3	22	2	6	.
2007	S07	Aug07	17	DWRS	3	22	2	6	8
2007	F07	Sep07	18	DWRS	3	22	2	6	.
2007	F07	Sep07	19	DWRS	3	18	2	6	.
2007	F07	Sep07	20	DWRS	3	13	2	6	8
2007	F07	Sep07	21	DWRS	3	6	2	6	.
2007	F07	Oct07	22	DWRS	3	9	2	6	.
2007	F07	Oct07	23	DWRS	3	8	2	6	.
2007	F07	Oct07	24	DWRS	3	16	2	6	8
2007	F07	Oct07	25	DWRS	3	15	2	6	.
2007	F07	Oct07	26	DWRS	3	0	2	6	.
2007	F07	Nov07	27	DWRS	3	16	2	6	.
2007	F07	Nov07	28	DWRS	3	14	2	6	8
2007	F07	Nov07	29	DWRS	3	10	2	6	.
2007	F07	Nov07	30	DWRS	3	6	2	6	.
2007	S07	May07	1	DWRS	4	26	2	6	6
2007	S07	May07	2	DWRS	4	26	2	6	.
2007	S07	May07	3	DWRS	4	33	2	6	6
2007	S07	May07	4	DWRS	4	25	2	6	6
2007	S07	Jun07	5	DWRS	4	26	2	6	.
2007	S07	Jun07	6	DWRS	4	23	2	6	.
2007	S07	Jun07	7	DWRS	4	19	2	6	6
2007	S07	Jun07	8	DWRS	4	10	2	6	.
2007	S07	Jul07	9	DWRS	4	9	2	6	6
2007	S07	Jul07	10	DWRS	4	19	2	6	.
2007	S07	Jul07	11	DWRS	4	13	2	6	.

2007	S07	Jul07 12	DWRS	4	21	2	6	6
2007	S07	Jul07 13	DWRS	4	20	2	6	.
2007	S07	Aug07 14	DWRS	4	14	2	6	7
2007	S07	Aug07 15	DWRS	4	26	2	6	.
2007	S07	Aug07 16	DWRS	4	27	2	6	.
2007	S07	Aug07 17	DWRS	4	26	2	6	7
2007	F07	Sep07 18	DWRS	4	27	2	6	.
2007	F07	Sep07 19	DWRS	4	24	2	6	.
2007	F07	Sep07 20	DWRS	4	20	2	6	6
2007	F07	Sep07 21	DWRS	4	10	2	6	.
2007	F07	Oct07 22	DWRS	4	10	2	6	.
2007	F07	Oct07 23	DWRS	4	10	2	6	.
2007	F07	Oct07 24	DWRS	4	20	2	6	6
2007	F07	Oct07 25	DWRS	4	20	2	6	.
2007	F07	Oct07 26	DWRS	4	0	2	6	.
2007	F07	Nov07 27	DWRS	4	20	2	6	.
2007	F07	Nov07 28	DWRS	4	17	2	6	6
2007	F07	Nov07 29	DWRS	4	15	2	6	.
2007	F07	Nov07 30	DWRS	4	7	2	6	.
2006	S06	Apr06 1	WOS	1	29	2	.	.
2006	S06	May06 2	WOS	1	27	2	.	.
2006	S06	May06 3	WOS	1	27	2	.	4
2006	S06	May06 4	WOS	1	29	2	.	3
2006	S06	May06 5	WOS	1	27	2	.	3
2006	S06	June06	6	WOS	1	35	2	.	.
2006	S06	June06	7	WOS	1	33	2	.	3
2006	S06	June06	8	WOS	1	35	2	.	.
2006	S06	June06	9	WOS	1	33	2	.	3
2006	S06	June06	10	WOS	1	33	2	.	.
2006	S06	Apr06 1	WOS	2	28	2	.	.
2006	S06	May06 2	WOS	2	26	2	.	.
2006	S06	May06 3	WOS	2	27	2	.	6
2006	S06	May06 4	WOS	2	25	2	.	5
2006	S06	May06 5	WOS	2	27	2	.	4
2006	S06	June06	6	WOS	2	33	2	.	.
2006	S06	June06	7	WOS	2	33	2	.	4
2006	S06	June06	8	WOS	2	33	2	.	.
2006	S06	June06	9	WOS	2	33	2	.	5
2006	S06	June06	10	WOS	2	33	2	.	.
2006	S06	Apr06 1	WOS	3	27	2	.	.
2006	S06	May06 2	WOS	3	26	2	.	.
2006	S06	May06 3	WOS	3	27	2	.	8
2006	S06	May06 4	WOS	3	25	2	.	8
2006	S06	May06 5	WOS	3	26	2	.	7
2006	S06	June06	6	WOS	3	32	2	.	.
2006	S06	June06	7	WOS	3	31	2	.	8
2006	S06	June06	8	WOS	3	31	2	.	.
2006	S06	June06	9	WOS	3	31	2	.	8
2006	S06	June06	10	WOS	3	29	2	.	.
2006	S06	Apr06 1	WOS	4	27	2	.	.
2006	S06	May06 2	WOS	4	26	2	.	.
2006	S06	May06 3	WOS	4	27	2	.	8
2006	S06	May06 4	WOS	4	27	2	.	7
2006	S06	May06 5	WOS	4	27	2	.	6
2006	S06	June06	6	WOS	4	33	2	.	.
2006	S06	June06	7	WOS	4	32	2	.	6
2006	S06	June06	8	WOS	4	33	2	.	.

2006	S06	June06	9	WOS	4	33	2	.	6
2006	S06	June06	10	WOS	4	32	2	.	.
2006	F06	Sep06	1	WOS	1	33	2	.	4
2006	F06	Oct06	2	WOS	1	33	2	.	4
2006	F06	Oct06	3	WOS	1	29	2	.	.
2006	F06	Oct06	4	WOS	1	29	2	.	4
2006	F06	Oct06	5	WOS	1	29	2	.	.
2006	F06	Nov06	6	WOS	1	13	2	.	.
2006	F06	Nov06	7	WOS	1	21	2	.	.
2006	F06	Nov06	8	WOS	1	23	2	.	4
2006	F06	Nov06	9	WOS	1	23	2	.	.
2006	F06	Dec06	10	WOS	1	21	2	.	3
2006	F06	Dec06	11	WOS	1	21	2	.	4
2006	F06	Dec06	12	WOS	1	21	2	.	.
2006	F06	Sep06	1	WOS	2	31	2	.	6
2006	F06	Oct06	2	WOS	2	33	2	.	7
2006	F06	Oct06	3	WOS	2	28	2	.	.
2006	F06	Oct06	4	WOS	2	28	2	.	7
2006	F06	Oct06	5	WOS	2	29	2	.	.
2006	F06	Nov06	6	WOS	2	10	2	.	.
2006	F06	Nov06	7	WOS	2	22	2	.	.
2006	F06	Nov06	8	WOS	2	21	2	.	6
2006	F06	Nov06	9	WOS	2	21	2	.	.
2006	F06	Dec06	10	WOS	2	20	2	.	5
2006	F06	Dec06	11	WOS	2	21	2	.	5
2006	F06	Dec06	12	WOS	2	21	2	.	.
2006	F06	Sep06	1	WOS	3	32	2	.	8
2006	F06	Oct06	2	WOS	3	32	2	.	8
2006	F06	Oct06	3	WOS	3	28	2	.	.
2006	F06	Oct06	4	WOS	3	28	2	.	8
2006	F06	Oct06	5	WOS	3	28	2	.	.
2006	F06	Nov06	6	WOS	3	10	2	.	.
2006	F06	Nov06	7	WOS	3	21	2	.	.
2006	F06	Nov06	8	WOS	3	20	2	.	8
2006	F06	Nov06	9	WOS	3	21	2	.	.
2006	F06	Dec06	10	WOS	3	21	2	.	8
2006	F06	Dec06	11	WOS	3	20	2	.	8
2006	F06	Dec06	12	WOS	3	21	2	.	.
2006	F06	Sep06	1	WOS	4	32	2	.	7
2006	F06	Oct06	2	WOS	4	33	2	.	6
2006	F06	Oct06	3	WOS	4	28	2	.	.
2006	F06	Oct06	4	WOS	4	28	2	.	7
2006	F06	Oct06	5	WOS	4	29	2	.	.
2006	F06	Nov06	6	WOS	4	9	2	.	.
2006	F06	Nov06	7	WOS	4	21	2	.	.
2006	F06	Nov06	8	WOS	4	21	2	.	7
2006	F06	Nov06	9	WOS	4	21	2	.	.
2006	F06	Dec06	10	WOS	4	20	2	.	6
2006	F06	Dec06	11	WOS	4	21	2	.	6
2006	F06	Dec06	12	WOS	4	21	2	.	.
2007	S07	May07	1	WOS	1	42	2	.	4
2007	S07	May07	2	WOS	1	44	2	.	.
2007	S07	May07	3	WOS	1	52	2	.	4
2007	S07	May07	4	WOS	1	44	2	.	5
2007	S07	Jun07	5	WOS	1	44	2	.	.
2007	S07	Jun07	6	WOS	1	38	2	.	.
2007	S07	Jun07	7	WOS	1	33	2	.	5

2007	S07	Jun07	8	WOS	1	19	2	.	.
2007	S07	Jul07	9	WOS	1	40	2	.	5
2007	S07	Jul07	10	WOS	1	52	2	.	.
2007	S07	Jul07	11	WOS	1	40	2	.	.
2007	S07	Jul07	12	WOS	1	33	2	.	6
2007	S07	Jul07	13	WOS	1	31	2	.	.
2007	S07	Aug07	14	WOS	1	42	2	.	6
2007	S07	Aug07	15	WOS	1	44	2	.	.
2007	S07	Aug07	16	WOS	1	42	2	.	.
2007	S07	Aug07	17	WOS	1	44	2	.	7
2007	F07	Sep07	18	WOS	1	42	2	.	.
2007	F07	Sep07	19	WOS	1	38	2	.	.
2007	F07	Sep07	20	WOS	1	33	2	.	6
2007	F07	Sep07	21	WOS	1	33	2	.	.
2007	F07	Oct07	22	WOS	1	31	2	.	.
2007	F07	Oct07	23	WOS	1	31	2	.	.
2007	F07	Oct07	24	WOS	1	31	2	.	5
2007	F07	Oct07	25	WOS	1	29	2	.	.
2007	F07	Oct07	26	WOS	1	29	2	.	.
2007	F07	Nov07	27	WOS	1	29	2	.	.
2007	F07	Nov07	28	WOS	1	25	2	.	4
2007	F07	Nov07	29	WOS	1	23	2	.	.
2007	F07	Nov07	30	WOS	1	21	2	.	.
2007	S07	May07	1	WOS	2	43	2	.	6
2007	S07	May07	2	WOS	2	46	2	.	.
2007	S07	May07	3	WOS	2	50	2	.	6
2007	S07	May07	4	WOS	2	43	2	.	7
2007	S07	Jun07	5	WOS	2	42	2	.	.
2007	S07	Jun07	6	WOS	2	39	2	.	.
2007	S07	Jun07	7	WOS	2	32	2	.	6
2007	S07	Jun07	8	WOS	2	18	2	.	.
2007	S07	Jul07	9	WOS	2	40	2	.	6
2007	S07	Jul07	10	WOS	2	55	2	.	.
2007	S07	Jul07	11	WOS	2	39	2	.	.
2007	S07	Jul07	12	WOS	2	32	2	.	7
2007	S07	Jul07	13	WOS	2	34	2	.	.
2007	S07	Aug07	14	WOS	2	41	2	.	7
2007	S07	Aug07	15	WOS	2	44	2	.	.
2007	S07	Aug07	16	WOS	2	44	2	.	.
2007	S07	Aug07	17	WOS	2	42	2	.	7
2007	F07	Sep07	18	WOS	2	41	2	.	.
2007	F07	Sep07	19	WOS	2	37	2	.	.
2007	F07	Sep07	20	WOS	2	33	2	.	7
2007	F07	Sep07	21	WOS	2	34	2	.	.
2007	F07	Oct07	22	WOS	2	31	2	.	.
2007	F07	Oct07	23	WOS	2	30	2	.	.
2007	F07	Oct07	24	WOS	2	29	2	.	6
2007	F07	Oct07	25	WOS	2	30	2	.	.
2007	F07	Oct07	26	WOS	2	31	2	.	.
2007	F07	Nov07	27	WOS	2	29	2	.	.
2007	F07	Nov07	28	WOS	2	25	2	.	5
2007	F07	Nov07	29	WOS	2	21	2	.	.
2007	F07	Nov07	30	WOS	2	21	2	.	.
2007	S07	May07	1	WOS	3	40	2	.	8
2007	S07	May07	2	WOS	3	37	2	.	.
2007	S07	May07	3	WOS	3	45	2	.	8
2007	S07	May07	4	WOS	3	38	2	.	8

2007	S07	Jun07	5	WOS	3	38	2	.	.
2007	S07	Jun07	6	WOS	3	34	2	.	.
2007	S07	Jun07	7	WOS	3	30	2	.	8
2007	S07	Jun07	8	WOS	3	15	2	.	.
2007	S07	Jul07	9	WOS	3	35	2	.	8
2007	S07	Jul07	10	WOS	3	47	2	.	.
2007	S07	Jul07	11	WOS	3	37	2	.	.
2007	S07	Jul07	12	WOS	3	29	2	.	7
2007	S07	Jul07	13	WOS	3	28	2	.	.
2007	S07	Aug07	14	WOS	3	39	2	.	8
2007	S07	Aug07	15	WOS	3	38	2	.	.
2007	S07	Aug07	16	WOS	3	38	2	.	.
2007	S07	Aug07	17	WOS	3	38	2	.	9
2007	F07	Sep07	18	WOS	3	38	2	.	.
2007	F07	Sep07	19	WOS	3	32	2	.	.
2007	F07	Sep07	20	WOS	3	28	2	.	8
2007	F07	Sep07	21	WOS	3	29	2	.	.
2007	F07	Oct07	22	WOS	3	31	2	.	.
2007	F07	Oct07	23	WOS	3	30	2	.	.
2007	F07	Oct07	24	WOS	3	28	2	.	8
2007	F07	Oct07	25	WOS	3	29	2	.	.
2007	F07	Oct07	26	WOS	3	28	2	.	.
2007	F07	Nov07	27	WOS	3	29	2	.	.
2007	F07	Nov07	28	WOS	3	25	2	.	8
2007	F07	Nov07	29	WOS	3	22	2	.	.
2007	F07	Nov07	30	WOS	3	21	2	.	.
2007	S07	May07	1	WOS	4	43	2	.	6
2007	S07	May07	2	WOS	4	42	2	.	.
2007	S07	May07	3	WOS	4	50	2	.	6
2007	S07	May07	4	WOS	4	43	2	.	6
2007	S07	Jun07	5	WOS	4	42	2	.	.
2007	S07	Jun07	6	WOS	4	38	2	.	.
2007	S07	Jun07	7	WOS	4	33	2	.	6
2007	S07	Jun07	8	WOS	4	16	2	.	.
2007	S07	Jul07	9	WOS	4	40	2	.	6
2007	S07	Jul07	10	WOS	4	51	2	.	.
2007	S07	Jul07	11	WOS	4	39	2	.	.
2007	S07	Jul07	12	WOS	4	32	2	.	7
2007	S07	Jul07	13	WOS	4	31	2	.	.
2007	S07	Aug07	14	WOS	4	41	2	.	7
2007	S07	Aug07	15	WOS	4	41	2	.	.
2007	S07	Aug07	16	WOS	4	42	2	.	.
2007	S07	Aug07	17	WOS	4	41	2	.	7
2007	F07	Sep07	18	WOS	4	41	2	.	.
2007	F07	Sep07	19	WOS	4	37	2	.	.
2007	F07	Sep07	20	WOS	4	31	2	.	7
2007	F07	Sep07	21	WOS	4	31	2	.	.
2007	F07	Oct07	22	WOS	4	31	2	.	.
2007	F07	Oct07	23	WOS	4	30	2	.	.
2007	F07	Oct07	24	WOS	4	28	2	.	6
2007	F07	Oct07	25	WOS	4	29	2	.	.
2007	F07	Oct07	26	WOS	4	28	2	.	.
2007	F07	Nov07	27	WOS	4	29	2	.	.
2007	F07	Nov07	28	WOS	4	26	2	.	6
2007	F07	Nov07	29	WOS	4	21	2	.	.
2007	F07	Nov07	30	WOS	4	21	2	.	.
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2006	S06	May06 3	NON	1	.	.	.	1
2006	S06	May06 4	NON	1	.	.	.	1
2006	S06	May06 5	NON	1	.	.	.	1
2006	S06	June06	6	NON	1	.	.	.	.
2006	S06	June06	7	NON	1	.	.	.	1
2006	S06	June06	8	NON	1	.	.	.	.
2006	S06	June06	9	NON	1	.	.	.	1
2006	S06	June06	10	NON	1	.	.	.	.
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2006	S06	May06 5	NON	2	.	.	.	1
2006	S06	June06	6	NON	2	.	.	.	.
2006	S06	June06	7	NON	2	.	.	.	1
2006	S06	June06	8	NON	2	.	.	.	.
2006	S06	June06	9	NON	2	.	.	.	1
2006	S06	June06	10	NON	2	.	.	.	.
2006	S06	Apr06 1	NON	3	.	.	.	.
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2006	S06	May06 5	NON	3	.	.	.	1
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2006	S06	June06	7	NON	3	.	.	.	1
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2006	S06	June06	9	NON	3	.	.	.	2
2006	S06	June06	10	NON	3	.	.	.	.
2006	S06	Apr06 1	NON	4	.	.	.	.
2006	S06	May06 2	NON	4	.	.	.	.
2006	S06	May06 3	NON	4	.	.	.	4
2006	S06	May06 4	NON	4	.	.	.	1
2006	S06	May06 5	NON	4	.	.	.	1
2006	S06	June06	6	NON	4	.	.	.	.
2006	S06	June06	7	NON	4	.	.	.	1
2006	S06	June06	8	NON	4	.	.	.	.
2006	S06	June06	9	NON	4	.	.	.	2
2006	S06	June06	10	NON	4	.	.	.	.
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2007	F07	Sep07 21	NON	1	.	.	.	.
2007	F07	Oct07 22	NON	1	.	.	.	.
2007	F07	Oct07 23	NON	1	.	.	.	.
2007	F07	Oct07 24	NON	1	.	.	.	4
2007	F07	Oct07 25	NON	1	.	.	.	.
2007	F07	Oct07 26	NON	1	.	.	.	.
2007	F07	Nov07 27	NON	1	.	.	.	.
2007	F07	Nov07 28	NON	1	.	.	.	3
2007	F07	Nov07 29	NON	1	.	.	.	.
2007	F07	Nov07 30	NON	1	.	.	.	.
2007	F07	Sep07 18	NON	2	.	.	.	.
2007	F07	Sep07 19	NON	2	.	.	.	.
2007	F07	Sep07 20	NON	2	.	.	.	5
2007	F07	Sep07 21	NON	2	.	.	.	.
2007	F07	Oct07 22	NON	2	.	.	.	.

2007	F07	Oct07	23	NON	2	.	.	.	.	
2007	F07	Oct07	24	NON	2	.	.	.	6	
2007	F07	Oct07	25	NON	2	.	.	.	.	
2007	F07	Oct07	26	NON	2	.	.	.	.	
2007	F07	Nov07	27	NON	2	.	.	.	.	
2007	F07	Nov07	28	NON	2	.	.	.	5	
2007	F07	Nov07	29	NON	2	.	.	.	.	
2007	F07	Nov07	30	NON	2	.	.	.	.	
2007	F07	Sep07	18	NON	3	.	.	.	.	
2007	F07	Sep07	19	NON	3	.	.	.	.	
2007	F07	Sep07	20	NON	3	.	.	.	6	
2007	F07	Sep07	21	NON	3	.	.	.	.	
2007	F07	Oct07	22	NON	3	.	.	.	.	
2007	F07	Oct07	23	NON	3	.	.	.	.	
2007	F07	Oct07	24	NON	3	.	.	.	7	
2007	F07	Oct07	25	NON	3	.	.	.	.	
2007	F07	Oct07	26	NON	3	.	.	.	.	
2007	F07	Nov07	27	NON	3	.	.	.	.	
2007	F07	Nov07	28	NON	3	.	.	.	6	
2007	F07	Nov07	29	NON	3	.	.	.	.	
2007	F07	Nov07	30	NON	3	.	.	.	.	
2007	F07	Sep07	18	NON	4	.	.	.	.	
2007	F07	Sep07	19	NON	4	.	.	.	.	
2007	F07	Sep07	20	NON	4	.	.	.	3	
2007	F07	Sep07	21	NON	4	.	.	.	.	
2007	F07	Oct07	22	NON	4	.	.	.	.	
2007	F07	Oct07	23	NON	4	.	.	.	.	
2007	F07	Oct07	24	NON	4	.	.	.	5	
2007	F07	Oct07	25	NON	4	.	.	.	.	
2007	F07	Oct07	26	NON	4	.	.	.	.	
2007	F07	Nov07	27	NON	4	.	.	.	.	
2007	F07	Nov07	28	NON	4	.	.	.	5	
2007	F07	Nov07	29	NON	4	.	.	.	.	
2007	F07	Nov07	30	NON	4	.	.	.	.	
2007	F07	Sep07	18	RS1-3mm	1	0	1	3	.	
2007	F07	Sep07	19	RS1-3mm	1	42	1	3	.	
2007	F07	Sep07	20	RS1-3mm	1	32	1	3	6	
2007	F07	Sep07	21	RS1-3mm	1	0	1	3	.	
2007	F07	Oct07	22	RS1-3mm	1	32	1	3	.	
2007	F07	Oct07	23	RS1-3mm	1	0	1	3	.	
2007	F07	Oct07	24	RS1-3mm	1	29	1	3	5	
2007	F07	Oct07	25	RS1-3mm	1	28	1	3	.	
2007	F07	Oct07	26	RS1-3mm	1	0	1	3	.	
2007	F07	Nov07	27	RS1-3mm	1	29	1	3	.	
2007	F07	Nov07	28	RS1-3mm	1	29	1	3	4	
2007	F07	Nov07	29	RS1-3mm	1	21	1	3	.	
2007	F07	Nov07	30	RS1-3mm	1	0	1	3	.	
2007	F07	Sep07	18	RS1-3mm	2	0	1	3	.	
2007	F07	Sep07	19	RS1-3mm	2	42	1	3	.	
2007	F07	Sep07	20	RS1-3mm	2	32	1	3	8	
2007	F07	Sep07	21	RS1-3mm	2	0	1	3	.	
2007	F07	Oct07	22	RS1-3mm	2	33	1	3	.	
2007	F07	Oct07	23	RS1-3mm	2	0	1	3	.	
2007	F07	Oct07	24	RS1-3mm	2	29	1	3	8	
2007	F07	Oct07	25	RS1-3mm	2	30	1	3	.	
2007	F07	Oct07	26	RS1-3mm	2	0	1	3	.	
2007	F07	Nov07	27	RS1-3mm	2	29	1	3	.	

```
2007  F07   Nov07 28    RS1-3mm     2     30    1     3     7
2007  F07   Nov07 29    RS1-3mm     2     22    1     3     .
2007  F07   Nov07 30    RS1-3mm     2     0     1     3     .
2007  F07   Sep07 18    RS1-3mm     3     0     1     3     .
2007  F07   Sep07 19    RS1-3mm     3     42    1     3     .
2007  F07   Sep07 20    RS1-3mm     3     31    1     3     7
2007  F07   Sep07 21    RS1-3mm     3     0     1     3     .
2007  F07   Oct07 22    RS1-3mm     3     32    1     3     .
2007  F07   Oct07 23    RS1-3mm     3     0     1     3     .
2007  F07   Oct07 24    RS1-3mm     3     29    1     3     7
2007  F07   Oct07 25    RS1-3mm     3     29    1     3     .
2007  F07   Oct07 26    RS1-3mm     3     0     1     3     .
2007  F07   Nov07 27    RS1-3mm     3     29    1     3     .
2007  F07   Nov07 28    RS1-3mm     3     29    1     3     7
2007  F07   Nov07 29    RS1-3mm     3     21    1     3     .
2007  F07   Nov07 30    RS1-3mm     3     0     1     3     .
2007  F07   Sep07 18    RS1-3mm     4     0     1     3     .
2007  F07   Sep07 19    RS1-3mm     4     42    1     3     .
2007  F07   Sep07 20    RS1-3mm     4     33    1     3     6
2007  F07   Sep07 21    RS1-3mm     4     0     1     3     .
2007  F07   Oct07 22    RS1-3mm     4     33    1     3     .
2007  F07   Oct07 23    RS1-3mm     4     0     1     3     .
2007  F07   Oct07 24    RS1-3mm     4     29    1     3     5
2007  F07   Oct07 25    RS1-3mm     4     29    1     3     .
2007  F07   Oct07 26    RS1-3mm     4     0     1     3     .
2007  F07   Nov07 27    RS1-3mm     4     29    1     3     .
2007  F07   Nov07 28    RS1-3mm     4     29    1     3     5
2007  F07   Nov07 29    RS1-3mm     4     21    1     3     .
2007  F07   Nov07 30    RS1-3mm     4     0     1     3     .
run;
proc sort; by season;
      run;
proc glm; by season;
      title 'Turf Quality';
      class tmt rep week;
      model mm = tmt rep week/ss3;
      means tmt/duncan;
      run;
proc mixed; by season;
      title 'Turf Quality';
      class tmt rep week ;
      model TQ = tmt; random week rep;
      lsmeans tmt/pdiff;
      run;
proc glm; by season;
      title 'Water Applied';
      class tmt rep week;
      model TQ = tmt rep week/ss3;
      means tmt/duncan;
      run;
proc mixed; by season;
      title 'Water Applied';
      class tmt rep week ;
      model mm = tmt; random week rep;
      lsmeans tmt/pdiff;
      run;
```

ET Controllers Water Applied and Turf Quality

```
options nodate nonumber center formdlim="*" linesize=88;
data ET;
input year$ season$ month$ week$ tmt$ rep mm TQ;
cards;
2006  F06   Sep06 1     ETM   1     35    8
2006  F06   Oct06 2     ETM   1     35    8
2006  F06   Oct06 3     ETM   1     17    .
2006  F06   Oct06 4     ETM   1     33    8
2006  F06   Oct06 5     ETM   1     13    .
2006  F06   Nov06 6     ETM   1     0     .
2006  F06   Nov06 7     ETM   1     0     .
2006  F06   Nov06 8     ETM   1     0     8
2006  F06   Nov06 9     ETM   1     0     .
2006  F06   Dec06 10    ETM   1     13    8
2006  F06   Dec06 11    ETM   1     10    8
2006  F06   Dec06 12    ETM   1     21    .
2006  F06   Sep06 1     ETM   2     33    6
2006  F06   Oct06 2     ETM   2     35    6
2006  F06   Oct06 3     ETM   2     18    .
2006  F06   Oct06 4     ETM   2     31    6
2006  F06   Oct06 5     ETM   2     15    .
2006  F06   Nov06 6     ETM   2     0     .
2006  F06   Nov06 7     ETM   2     0     .
2006  F06   Nov06 8     ETM   2     0     4
2006  F06   Nov06 9     ETM   2     0     .
2006  F06   Dec06 10    ETM   2     10    4
2006  F06   Dec06 11    ETM   2     10    4
2006  F06   Dec06 12    ETM   2     21    .
2006  F06   Sep06 1     ETM   3     29    7
2006  F06   Oct06 2     ETM   3     34    7
2006  F06   Oct06 3     ETM   3     18    .
2006  F06   Oct06 4     ETM   3     31    7
2006  F06   Oct06 5     ETM   3     15    .
2006  F06   Nov06 6     ETM   3     0     .
2006  F06   Nov06 7     ETM   3     0     .
2006  F06   Nov06 8     ETM   3     0     8
2006  F06   Nov06 9     ETM   3     0     .
2006  F06   Dec06 10    ETM   3     10    7
2006  F06   Dec06 11    ETM   3     10    8
2006  F06   Dec06 12    ETM   3     21    .
2006  F06   Sep06 1     ETM   4     33    8
2006  F06   Oct06 2     ETM   4     35    8
2006  F06   Oct06 3     ETM   4     18    .
2006  F06   Oct06 4     ETM   4     31    8
2006  F06   Oct06 5     ETM   4     14    .
2006  F06   Nov06 6     ETM   4     0     .
2006  F06   Nov06 7     ETM   4     0     .
2006  F06   Nov06 8     ETM   4     0     8
2006  F06   Nov06 9     ETM   4     0     .
2006  F06   Dec06 10    ETM   4     10    8
2006  F06   Dec06 11    ETM   4     10    8
2006  F06   Dec06 12    ETM   4     21    .
2006  F06   Sep06 1     TORO  1     6     5
2006  F06   Oct06 2     TORO  1     30    5
2006  F06   Oct06 3     TORO  1     9     .
2006  F06   Oct06 4     TORO  1     8     5
```

2006	F06	Oct06	5	TORO	1	9	.
2006	F06	Nov06	6	TORO	1	8	.
2006	F06	Nov06	7	TORO	1	11	.
2006	F06	Nov06	8	TORO	1	0	5
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2006	F06	Dec06	10	TORO	1	5	4
2006	F06	Dec06	11	TORO	1	10	6
2006	F06	Dec06	12	TORO	1	0	.
2006	F06	Sep06	1	TORO	2	5	6
2006	F06	Oct06	2	TORO	2	30	6
2006	F06	Oct06	3	TORO	2	9	.
2006	F06	Oct06	4	TORO	2	8	6
2006	F06	Oct06	5	TORO	2	9	.
2006	F06	Nov06	6	TORO	2	7	.
2006	F06	Nov06	7	TORO	2	11	.
2006	F06	Nov06	8	TORO	2	0	6
2006	F06	Nov06	9	TORO	2	9	.
2006	F06	Dec06	10	TORO	2	4	5
2006	F06	Dec06	11	TORO	2	11	6
2006	F06	Dec06	12	TORO	2	0	.
2006	F06	Sep06	1	TORO	3	6	8
2006	F06	Oct06	2	TORO	3	29	8
2006	F06	Oct06	3	TORO	3	9	.
2006	F06	Oct06	4	TORO	3	8	8
2006	F06	Oct06	5	TORO	3	9	.
2006	F06	Nov06	6	TORO	3	7	.
2006	F06	Nov06	7	TORO	3	11	.
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2006	F06	Dec06	10	TORO	3	4	8
2006	F06	Dec06	11	TORO	3	11	8
2006	F06	Dec06	12	TORO	3	0	.
2006	F06	Sep06	1	TORO	4	6	7
2006	F06	Oct06	2	TORO	4	29	8
2006	F06	Oct06	3	TORO	4	9	.
2006	F06	Oct06	4	TORO	4	8	7
2006	F06	Oct06	5	TORO	4	9	.
2006	F06	Nov06	6	TORO	4	7	.
2006	F06	Nov06	7	TORO	4	11	.
2006	F06	Nov06	8	TORO	4	0	8
2006	F06	Nov06	9	TORO	4	9	.
2006	F06	Dec06	10	TORO	4	4	7
2006	F06	Dec06	11	TORO	4	10	8
2006	F06	Dec06	12	TORO	4	0	.
2007	S07	May07	1	ETM	1	21	8
2007	S07	May07	2	ETM	1	23	.
2007	S07	May07	3	ETM	1	29	6
2007	S07	May07	4	ETM	1	23	4
2007	S07	Jun07	5	ETM	1	21	.
2007	S07	Jun07	6	ETM	1	19	.
2007	S07	Jun07	7	ETM	1	17	7
2007	S07	Jun07	8	ETM	1	0	.
2007	S07	Jul07	9	ETM	1	17	6
2007	S07	Jul07	10	ETM	1	17	.
2007	S07	Jul07	11	ETM	1	8	.
2007	S07	Jul07	12	ETM	1	0	5
2007	S07	Jul07	13	ETM	1	17	.

2007	S07	Aug07	14	ETM	1	0	6
2007	S07	Aug07	15	ETM	1	35	.
2007	S07	Aug07	16	ETM	1	0	.
2007	S07	Aug07	17	ETM	1	4	6
2007	F07	Sep07	18	ETM	1	21	.
2007	F07	Sep07	19	ETM	1	23	.
2007	F07	Sep07	20	ETM	1	15	8
2007	F07	Sep07	21	ETM	1	0	.
2007	F07	Oct07	22	ETM	1	17	.
2007	F07	Oct07	23	ETM	1	0	.
2007	F07	Oct07	24	ETM	1	17	6
2007	F07	Oct07	25	ETM	1	15	.
2007	F07	Oct07	26	ETM	1	0	.
2007	F07	Nov07	27	ETM	1	15	.
2007	F07	Nov07	28	ETM	1	10	6
2007	F07	Nov07	29	ETM	1	21	.
2007	F07	Nov07	30	ETM	1	13	.
2007	S07	May07	1	ETM	2	21	5
2007	S07	May07	2	ETM	2	22	.
2007	S07	May07	3	ETM	2	29	3
2007	S07	May07	4	ETM	2	22	2
2007	S07	Jun07	5	ETM	2	21	.
2007	S07	Jun07	6	ETM	2	17	.
2007	S07	Jun07	7	ETM	2	17	3
2007	S07	Jun07	8	ETM	2	0	.
2007	S07	Jul07	9	ETM	2	17	3
2007	S07	Jul07	10	ETM	2	17	.
2007	S07	Jul07	11	ETM	2	10	.
2007	S07	Jul07	12	ETM	2	0	3
2007	S07	Jul07	13	ETM	2	16	.
2007	S07	Aug07	14	ETM	2	0	4
2007	S07	Aug07	15	ETM	2	35	.
2007	S07	Aug07	16	ETM	2	0	.
2007	S07	Aug07	17	ETM	2	5	3
2007	F07	Sep07	18	ETM	2	21	.
2007	F07	Sep07	19	ETM	2	22	.
2007	F07	Sep07	20	ETM	2	16	4
2007	F07	Sep07	21	ETM	2	0	.
2007	F07	Oct07	22	ETM	2	17	.
2007	F07	Oct07	23	ETM	2	0	.
2007	F07	Oct07	24	ETM	2	16	4
2007	F07	Oct07	25	ETM	2	15	.
2007	F07	Oct07	26	ETM	2	0	.
2007	F07	Nov07	27	ETM	2	15	.
2007	F07	Nov07	28	ETM	2	11	4
2007	F07	Nov07	29	ETM	2	21	.
2007	F07	Nov07	30	ETM	2	11	.
2007	S07	May07	1	ETM	3	22	6
2007	S07	May07	2	ETM	3	23	.
2007	S07	May07	3	ETM	3	45	4
2007	S07	May07	4	ETM	3	22	3
2007	S07	Jun07	5	ETM	3	21	.
2007	S07	Jun07	6	ETM	3	17	.
2007	S07	Jun07	7	ETM	3	16	4
2007	S07	Jun07	8	ETM	3	0	.
2007	S07	Jul07	9	ETM	3	19	4
2007	S07	Jul07	10	ETM	3	17	.

2007	S07	Jul07	11	ETM	3	11	.
2007	S07	Jul07	12	ETM	3	0	5
2007	S07	Jul07	13	ETM	3	16	.
2007	S07	Aug07	14	ETM	3	0	6
2007	S07	Aug07	15	ETM	3	35	.
2007	S07	Aug07	16	ETM	3	0	.
2007	S07	Aug07	17	ETM	3	5	5
2007	F07	Sep07	18	ETM	3	21	.
2007	F07	Sep07	19	ETM	3	22	.
2007	F07	Sep07	20	ETM	3	16	6
2007	F07	Sep07	21	ETM	3	0	.
2007	F07	Oct07	22	ETM	3	21	.
2007	F07	Oct07	23	ETM	3	0	.
2007	F07	Oct07	24	ETM	3	16	7
2007	F07	Oct07	25	ETM	3	15	.
2007	F07	Oct07	26	ETM	3	0	.
2007	F07	Nov07	27	ETM	3	15	.
2007	F07	Nov07	28	ETM	3	11	6
2007	F07	Nov07	29	ETM	3	21	.
2007	F07	Nov07	30	ETM	3	11	.
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2007	S07	May07	2	ETM	4	22	.
2007	S07	May07	3	ETM	4	29	4
2007	S07	May07	4	ETM	4	21	3
2007	S07	Jun07	5	ETM	4	22	.
2007	S07	Jun07	6	ETM	4	17	.
2007	S07	Jun07	7	ETM	4	17	3
2007	S07	Jun07	8	ETM	4	0	.
2007	S07	Jul07	9	ETM	4	17	4
2007	S07	Jul07	10	ETM	4	16	.
2007	S07	Jul07	11	ETM	4	10	.
2007	S07	Jul07	12	ETM	4	0	4
2007	S07	Jul07	13	ETM	4	16	.
2007	S07	Aug07	14	ETM	4	0	5
2007	S07	Aug07	15	ETM	4	35	.
2007	S07	Aug07	16	ETM	4	0	.
2007	S07	Aug07	17	ETM	4	5	4
2007	F07	Sep07	18	ETM	4	21	.
2007	F07	Sep07	19	ETM	4	21	.
2007	F07	Sep07	20	ETM	4	16	5
2007	F07	Sep07	21	ETM	4	0	.
2007	F07	Oct07	22	ETM	4	17	.
2007	F07	Oct07	23	ETM	4	0	.
2007	F07	Oct07	24	ETM	4	15	6
2007	F07	Oct07	25	ETM	4	15	.
2007	F07	Oct07	26	ETM	4	0	.
2007	F07	Nov07	27	ETM	4	15	.
2007	F07	Nov07	28	ETM	4	10	6
2007	F07	Nov07	29	ETM	4	21	.
2007	F07	Nov07	30	ETM	4	11	.
2007	S07	May07	1	TORO	1	53	5
2007	S07	May07	2	TORO	1	28	.
2007	S07	May07	3	TORO	1	39	5
2007	S07	May07	4	TORO	1	35	5
2007	S07	Jun07	5	TORO	1	15	.
2007	S07	Jun07	6	TORO	1	31	.
2007	S07	Jun07	7	TORO	1	29	4

2007	S07	Jun07	8	TORO	1	26	.
2007	S07	Jul07	9	TORO	1	23	5
2007	S07	Jul07	10	TORO	1	18	.
2007	S07	Jul07	11	TORO	1	34	.
2007	S07	Jul07	12	TORO	1	8	5
2007	S07	Jul07	13	TORO	1	38	.
2007	S07	Aug07	14	TORO	1	28	7
2007	S07	Aug07	15	TORO	1	28	.
2007	S07	Aug07	16	TORO	1	30	.
2007	S07	Aug07	17	TORO	1	27	7
2007	F07	Sep07	18	TORO	1	10	.
2007	F07	Sep07	19	TORO	1	30	.
2007	F07	Sep07	20	TORO	1	21	6
2007	F07	Sep07	21	TORO	1	8	.
2007	F07	Oct07	22	TORO	1	19	.
2007	F07	Oct07	23	TORO	1	0	.
2007	F07	Oct07	24	TORO	1	17	6
2007	F07	Oct07	25	TORO	1	14	.
2007	F07	Oct07	26	TORO	1	0	.
2007	F07	Nov07	27	TORO	1	9	.
2007	F07	Nov07	28	TORO	1	13	5
2007	F07	Nov07	29	TORO	1	4	.
2007	F07	Nov07	30	TORO	1	6	.
2007	S07	May07	1	TORO	2	52	4
2007	S07	May07	2	TORO	2	28	.
2007	S07	May07	3	TORO	2	39	4
2007	S07	May07	4	TORO	2	35	5
2007	S07	Jun07	5	TORO	2	15	.
2007	S07	Jun07	6	TORO	2	30	.
2007	S07	Jun07	7	TORO	2	30	4
2007	S07	Jun07	8	TORO	2	25	.
2007	S07	Jul07	9	TORO	2	24	5
2007	S07	Jul07	10	TORO	2	17	.
2007	S07	Jul07	11	TORO	2	35	.
2007	S07	Jul07	12	TORO	2	8	6
2007	S07	Jul07	13	TORO	2	38	.
2007	S07	Aug07	14	TORO	2	27	6
2007	S07	Aug07	15	TORO	2	28	.
2007	S07	Aug07	16	TORO	2	29	.
2007	S07	Aug07	17	TORO	2	28	7
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2007	F07	Sep07	21	TORO	2	8	.
2007	F07	Oct07	22	TORO	2	18	.
2007	F07	Oct07	23	TORO	2	0	.
2007	F07	Oct07	24	TORO	2	18	6
2007	F07	Oct07	25	TORO	2	14	.
2007	F07	Oct07	26	TORO	2	0	.
2007	F07	Nov07	27	TORO	2	9	.
2007	F07	Nov07	28	TORO	2	11	4
2007	F07	Nov07	29	TORO	2	5	.
2007	F07	Nov07	30	TORO	2	5	.
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2007	S07	May07	2	TORO	3	28	.
2007	S07	May07	3	TORO	3	42	6
2007	S07	May07	4	TORO	3	37	6

2007	S07	Jun07	5	TORO	3	16	.
2007	S07	Jun07	6	TORO	3	32	.
2007	S07	Jun07	7	TORO	3	30	6
2007	S07	Jun07	8	TORO	3	28	.
2007	S07	Jul07	9	TORO	3	25	6
2007	S07	Jul07	10	TORO	3	19	.
2007	S07	Jul07	11	TORO	3	30	.
2007	S07	Jul07	12	TORO	3	8	7
2007	S07	Jul07	13	TORO	3	42	.
2007	S07	Aug07	14	TORO	3	31	7
2007	S07	Aug07	15	TORO	3	31	.
2007	S07	Aug07	16	TORO	3	32	.
2007	S07	Aug07	17	TORO	3	30	8
2007	F07	Sep07	18	TORO	3	11	.
2007	F07	Sep07	19	TORO	3	32	.
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2007	F07	Sep07	21	TORO	3	9	.
2007	F07	Oct07	22	TORO	3	20	.
2007	F07	Oct07	23	TORO	3	0	.
2007	F07	Oct07	24	TORO	3	19	7
2007	F07	Oct07	25	TORO	3	15	.
2007	F07	Oct07	26	TORO	3	0	.
2007	F07	Nov07	27	TORO	3	11	.
2007	F07	Nov07	28	TORO	3	13	6
2007	F07	Nov07	29	TORO	3	5	.
2007	F07	Nov07	30	TORO	3	6	.
2007	S07	May07	1	TORO	4	52	6
2007	S07	May07	2	TORO	4	27	.
2007	S07	May07	3	TORO	4	39	7
2007	S07	May07	4	TORO	4	35	8
2007	S07	Jun07	5	TORO	4	14	.
2007	S07	Jun07	6	TORO	4	31	.
2007	S07	Jun07	7	TORO	4	29	8
2007	S07	Jun07	8	TORO	4	25	.
2007	S07	Jul07	9	TORO	4	23	8
2007	S07	Jul07	10	TORO	4	17	.
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2007	F07	Sep07	19	TORO	4	29	.
2007	F07	Sep07	20	TORO	4	20	8
2007	F07	Sep07	21	TORO	4	8	.
2007	F07	Oct07	22	TORO	4	18	.
2007	F07	Oct07	23	TORO	4	0	.
2007	F07	Oct07	24	TORO	4	17	8
2007	F07	Oct07	25	TORO	4	13	.
2007	F07	Oct07	26	TORO	4	0	.
2007	F07	Nov07	27	TORO	4	10	.
2007	F07	Nov07	28	TORO	4	11	8
2007	F07	Nov07	29	TORO	4	4	.
2007	F07	Nov07	30	TORO	4	6	.
2006	F06	Sep06	1	WOS	1	33	4

2006	F06	Oct06	2	WOS	1	33	4
2006	F06	Oct06	3	WOS	1	29	.
2006	F06	Oct06	4	WOS	1	29	4
2006	F06	Oct06	5	WOS	1	29	.
2006	F06	Nov06	6	WOS	1	13	.
2006	F06	Nov06	7	WOS	1	21	.
2006	F06	Nov06	8	WOS	1	23	4
2006	F06	Nov06	9	WOS	1	23	.
2006	F06	Dec06	10	WOS	1	21	3
2006	F06	Dec06	11	WOS	1	21	4
2006	F06	Dec06	12	WOS	1	21	.
2006	F06	Sep06	1	WOS	2	31	6
2006	F06	Oct06	2	WOS	2	33	7
2006	F06	Oct06	3	WOS	2	28	.
2006	F06	Oct06	4	WOS	2	28	7
2006	F06	Oct06	5	WOS	2	29	.
2006	F06	Nov06	6	WOS	2	10	.
2006	F06	Nov06	7	WOS	2	22	.
2006	F06	Nov06	8	WOS	2	21	6
2006	F06	Nov06	9	WOS	2	21	.
2006	F06	Dec06	10	WOS	2	20	5
2006	F06	Dec06	11	WOS	2	21	5
2006	F06	Dec06	12	WOS	2	21	.
2006	F06	Sep06	1	WOS	3	32	8
2006	F06	Oct06	2	WOS	3	32	8
2006	F06	Oct06	3	WOS	3	28	.
2006	F06	Oct06	4	WOS	3	28	8
2006	F06	Oct06	5	WOS	3	28	.
2006	F06	Nov06	6	WOS	3	10	.
2006	F06	Nov06	7	WOS	3	21	.
2006	F06	Nov06	8	WOS	3	20	8
2006	F06	Nov06	9	WOS	3	21	.
2006	F06	Dec06	10	WOS	3	21	8
2006	F06	Dec06	11	WOS	3	20	8
2006	F06	Dec06	12	WOS	3	21	.
2006	F06	Sep06	1	WOS	4	32	7
2006	F06	Oct06	2	WOS	4	33	6
2006	F06	Oct06	3	WOS	4	28	.
2006	F06	Oct06	4	WOS	4	28	7
2006	F06	Oct06	5	WOS	4	29	.
2006	F06	Nov06	6	WOS	4	9	.
2006	F06	Nov06	7	WOS	4	21	.
2006	F06	Nov06	8	WOS	4	21	7
2006	F06	Nov06	9	WOS	4	21	.
2006	F06	Dec06	10	WOS	4	20	6
2006	F06	Dec06	11	WOS	4	21	6
2006	F06	Dec06	12	WOS	4	21	.
2007	S07	May07	1	WOS	1	42	4
2007	S07	May07	2	WOS	1	44	.
2007	S07	May07	3	WOS	1	52	4
2007	S07	May07	4	WOS	1	44	5
2007	S07	Jun07	5	WOS	1	44	.
2007	S07	Jun07	6	WOS	1	38	.
2007	S07	Jun07	7	WOS	1	33	5
2007	S07	Jun07	8	WOS	1	19	.
2007	S07	Jul07	9	WOS	1	40	5
2007	S07	Jul07	10	WOS	1	52	.

2007	S07	Jul07	11	WOS	1	40	.
2007	S07	Jul07	12	WOS	1	33	6
2007	S07	Jul07	13	WOS	1	31	.
2007	S07	Aug07	14	WOS	1	42	6
2007	S07	Aug07	15	WOS	1	44	.
2007	S07	Aug07	16	WOS	1	42	.
2007	S07	Aug07	17	WOS	1	44	7
2007	F07	Sep07	18	WOS	1	42	.
2007	F07	Sep07	19	WOS	1	38	.
2007	F07	Sep07	20	WOS	1	33	6
2007	F07	Sep07	21	WOS	1	33	.
2007	F07	Oct07	22	WOS	1	31	.
2007	F07	Oct07	23	WOS	1	31	.
2007	F07	Oct07	24	WOS	1	31	5
2007	F07	Oct07	25	WOS	1	29	.
2007	F07	Oct07	26	WOS	1	29	.
2007	F07	Nov07	27	WOS	1	29	.
2007	F07	Nov07	28	WOS	1	25	4
2007	F07	Nov07	29	WOS	1	23	.
2007	F07	Nov07	30	WOS	1	21	.
2007	S07	May07	1	WOS	2	43	6
2007	S07	May07	2	WOS	2	46	.
2007	S07	May07	3	WOS	2	50	6
2007	S07	May07	4	WOS	2	43	7
2007	S07	Jun07	5	WOS	2	42	.
2007	S07	Jun07	6	WOS	2	39	.
2007	S07	Jun07	7	WOS	2	32	6
2007	S07	Jun07	8	WOS	2	18	.
2007	S07	Jul07	9	WOS	2	40	6
2007	S07	Jul07	10	WOS	2	55	.
2007	S07	Jul07	11	WOS	2	39	.
2007	S07	Jul07	12	WOS	2	32	7
2007	S07	Jul07	13	WOS	2	34	.
2007	S07	Aug07	14	WOS	2	41	7
2007	S07	Aug07	15	WOS	2	44	.
2007	S07	Aug07	16	WOS	2	44	.
2007	S07	Aug07	17	WOS	2	42	7
2007	F07	Sep07	18	WOS	2	41	.
2007	F07	Sep07	19	WOS	2	37	.
2007	F07	Sep07	20	WOS	2	33	7
2007	F07	Sep07	21	WOS	2	34	.
2007	F07	Oct07	22	WOS	2	31	.
2007	F07	Oct07	23	WOS	2	30	.
2007	F07	Oct07	24	WOS	2	29	6
2007	F07	Oct07	25	WOS	2	30	.
2007	F07	Oct07	26	WOS	2	31	.
2007	F07	Nov07	27	WOS	2	29	.
2007	F07	Nov07	28	WOS	2	25	5
2007	F07	Nov07	29	WOS	2	21	.
2007	F07	Nov07	30	WOS	2	21	.
2007	S07	May07	1	WOS	3	40	8
2007	S07	May07	2	WOS	3	37	.
2007	S07	May07	3	WOS	3	45	8
2007	S07	May07	4	WOS	3	38	8
2007	S07	Jun07	5	WOS	3	38	.
2007	S07	Jun07	6	WOS	3	34	.
2007	S07	Jun07	7	WOS	3	30	8

2007	S07	Jun07	8	WOS	3	15	.
2007	S07	Jul07	9	WOS	3	35	8
2007	S07	Jul07	10	WOS	3	47	.
2007	S07	Jul07	11	WOS	3	37	.
2007	S07	Jul07	12	WOS	3	29	7
2007	S07	Jul07	13	WOS	3	28	.
2007	S07	Aug07	14	WOS	3	39	8
2007	S07	Aug07	15	WOS	3	38	.
2007	S07	Aug07	16	WOS	3	38	.
2007	S07	Aug07	17	WOS	3	38	9
2007	F07	Sep07	18	WOS	3	38	.
2007	F07	Sep07	19	WOS	3	32	.
2007	F07	Sep07	20	WOS	3	28	8
2007	F07	Sep07	21	WOS	3	29	.
2007	F07	Oct07	22	WOS	3	31	.
2007	F07	Oct07	23	WOS	3	30	.
2007	F07	Oct07	24	WOS	3	28	8
2007	F07	Oct07	25	WOS	3	29	.
2007	F07	Oct07	26	WOS	3	28	.
2007	F07	Nov07	27	WOS	3	29	.
2007	F07	Nov07	28	WOS	3	25	8
2007	F07	Nov07	29	WOS	3	22	.
2007	F07	Nov07	30	WOS	3	21	.
2007	S07	May07	1	WOS	4	43	6
2007	S07	May07	2	WOS	4	42	.
2007	S07	May07	3	WOS	4	50	6
2007	S07	May07	4	WOS	4	43	6
2007	S07	Jun07	5	WOS	4	42	.
2007	S07	Jun07	6	WOS	4	38	.
2007	S07	Jun07	7	WOS	4	33	6
2007	S07	Jun07	8	WOS	4	16	.
2007	S07	Jul07	9	WOS	4	40	6
2007	S07	Jul07	10	WOS	4	51	.
2007	S07	Jul07	11	WOS	4	39	.
2007	S07	Jul07	12	WOS	4	32	7
2007	S07	Jul07	13	WOS	4	31	.
2007	S07	Aug07	14	WOS	4	41	7
2007	S07	Aug07	15	WOS	4	41	.
2007	S07	Aug07	16	WOS	4	42	.
2007	S07	Aug07	17	WOS	4	41	7
2007	F07	Sep07	18	WOS	4	41	.
2007	F07	Sep07	19	WOS	4	37	.
2007	F07	Sep07	20	WOS	4	31	7
2007	F07	Sep07	21	WOS	4	31	.
2007	F07	Oct07	22	WOS	4	31	.
2007	F07	Oct07	23	WOS	4	30	.
2007	F07	Oct07	24	WOS	4	28	6
2007	F07	Oct07	25	WOS	4	29	.
2007	F07	Oct07	26	WOS	4	28	.
2007	F07	Nov07	27	WOS	4	29	.
2007	F07	Nov07	28	WOS	4	26	6
2007	F07	Nov07	29	WOS	4	21	.
2007	F07	Nov07	30	WOS	4	21	.
2007	F07	Sep07	18	NON	1	.	.
2007	F07	Sep07	19	NON	1	.	.
2007	F07	Sep07	20	NON	1	.	5
2007	F07	Sep07	21	NON	1	.	.

```
2007  F07   Oct07 22    NON   1      .      .
2007  F07   Oct07 23    NON   1      .      .
2007  F07   Oct07 24    NON   1      .      4
2007  F07   Oct07 25    NON   1      .      .
2007  F07   Oct07 26    NON   1      .      .
2007  F07   Nov07 27    NON   1      .      .
2007  F07   Nov07 28    NON   1      .      3
2007  F07   Nov07 29    NON   1      .      .
2007  F07   Nov07 30    NON   1      .      .
2007  F07   Sep07 18    NON   2      .      .
2007  F07   Sep07 19    NON   2      .      .
2007  F07   Sep07 20    NON   2      .      5
2007  F07   Sep07 21    NON   2      .      .
2007  F07   Oct07 22    NON   2      .      .
2007  F07   Oct07 23    NON   2      .      .
2007  F07   Oct07 24    NON   2      .      6
2007  F07   Oct07 25    NON   2      .      .
2007  F07   Oct07 26    NON   2      .      .
2007  F07   Nov07 27    NON   2      .      .
2007  F07   Nov07 28    NON   2      .      5
2007  F07   Nov07 29    NON   2      .      .
2007  F07   Nov07 30    NON   2      .      .
2007  F07   Sep07 18    NON   3      .      .
2007  F07   Sep07 19    NON   3      .      .
2007  F07   Sep07 20    NON   3      .      6
2007  F07   Sep07 21    NON   3      .      .
2007  F07   Oct07 22    NON   3      .      .
2007  F07   Oct07 23    NON   3      .      .
2007  F07   Oct07 24    NON   3      .      7
2007  F07   Oct07 25    NON   3      .      .
2007  F07   Oct07 26    NON   3      .      .
2007  F07   Nov07 27    NON   3      .      .
2007  F07   Nov07 28    NON   3      .      6
2007  F07   Nov07 29    NON   3      .      .
2007  F07   Nov07 30    NON   3      .      .
2007  F07   Sep07 18    NON   4      .      .
2007  F07   Sep07 19    NON   4      .      .
2007  F07   Sep07 20    NON   4      .      3
2007  F07   Sep07 21    NON   4      .      .
2007  F07   Oct07 22    NON   4      .      .
2007  F07   Oct07 23    NON   4      .      .
2007  F07   Oct07 24    NON   4      .      5
2007  F07   Oct07 25    NON   4      .      .
2007  F07   Oct07 26    NON   4      .      .
2007  F07   Nov07 27    NON   4      .      .
2007  F07   Nov07 28    NON   4      .      5
2007  F07   Nov07 29    NON   4      .      .
2007  F07   Nov07 30    NON   4      .      .
run;
proc sort;
      by season;
      run;
proc glm; by season;
      title 'Turf Quality';
      class tmt rep week;
      model TQ = tmt rep week/ss3;
      means tmt/duncan;
```

```
      run;
proc mixed; by season;
      title 'Turf Quality';
      class tmt rep week ;
      model TQ = tmt; random week rep;
      lsmeans tmt/pdiff;
      run;
proc glm; by season;
      title 'Water Applied';
      class tmt rep week;
      model mm = tmt rep week/ss3;
      means tmt/duncan;
      run;
proc mixed; by season;
      title 'Water Applied';
      class tmt rep week ;
      model mm = tmt; random week rep;
      lsmeans tmt/pdiff;
      run;
```

Individually Controlled Acclima Treatment Water Applied and Turf Quality

```
options nodate nonumber center formdlim="*" linesize=88;
data ACIR;
input year$ season$ month$ week$ tmt$ rep mm type$ TQ;
cards;

2006  S06   Apr06 1     ACIR  1     14    SMS   .
2006  S06   May06 2     ACIR  1     27    SMS   .
2006  S06   May06 3     ACIR  1     27    SMS   7
2006  S06   May06 4     ACIR  1     38    SMS   7
2006  S06   May06 5     ACIR  1     27    SMS   6
2006  S06   June06      6     ACIR  1     34    SMS   .
2006  S06   June06      7     ACIR  1     17    SMS   5
2006  S06   June06      8     ACIR  1     17    SMS   .
2006  S06   June06      9     ACIR  1     17    SMS   5
2006  S06   June06      10    ACIR  1     16    SMS   .
2006  S06   Apr06 1     ACIR  2     14    SMS   .
2006  S06   May06 2     ACIR  2     27    SMS   .
2006  S06   May06 3     ACIR  2     28    SMS   4
2006  S06   May06 4     ACIR  2     41    SMS   5
2006  S06   May06 5     ACIR  2     27    SMS   4
2006  S06   June06      6     ACIR  2     17    SMS   .
2006  S06   June06      7     ACIR  2     18    SMS   3
2006  S06   June06      8     ACIR  2     17    SMS   .
2006  S06   June06      9     ACIR  2     17    SMS   3
2006  S06   June06      10    ACIR  2     17    SMS   .
2006  S06   Apr06 1     ACIR  3     0     SMS   .
2006  S06   May06 2     ACIR  3     35    SMS   .
2006  S06   May06 3     ACIR  3     24    SMS   6
2006  S06   May06 4     ACIR  3     30    SMS   7
2006  S06   May06 5     ACIR  3     23    SMS   5
2006  S06   June06      6     ACIR  3     17    SMS   .
2006  S06   June06      7     ACIR  3     34    SMS   7
2006  S06   June06      8     ACIR  3     17    SMS   .
2006  S06   June06      9     ACIR  3     17    SMS   7
2006  S06   June06      10    ACIR  3     0     SMS   .
2006  S06   Apr06 1     ACIR  4     0     SMS   .
2006  S06   May06 2     ACIR  4     19    SMS   .
2006  S06   May06 3     ACIR  4     24    SMS   7
2006  S06   May06 4     ACIR  4     18    SMS   6
2006  S06   May06 5     ACIR  4     27    SMS   6
2006  S06   June06      6     ACIR  4     33    SMS   .
2006  S06   June06      7     ACIR  4     8     SMS   7
2006  S06   June06      8     ACIR  4     17    SMS   .
2006  S06   June06      9     ACIR  4     17    SMS   7
2006  S06   June06      10    ACIR  4     0     SMS   .
2006  F06   Sep06 1     ACIR  1     17    SMS   8
2006  F06   Oct06 2     ACIR  1     17    SMS   7
2006  F06   Oct06 3     ACIR  1     15    SMS   .
2006  F06   Oct06 4     ACIR  1     15    SMS   7
2006  F06   Oct06 5     ACIR  1     29    SMS   .
2006  F06   Nov06 6     ACIR  1     10    SMS   .
2006  F06   Nov06 7     ACIR  1     0     SMS   .
2006  F06   Nov06 8     ACIR  1     0     SMS   7
2006  F06   Nov06 9     ACIR  1     0     SMS   .
2006  F06   Dec06 10    ACIR  1     10    SMS   6
2006  F06   Dec06 11    ACIR  1     0     SMS   7
```

2006	F06	Dec06	12	ACIR	1	11	SMS	.
2006	F06	Sep06	1	ACIR	2	34	SMS	5
2006	F06	Oct06	2	ACIR	2	33	SMS	5
2006	F06	Oct06	3	ACIR	2	29	SMS	.
2006	F06	Oct06	4	ACIR	2	29	SMS	5
2006	F06	Oct06	5	ACIR	2	29	SMS	.
2006	F06	Nov06	6	ACIR	2	10	SMS	.
2006	F06	Nov06	7	ACIR	2	10	SMS	.
2006	F06	Nov06	8	ACIR	2	10	SMS	5
2006	F06	Nov06	9	ACIR	2	10	SMS	.
2006	F06	Dec06	10	ACIR	2	0	SMS	4
2006	F06	Dec06	11	ACIR	2	10	SMS	5
2006	F06	Dec06	12	ACIR	2	10	SMS	.
2006	F06	Sep06	1	ACIR	3	17	SMS	7
2006	F06	Oct06	2	ACIR	3	17	SMS	6
2006	F06	Oct06	3	ACIR	3	15	SMS	.
2006	F06	Oct06	4	ACIR	3	15	SMS	7
2006	F06	Oct06	5	ACIR	3	15	SMS	.
2006	F06	Nov06	6	ACIR	3	0	SMS	.
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2006	F06	Nov06	8	ACIR	3	0	SMS	8
2006	F06	Nov06	9	ACIR	3	0	SMS	.
2006	F06	Dec06	10	ACIR	3	10	SMS	7
2006	F06	Dec06	11	ACIR	3	0	SMS	8
2006	F06	Dec06	12	ACIR	3	10	SMS	.
2006	F06	Sep06	1	ACIR	4	0	SMS	8
2006	F06	Oct06	2	ACIR	4	16	SMS	7
2006	F06	Oct06	3	ACIR	4	15	SMS	.
2006	F06	Oct06	4	ACIR	4	13	SMS	7
2006	F06	Oct06	5	ACIR	4	22	SMS	.
2006	F06	Nov06	6	ACIR	4	0	SMS	.
2006	F06	Nov06	7	ACIR	4	0	SMS	.
2006	F06	Nov06	8	ACIR	4	0	SMS	8
2006	F06	Nov06	9	ACIR	4	0	SMS	.
2006	F06	Dec06	10	ACIR	4	0	SMS	7
2006	F06	Dec06	11	ACIR	4	0	SMS	7
2006	F06	Dec06	12	ACIR	4	10	SMS	.
2007	S07	May07	1	ACIR	1	42	SMS	6
2007	S07	May07	2	ACIR	1	22	SMS	.
2007	S07	May07	3	ACIR	1	50	SMS	6
2007	S07	May07	4	ACIR	1	21	SMS	6
2007	S07	Jun07	5	ACIR	1	21	SMS	.
2007	S07	Jun07	6	ACIR	1	39	SMS	.
2007	S07	Jun07	7	ACIR	1	16	SMS	5
2007	S07	Jun07	8	ACIR	1	0	SMS	.
2007	S07	Jul07	9	ACIR	1	17	SMS	6
2007	S07	Jul07	10	ACIR	1	16	SMS	.
2007	S07	Jul07	11	ACIR	1	3	SMS	.
2007	S07	Jul07	12	ACIR	1	16	SMS	6
2007	S07	Jul07	13	ACIR	1	16	SMS	.
2007	S07	Aug07	14	ACIR	1	20	SMS	7
2007	S07	Aug07	15	ACIR	1	20	SMS	.
2007	S07	Aug07	16	ACIR	1	21	SMS	.
2007	S07	Aug07	17	ACIR	1	0	SMS	7
2007	F07	Sep07	18	ACIR	1	20	SMS	.
2007	F07	Sep07	19	ACIR	1	16	SMS	.
2007	F07	Sep07	20	ACIR	1	15	SMS	6

2007	F07	Sep07	21	ACIR	1	0	SMS	.
2007	F07	Oct07	22	ACIR	1	16	SMS	.
2007	F07	Oct07	23	ACIR	1	0	SMS	.
2007	F07	Oct07	24	ACIR	1	14	SMS	6
2007	F07	Oct07	25	ACIR	1	0	SMS	.
2007	F07	Oct07	26	ACIR	1	0	SMS	.
2007	F07	Nov07	27	ACIR	1	0	SMS	.
2007	F07	Nov07	28	ACIR	1	10	SMS	5
2007	F07	Nov07	29	ACIR	1	0	SMS	.
2007	F07	Nov07	30	ACIR	1	0	SMS	.
2007	S07	May07	1	ACIR	2	44	SMS	4
2007	S07	May07	2	ACIR	2	22	SMS	.
2007	S07	May07	3	ACIR	2	29	SMS	4
2007	S07	May07	4	ACIR	2	43	SMS	4
2007	S07	Jun07	5	ACIR	2	44	SMS	.
2007	S07	Jun07	6	ACIR	2	39	SMS	.
2007	S07	Jun07	7	ACIR	2	17	SMS	4
2007	S07	Jun07	8	ACIR	2	0	SMS	.
2007	S07	Jul07	9	ACIR	2	17	SMS	4
2007	S07	Jul07	10	ACIR	2	17	SMS	.
2007	S07	Jul07	11	ACIR	2	8	SMS	.
2007	S07	Jul07	12	ACIR	2	17	SMS	4
2007	S07	Jul07	13	ACIR	2	16	SMS	.
2007	S07	Aug07	14	ACIR	2	21	SMS	6
2007	S07	Aug07	15	ACIR	2	43	SMS	.
2007	S07	Aug07	16	ACIR	2	42	SMS	.
2007	S07	Aug07	17	ACIR	2	22	SMS	7
2007	F07	Sep07	18	ACIR	2	21	SMS	.
2007	F07	Sep07	19	ACIR	2	37	SMS	.
2007	F07	Sep07	20	ACIR	2	17	SMS	6
2007	F07	Sep07	21	ACIR	2	0	SMS	.
2007	F07	Oct07	22	ACIR	2	16	SMS	.
2007	F07	Oct07	23	ACIR	2	0	SMS	.
2007	F07	Oct07	24	ACIR	2	15	SMS	6
2007	F07	Oct07	25	ACIR	2	16	SMS	.
2007	F07	Oct07	26	ACIR	2	0	SMS	.
2007	F07	Nov07	27	ACIR	2	15	SMS	.
2007	F07	Nov07	28	ACIR	2	10	SMS	4
2007	F07	Nov07	29	ACIR	2	10	SMS	.
2007	F07	Nov07	30	ACIR	2	0	SMS	.
2007	S07	May07	1	ACIR	3	22	SMS	6
2007	S07	May07	2	ACIR	3	22	SMS	.
2007	S07	May07	3	ACIR	3	28	SMS	4
2007	S07	May07	4	ACIR	3	44	SMS	6
2007	S07	Jun07	5	ACIR	3	21	SMS	.
2007	S07	Jun07	6	ACIR	3	39	SMS	.
2007	S07	Jun07	7	ACIR	3	17	SMS	6
2007	S07	Jun07	8	ACIR	3	0	SMS	.
2007	S07	Jul07	9	ACIR	3	17	SMS	6
2007	S07	Jul07	10	ACIR	3	16	SMS	.
2007	S07	Jul07	11	ACIR	3	3	SMS	.
2007	S07	Jul07	12	ACIR	3	16	SMS	6
2007	S07	Jul07	13	ACIR	3	17	SMS	.
2007	S07	Aug07	14	ACIR	3	0	SMS	7
2007	S07	Aug07	15	ACIR	3	41	SMS	.
2007	S07	Aug07	16	ACIR	3	21	SMS	.
2007	S07	Aug07	17	ACIR	3	21	SMS	7

```
2007  F07   Sep07 18    ACIR  3     0     SMS   .
2007  F07   Sep07 19    ACIR  3     17    SMS   .
2007  F07   Sep07 20    ACIR  3     0     SMS   6
2007  F07   Sep07 21    ACIR  3     0     SMS   .
2007  F07   Oct07 22    ACIR  3     16    SMS   .
2007  F07   Oct07 23    ACIR  3     0     SMS   .
2007  F07   Oct07 24    ACIR  3     15    SMS   7
2007  F07   Oct07 25    ACIR  3     0     SMS   .
2007  F07   Oct07 26    ACIR  3     0     SMS   .
2007  F07   Nov07 27    ACIR  3     0     SMS   .
2007  F07   Nov07 28    ACIR  3     15    SMS   7
2007  F07   Nov07 29    ACIR  3     11    SMS   .
2007  F07   Nov07 30    ACIR  3     0     SMS   .
2007  S07   May07 1     ACIR  4     11    SMS   6
2007  S07   May07 2     ACIR  4     33    SMS   .
2007  S07   May07 3     ACIR  4     29    SMS   6
2007  S07   May07 4     ACIR  4     21    SMS   6
2007  S07   Jun07 5     ACIR  4     22    SMS   .
2007  S07   Jun07 6     ACIR  4     39    SMS   .
2007  S07   Jun07 7     ACIR  4     17    SMS   6
2007  S07   Jun07 8     ACIR  4     0     SMS   .
2007  S07   Jul07 9     ACIR  4     17    SMS   6
2007  S07   Jul07 10    ACIR  4     17    SMS   .
2007  S07   Jul07 11    ACIR  4     30    SMS   .
2007  S07   Jul07 12    ACIR  4     17    SMS   6
2007  S07   Jul07 13    ACIR  4     0     SMS   .
2007  S07   Aug07 14    ACIR  4     0     SMS   6
2007  S07   Aug07 15    ACIR  4     41    SMS   .
2007  S07   Aug07 16    ACIR  4     21    SMS   .
2007  S07   Aug07 17    ACIR  4     20    SMS   7
2007  F07   Sep07 18    ACIR  4     21    SMS   .
2007  F07   Sep07 19    ACIR  4     16    SMS   .
2007  F07   Sep07 20    ACIR  4     17    SMS   7
2007  F07   Sep07 21    ACIR  4     0     SMS   .
2007  F07   Oct07 22    ACIR  4     16    SMS   .
2007  F07   Oct07 23    ACIR  4     0     SMS   .
2007  F07   Oct07 24    ACIR  4     14    SMS   7
2007  F07   Oct07 25    ACIR  4     0     SMS   .
2007  F07   Oct07 26    ACIR  4     0     SMS   .
2007  F07   Nov07 27    ACIR  4     0     SMS   .
2007  F07   Nov07 28    ACIR  4     10    SMS   7
2007  F07   Nov07 29    ACIR  4     21    SMS   .
2007  F07   Nov07 30    ACIR  4     0     SMS   .
run;
proc sort;
      by season;
      run;
proc glm; by season;
      title 'Turf Quality';
      class  rep week;
      model TQ =  rep week/ss3;
      means rep/duncan;
      run;
      quit;
proc mixed; by season;
      title 'Turf Quality';
      class  rep week ;
```

```
      model TQ = rep; random week;
      lsmeans rep/pdiff;
      run;
proc glm; by season;
      title 'Water Applied';
      class  rep week;
      model mm =  rep week/ss3;
      means rep/duncan;
      run;
proc mixed; by season;
      title 'Water Applied';
      class  rep week;
      model mm = rep; random week;
      lsmeans rep/pdiff;
      run;
```

APPENDIX B
CHAPTER 3 STATISTICAL ANALYSIS

Soil Moisture Sensor Range

```
options nodate nonumber center formdlim="*" linesize=88;
data sensor range;
input tmt$ type$ rep$ season$ range;
cards;
AC10  AC    2     S06   0.4   11.7  11.3
AC7.1 AC    4     S06   0.0   7.1   7.2
AC7.2 AC    5     S06   1.9   7.3   5.4
AC7.3 AC    6     S06   1.5   6.9   5.4
AC7.4 AC    7     S06   1.0   7.7   6.700
LLMed LL    2     S06   2.9   9.50  6.60
AC10  AC    2     F06   0.0   11.3  11.5
AC7.1 AC    4     F06   0.1   6.4   6.3
AC7.2 AC    5     F06   0.0   6.8   7.5
AC7.3 AC    6     F06   0.5   7.3   6.8
AC7.4 AC    7     F06   0.7   7.1   6.4
LLMed LL    2     F06   2.0   10.0  8.0
AC10  AC    2     S07   0.9   11.4  10.5
AC7.1 AC    4     S07   0.1   6.4   6.3
AC7.2 AC    5     S07   0.5   6.0   5.5
AC7.3 AC    6     S07   1.5   6.5   5.0
AC7.4 AC    7     S07   1.3   7.5   6.2
LLMed LL    2     S07   4.4   11.1  6.7
AC10  AC    2     F07   0.1   11.0  10.9
AC7.1 AC    4     F07   0.0   5.8   5.9
AC7.2 AC    5     F07   0.0   5.5   5.9
AC7.3 AC    6     F07   1.5   6.3   4.8
AC7.4 AC    7     F07   0.1   6.8   6.7
LLMed LL    2     F07   1.7   10.0  8.3
run;
proc glm;
      title 'Sensor Range';
      class tmt season;
      model range = tmt season/ss3;
      means tmt/duncan;
      run;
```

ACIR Irrigation Events

```
options nodate nonumber center formdlim="*" linesize=88;
data ACIR Max Min;
     input tmt$ type$ rep$ season$ range maxI minB;
     cards;
AC7.1 AC    4     S06   0.0   7.1   7.2
AC7.2 AC    5     S06   1.9   7.3   5.4
AC7.3 AC    6     S06   1.5   6.9   5.4
AC7.4 AC    7     S06   1.0   7.7   6.7
AC7.1 AC    4     F06   0.1   6.4   6.3
AC7.2 AC    5     F06   0.0   6.8   7.5
AC7.3 AC    6     F06   0.5   7.3   6.8
AC7.4 AC    7     F06   0.7   7.1   6.4
AC7.1 AC    4     S07   0.1   6.4   6.3
AC7.2 AC    5     S07   0.5   6.0   5.5
AC7.3 AC    6     S07   1.5   6.5   5.0
AC7.4 AC    7     S07   1.3   7.5   6.2
AC7.1 AC    4     F07   0.0   5.8   5.9
AC7.2 AC    5     F07   0.0   5.5   5.9
AC7.3 AC    6     F07   1.5   6.3   4.8
AC7.4 AC    7     F07   0.1   6.8   6.7
run;

proc glm;
      title 'Max Allowed';
      class tmt season;
      model maxI = tmt season/ss3;
      means tmt/duncan;
      run;
proc mixed;
      title 'Max Allowed';
      class season rep tmt ;
      model maxI = tmt; random season rep;
      lsmeans tmt/pdiff;
      run;
proc glm;
      title 'Min Bypassed';
      class tmt season;
      model minB = tmt season/ss3;
      means tmt/duncan;
      run;
 proc mixed;
      title 'Min Bypassed';
      class season rep tmt ;
      model minB = tmt; random season rep;
      lsmeans tmt/pdiff;
      run;
```

APPENDIX C
CHAPTER 4 STATISTICAL ANALYSIS

Manual ET Data Comparisons

```
options nodate nonumber center formdlim="*" linesize = 88;
data ET manual;
input date$ ET type$;
cards;
9/28/2006   4.32  ETM
9/29/2006   3.81  ETM
10/2/2006   3.81  ETM
10/4/2006   4.83  ETM
10/5/2006   5.33  ETM
10/9/2006   3.81  ETM
10/11/2006  4.32  ETM
10/13/2006  2.79  ETM
10/16/2006  4.06  ETM
10/18/2006  2.79  ETM
10/20/2006  2.03  ETM
10/23/2006  3.56  ETM
10/25/2006  3.56  ETM
10/27/2006  2.79  ETM
10/30/2006  3.30  ETM
11/1/2006   3.05  ETM
11/3/2006   2.54  ETM
11/6/2006   2.79  ETM
11/8/2006   1.27  ETM
11/10/2006  2.54  ETM
11/13/2006  3.05  ETM
11/15/2006  1.78  ETM
11/17/2006  2.29  ETM
11/20/2006  2.79  ETM
11/22/2006  2.29  ETM
11/27/2006  2.54  ETM
12/1/2006   1.78  ETM
12/4/2006   2.03  ETM
12/6/2006   2.54  ETM
12/8/2006   2.03  ETM
12/11/2006  2.03  ETM
12/13/2006  1.78  ETM
12/15/2006  1.02  ETM
12/18/2006  2.03  ETM
12/19/2006  2.03  ETM
12/20/2006  2.54  ETM
12/22/2006  1.78  ETM
12/27/2006  2.03  ETM
1/8/2007    2.03  ETM
1/10/2007   2.54  ETM
1/17/2007   2.29  ETM
1/18/2007   1.52  ETM
1/23/2007   2.03  ETM
1/24/2007   2.54  ETM
1/26/2007   1.52  ETM
1/29/2007   2.03  ETM
1/31/2007   1.78  ETM
```

2/2/2007	2.03	ETM
2/8/2007	3.05	ETM
2/13/2007	2.03	ETM
2/15/2007	0.76	ETM
2/16/2007	2.03	ETM
2/20/2007	2.79	ETM
2/21/2007	2.54	ETM
2/26/2007	2.29	ETM
2/28/2007	3.30	ETM
3/7/2007	3.05	ETM
3/14/2007	4.06	ETM
3/16/2007	2.79	ETM
3/21/2007	2.54	ETM
3/23/2007	3.81	ETM
3/28/2007	3.56	ETM
4/4/2007	3.81	ETM
4/6/2007	3.56	ETM
4/9/2007	3.56	ETM
4/12/2007	3.81	ETM
4/17/2007	4.32	ETM
4/24/2007	4.83	ETM
4/25/2007	5.59	ETM
5/2/2007	4.32	ETM
5/7/2007	4.32	ETM
5/14/2007	2.54	ETM
5/20/2007	6.35	ETM
5/21/2007	5.84	ETM
5/22/2007	6.35	ETM
5/23/2007	6.10	ETM
5/24/2007	5.59	ETM
5/25/2007	4.83	ETM
5/27/2007	5.84	ETM
5/28/2007	5.84	ETM
5/29/2007	6.10	ETM
6/6/2007	4.83	ETM
6/13/2007	4.06	ETM
6/15/2007	6.10	ETM
6/22/2007	9.14	ETM
6/25/2007	6.86	ETM
6/27/2007	5.08	ETM
6/29/2007	4.57	ETM
7/9/2007	6.35	ETM
7/10/2007	5.84	ETM
7/12/2007	5.33	ETM
7/18/2007	4.57	ETM
7/19/2007	4.57	ETM
7/24/2007	2.03	ETM
7/25/2007	4.06	ETM
7/27/2007	4.32	ETM
8/1/2007	2.29	ETM
8/3/2007	2.79	ETM
8/6/2007	5.84	ETM
8/10/2007	4.57	ETM
8/16/2007	2.79	ETM
8/21/2007	5.33	ETM
8/22/2007	5.08	ETM
8/24/2007	5.33	ETM

8/28/2007	5.08	ETM
9/5/2007	5.08	ETM
9/7/2007	5.33	ETM
9/14/2007	3.81	ETM
9/17/2007	4.32	ETM
9/19/2007	2.79	ETM
9/25/2007	4.06	ETM
9/27/2007	3.81	ETM
10/5/2007	3.05	ETM
10/9/2007	3.81	ETM
10/11/2007	4.06	ETM
10/16/2007	3.81	ETM
10/19/2007	3.81	ETM
10/23/2007	3.30	ETM
10/25/2007	0.76	ETM
11/1/2007	2.54	ETM
11/5/2007	3.30	ETM
11/9/2007	2.79	ETM
11/14/2007	2.54	ETM
11/16/2007	3.05	ETM
11/21/2007	2.79	ETM
11/26/2007	2.29	ETM
11/30/2007	1.02	ETM
9/28/2006	3.56	TORO
9/29/2006	3.56	TORO
10/2/2006	3.56	TORO
10/4/2006	3.30	TORO
10/5/2006	3.56	TORO
10/9/2006	3.05	TORO
10/11/2006	2.79	TORO
10/13/2006	3.05	TORO
10/16/2006	2.79	TORO
10/18/2006	2.79	TORO
10/20/2006	2.79	TORO
10/23/2006	3.81	TORO
10/25/2006	3.81	TORO
10/27/2006	3.05	TORO
10/30/2006	3.30	TORO
11/1/2006	3.81	TORO
11/3/2006	3.56	TORO
11/6/2006	3.56	TORO
11/8/2006	3.30	TORO
11/10/2006	3.30	TORO
11/13/2006	1.27	TORO
11/15/2006	1.27	TORO
11/17/2006	1.27	TORO
11/20/2006	2.54	TORO
11/22/2006	2.79	TORO
11/27/2006	3.05	TORO
12/1/2006	3.05	TORO
12/4/2006	3.05	TORO
12/6/2006	2.79	TORO
12/8/2006	1.02	TORO
12/11/2006	1.02	TORO
12/13/2006	1.27	TORO
12/15/2006	1.78	TORO
12/18/2006	2.03	TORO

12/19/2006	2.29	TORO
12/20/2006	2.29	TORO
12/22/2006	1.78	TORO
12/27/2006	0.76	TORO
1/8/2007	2.79	TORO
1/10/2007	2.79	TORO
1/17/2007	2.79	TORO
1/18/2007	2.03	TORO
1/23/2007	2.54	TORO
1/24/2007	2.54	TORO
1/26/2007	2.03	TORO
1/29/2007	2.79	TORO
1/31/2007	1.27	TORO
2/2/2007	2.79	TORO
2/8/2007	3.30	TORO
2/13/2007	2.54	TORO
2/15/2007	1.52	TORO
2/16/2007	1.52	TORO
2/20/2007	2.54	TORO
2/21/2007	3.56	TORO
2/26/2007	3.81	TORO
2/28/2007	3.30	TORO
3/7/2007	4.06	TORO
3/14/2007	4.83	TORO
3/16/2007	4.57	TORO
3/21/2007	4.57	TORO
3/23/2007	5.33	TORO
3/28/2007	5.08	TORO
4/4/2007	5.84	TORO
4/6/2007	4.32	TORO
4/9/2007	5.33	TORO
4/12/2007	1.52	TORO
4/17/2007	6.60	TORO
4/24/2007	6.60	TORO
4/25/2007	6.60	TORO
5/2/2007	7.37	TORO
5/7/2007	6.35	TORO
5/14/2007	6.10	TORO
5/20/2007	6.35	TORO
5/21/2007	6.10	TORO
5/22/2007	6.35	TORO
5/23/2007	6.60	TORO
5/24/2007	7.11	TORO
5/25/2007	7.11	TORO
5/27/2007	6.35	TORO
5/28/2007	6.60	TORO
5/29/2007	6.60	TORO
6/6/2007	5.33	TORO
6/13/2007	6.35	TORO
6/15/2007	6.60	TORO
6/22/2007	6.35	TORO
6/25/2007	6.35	TORO
6/27/2007	6.86	TORO
6/29/2007	7.37	TORO
7/9/2007	5.08	TORO
7/10/2007	7.11	TORO
7/12/2007	7.11	TORO

7/18/2007	5.84	TORO
7/19/2007	5.84	TORO
7/24/2007	6.10	TORO
7/25/2007	4.57	TORO
7/27/2007	6.60	TORO
8/1/2007	4.06	TORO
8/3/2007	2.29	TORO
8/6/2007	6.60	TORO
8/10/2007	5.84	TORO
8/16/2007	6.86	TORO
8/21/2007	5.84	TORO
8/22/2007	6.60	TORO
8/24/2007	6.60	TORO
8/28/2007	4.32	TORO
9/5/2007	6.10	TORO
9/7/2007	6.10	TORO
9/14/2007	5.08	TORO
9/17/2007	5.33	TORO
9/19/2007	5.08	TORO
9/25/2007	5.33	TORO
9/27/2007	4.57	TORO
10/5/2007	4.06	TORO
10/9/2007	4.06	TORO
10/11/2007	4.57	TORO
10/16/2007	4.06	TORO
10/19/2007	3.81	TORO
10/23/2007	2.29	TORO
10/25/2007	3.81	TORO
11/1/2007	4.06	TORO
11/5/2007	3.56	TORO
11/9/2007	2.79	TORO
11/14/2007	2.79	TORO
11/16/2007	2.79	TORO
11/21/2007	2.54	TORO
11/26/2007	1.27	TORO
11/30/2007	1.52	TORO
9/28/2006	3.75	WS
9/29/2006	3.90	WS
10/2/2006	3.60	WS
10/4/2006	4.12	WS
10/5/2006	3.76	WS
10/9/2006	3.48	WS
10/11/2006	3.97	WS
10/13/2006	3.14	WS
10/16/2006	2.69	WS
10/18/2006	3.56	WS
10/20/2006	3.72	WS
10/23/2006	3.56	WS
10/25/2006	3.23	WS
10/27/2006	3.12	WS
10/30/2006	2.90	WS
11/1/2006	3.00	WS
11/3/2006	2.90	WS
11/6/2006	2.40	WS
11/8/2006	3.18	WS
11/10/2006	2.20	WS
11/13/2006	2.37	WS

11/15/2006	3.11	WS
11/17/2006	2.06	WS
11/20/2006	2.35	WS
11/22/2006	1.95	WS
11/27/2006	1.91	WS
12/1/2006	1.95	WS
12/4/2006	2.68	WS
12/6/2006	1.80	WS
12/8/2006	2.40	WS
12/11/2006	1.99	WS
12/13/2006	1.56	WS
12/15/2006	1.23	WS
12/18/2006	1.94	WS
12/19/2006	2.05	WS
12/20/2006	1.69	WS
12/22/2006	1.68	WS
12/27/2006	1.90	WS
1/8/2007	1.36	WS
1/10/2007	1.34	WS
1/17/2007	1.35	WS
1/18/2007	1.35	WS
1/23/2007	2.33	WS
1/24/2007	1.78	WS
1/26/2007	1.89	WS
1/29/2007	2.16	WS
1/31/2007	2.79	WS
2/2/2007	1.25	WS
2/8/2007	1.40	WS
2/13/2007	1.79	WS
2/15/2007	2.05	WS
2/16/2007	1.50	WS
2/20/2007	1.85	WS
2/21/2007	2.92	WS
2/26/2007	3.31	WS
2/28/2007	3.50	WS
3/7/2007	3.69	WS
3/14/2007	4.14	WS
3/16/2007	3.52	WS
3/21/2007	3.44	WS
3/23/2007	3.94	WS
3/28/2007	4.08	WS
4/4/2007	4.87	WS
4/6/2007	5.34	WS
4/9/2007	1.55	WS
4/12/2007	5.24	WS
4/17/2007	6.46	WS
4/24/2007	4.98	WS
4/25/2007	4.62	WS
5/2/2007	5.04	WS
5/7/2007	5.91	WS
5/14/2007	4.62	WS
5/20/2007	5.41	WS
5/21/2007	5.19	WS
5/22/2007	5.57	WS
5/23/2007	5.66	WS
5/24/2007	5.66	WS
5/25/2007	4.66	WS

```
5/27/2007   5.06  WS
5/28/2007   5.03  WS
5/29/2007   5.47  WS
6/6/2007    5.27  WS
6/13/2007   5.00  WS
6/15/2007   5.79  WS
6/22/2007   5.72  WS
6/25/2007   3.95  WS
6/27/2007   5.67  WS
6/29/2007   4.57  WS
7/9/2007    6.53  WS
7/10/2007   5.19  WS
7/12/2007   4.57  WS
7/18/2007   5.52  WS
7/19/2007   5.46  WS
7/24/2007   3.44  WS
7/25/2007   4.23  WS
7/27/2007   3.66  WS
8/1/2007    2.55  WS
8/3/2007    4.57  WS
8/6/2007    5.55  WS
8/10/2007   5.54  WS
8/16/2007   4.68  WS
8/21/2007   4.79  WS
8/22/2007   5.43  WS
8/24/2007   3.56  WS
8/28/2007   5.24  WS
9/5/2007    3.79  WS
9/7/2007    5.20  WS
9/14/2007   4.24  WS
9/17/2007   2.81  WS
9/19/2007   1.21  WS
9/25/2007   3.95  WS
9/27/2007   4.15  WS
10/5/2007   2.33  WS
10/9/2007   3.59  WS
10/11/2007  3.69  WS
10/16/2007  2.89  WS
10/19/2007  3.22  WS
10/23/2007  3.34  WS
10/25/2007  2.49  WS
11/1/2007   2.84  WS
11/5/2007   2.72  WS
11/9/2007   2.63  WS
11/14/2007  2.17  WS
11/16/2007  2.42  WS
11/21/2007  2.39  WS
11/26/2007  2.30  WS
11/30/2007  2.20  WS
run;
proc glm;
      title 'Manual ET Comparison';
      class date type;
      model ET = date type;
      means type/Duncan;
      run;
proc mixed;
```

```
class  type;
model ET =  type;
lsmeans type/pdiff;
run;
```

Manufacturer ET Data Comparisons

```
options nodate nonumber center formdlim="*" linesize = 88;
data ET Manufacturer;
input date$ ET type$;
cards;
6/13/2007   6.86  TORO
6/14/2007   6.60  TORO
6/15/2007   6.35  TORO
6/16/2007   6.35  TORO
6/17/2007   6.86  TORO
6/18/2007   5.84  TORO
7/3/2007    5.59  TORO
7/4/2007    4.32  TORO
7/5/2007    4.06  TORO
7/6/2007    5.33  TORO
7/7/2007    4.57  TORO
7/8/2007    7.37  TORO
7/9/2007    7.11  TORO
7/10/2007   5.33  TORO
7/11/2007   7.11  TORO
7/12/2007   6.10  TORO
7/13/2007   5.59  TORO
7/14/2007   5.59  TORO
7/15/2007   5.84  TORO
7/16/2007   5.33  TORO
7/17/2007   5.84  TORO
8/5/2007    6.60  TORO
8/6/2007    6.86  TORO
8/7/2007    6.10  TORO
8/8/2007    5.84  TORO
8/9/2007    5.08  TORO
8/10/2007   4.83  TORO
9/2/2007    4.57  TORO
9/3/2007    4.57  TORO
9/4/2007    6.10  TORO
9/5/2007    6.35  TORO
9/6/2007    6.10  TORO
9/7/2007    5.84  TORO
10/2/2007   2.79  TORO
10/3/2007   3.81  TORO
10/4/2007   4.06  TORO
10/5/2007   3.56  TORO
10/6/2007   4.32  TORO
10/7/2007   3.30  TORO
10/8/2007   4.06  TORO
10/9/2007   3.56  TORO
10/10/2007  4.57  TORO
10/11/2007  4.83  TORO
10/12/2007  3.81  TORO
10/13/2007  4.06  TORO
10/14/2007  2.54  TORO
10/15/2007  4.06  TORO
10/16/2007  3.56  TORO
10/17/2007  3.56  TORO
10/18/2007  3.81  TORO
10/19/2007  4.06  TORO
10/23/2007  4.06  TORO
```

10/24/2007	1.78	TORO
10/25/2007	3.05	TORO
10/26/2007	3.56	TORO
10/27/2007	2.54	TORO
10/28/2007	2.54	TORO
6/13/2007	3.53	ETM
6/14/2007	4.09	ETM
6/15/2007	5.83	ETM
6/16/2007	5.92	ETM
6/17/2007	6.05	ETM
6/18/2007	6.05	ETM
7/3/2007	4.33	ETM
7/4/2007	4.56	ETM
7/5/2007	3.97	ETM
7/6/2007	4.00	ETM
7/7/2007	3.88	ETM
7/8/2007	5.89	ETM
7/9/2007	5.55	ETM
7/10/2007	5.72	ETM
7/11/2007	5.49	ETM
7/12/2007	3.68	ETM
7/13/2007	3.55	ETM
7/14/2007	3.04	ETM
7/15/2007	4.26	ETM
7/16/2007	5.05	ETM
7/17/2007	4.13	ETM
8/5/2007	5.62	ETM
8/6/2007	5.29	ETM
8/7/2007	4.39	ETM
8/8/2007	4.20	ETM
8/9/2007	3.63	ETM
8/10/2007	5.31	ETM
9/2/2007	3.14	ETM
9/3/2007	5.04	ETM
9/4/2007	5.11	ETM
9/5/2007	3.60	ETM
9/6/2007	5.19	ETM
9/7/2007	5.20	ETM
10/2/2007	1.43	ETM
10/3/2007	3.49	ETM
10/4/2007	2.94	ETM
10/5/2007	1.83	ETM
10/6/2007	3.93	ETM
10/7/2007	2.29	ETM
10/8/2007	3.80	ETM
10/9/2007	3.84	ETM
10/10/2007	3.64	ETM
10/11/2007	3.42	ETM
10/12/2007	3.57	ETM
10/13/2007	3.85	ETM
10/14/2007	2.49	ETM
10/15/2007	4.17	ETM
10/16/2007	2.66	ETM
10/17/2007	3.43	ETM
10/18/2007	3.41	ETM
10/19/2007	2.88	ETM
10/23/2007	3.34	ETM

10/24/2007	0.80	ETM
10/25/2007	1.91	ETM
10/26/2007	1.57	ETM
10/27/2007	1.12	ETM
10/28/2007	2.75	ETM
6/13/2007	5.00	WS
6/14/2007	4.82	WS
6/15/2007	5.79	WS
6/16/2007	5.59	WS
6/17/2007	6.15	WS
6/18/2007	5.95	WS
7/3/2007	4.00	WS
7/4/2007	3.44	WS
7/5/2007	4.32	WS
7/6/2007	5.71	WS
7/7/2007	5.80	WS
7/8/2007	5.93	WS
7/9/2007	6.53	WS
7/10/2007	5.19	WS
7/11/2007	5.97	WS
7/12/2007	4.57	WS
7/13/2007	4.93	WS
7/14/2007	2.89	WS
7/15/2007	4.05	WS
7/16/2007	5.13	WS
7/17/2007	4.93	WS
8/5/2007	5.73	WS
8/6/2007	5.55	WS
8/7/2007	5.56	WS
8/8/2007	5.38	WS
8/9/2007	5.38	WS
8/10/2007	5.54	WS
9/2/2007	2.89	WS
9/3/2007	4.51	WS
9/4/2007	5.07	WS
9/5/2007	3.79	WS
9/6/2007	4.38	WS
9/7/2007	5.20	WS
10/2/2007	1.26	WS
10/3/2007	3.39	WS
10/4/2007	2.89	WS
10/5/2007	2.33	WS
10/6/2007	3.09	WS
10/7/2007	3.37	WS
10/8/2007	3.78	WS
10/9/2007	3.59	WS
10/10/2007	3.29	WS
10/11/2007	3.69	WS
10/12/2007	3.50	WS
10/13/2007	3.42	WS
10/14/2007	2.61	WS
10/15/2007	3.62	WS
10/16/2007	2.89	WS
10/17/2007	2.85	WS
10/18/2007	3.08	WS
10/19/2007	3.22	WS
10/23/2007	3.34	WS

```
10/24/2007  1.26  WS
10/25/2007  2.49  WS
10/26/2007  1.42  WS
10/27/2007  1.20  WS
10/28/2007  2.24  WS
6/7/2007    5.334 TORO
6/8/2007    5.08  TORO
6/9/2007    5.588 TORO
6/10/2007   6.096 TORO
6/11/2007   6.858 TORO
6/12/2007   6.35  TORO
6/7/2007    3.04  ETM
6/8/2007    4.85  ETM
6/9/2007    6.17  ETM
6/10/2007   4.73  ETM
6/11/2007   5.22  ETM
6/12/2007   3.53  ETM
6/7/2007    4.72  WS
6/8/2007    5.04  WS
6/9/2007    6.00  WS
6/10/2007   5.95  WS
6/11/2007   5.95  WS
6/12/2007   2.70  WS
run;
proc glm;
      title 'ET Manufacturer data';
      class date type;
      model ET = date type;
      means type/Duncan;
      run;
proc mixed;
      class  type;
      model ET =  type;
      lsmeans type/pdiff;
      run;
```

Manufacturer Weekly ET Data Comparisons

```
options nodate nonumber center formdlim="*" linesize = 88;
data ET;
input week$ ET type$;
cards;
1     38.35 TORO
2     40.89 TORO
3     25.91 TORO
4     27.43 TORO
5     23.88 TORO
1     32.17 ETM
2     30.78 ETM
3     19.73 ETM
4     24.98 ETM
5     18.44 ETM
1     35.73 WS
2     32.72 WS
3     20.11 WS
4     23.72 WS
5     19.14 WS
6     42.16 TORO
6     31.07 ETM
6     35.36 WS
run;
proc glm;
      title 'ET Manufacturer Weekly Sum Compared';
      class week type;
      model ET = week type;
      means type/Duncan;
      run;
proc mixed;
      class  type;
      model ET =  type;
      lsmeans type/pdiff;
      run;
```

APPENDIX D
CHAPTER 5 STATISTICAL ANALYSIS

Rooting Depth Comparisons

```
options nodate nonumber center formdlim="*" linesize = 88;
data roots;
input tmt$ plot$ year$ block$ freq$ mrootsA mrootsB watertot waterweekly;
cards;
NON    A01    2006  1     0     0.35  0.01  97.2  2.8   3.1   0.0
NON    A09    2006  3     0     0.81  0.06  93.1  6.9   3.3   0.0
NON    B06    2006  2     0     0.69  0.01  98.6  1.4   2.1   0.0
NON    C10    2006  4     0     1.03  0.16  86.6  13.4  1.5   0.0
NON    A01    2007  1     .     0.86  0.06  93.5  6.5   477.9 39.8
NON    A09    2007  3     .     0.75  0.53  58.6  41.4  469.5 39.1
NON    B06    2007  2     .     0.81  0.42  65.9  34.1  465.4 38.8
NON    C10    2007  4     .     0.72  0     100.0 0.0   454.9 37.9
RS1-3mm      A12    2006  1     1     1.29  0.08  94.2  5.8   212.7 22.7
RS1-3mm      B01    2006  2     1     1.54  0.42  78.6  21.4  208.1 22.5
RS1-3mm      B08    2006  3     1     0.78  0     100.0 0.0   204.7 21.4
RS1-3mm      C06    2006  4     1     1.38  0.44  75.8  24.2  204.7 22.5
RS1-3mm      A12    2007  4     1     0.71  0.12  85.5  14.5  480.0 40.0
RS1-3mm      B01    2007  1     1     1.02  0.27  79.1  20.9  474.8 39.6
RS1-3mm      B08    2007  3     1     0.91  0.23  79.8  20.2  481.0 40.1
RS1-3mm      C06    2007  2     1     1.03  0.52  66.5  33.5  472.7 39.4
AC10   E05    2006  2     2     0.9   0.1   90.0  10.0  216.2 27.2
AC10   E08    2006  3     2     0.75  0.25  75.0  25.0  221.4 28.2
AC10   E11    2006  4     2     0.81  0.02  97.6  2.4   218.7 27.6
AC10   F02    2006  1     2     1.48  0.15  90.8  9.2   216.0 27.4
AC13   D07    2006  3     2     1.19  0.16  88.1  11.9  246.7 30.5
AC13   E06    2006  2     2     1.94  0.85  69.5  30.5  259.6 31.9
AC13   F01    2006  1     2     0.78  0.09  89.7  10.3  261.1 32.1
AC13   F11    2006  4     2     0.84  0.26  76.4  23.6  254.0 31.2
AC7    D12    2006  4     2     0.46  0.15  75.4  24.6  157.4 19.0
AC7    E02    2006  1     2     0.83  0.32  72.2  27.8  163.8 19.7
AC7    E04    2006  2     2     0.82  0.2   80.4  19.6  163.8 19.7
AC7    F07    2006  3     2     0.75  0     100.0 0.0   167.6 20.6
ACIR   D03    2006  1     2     1.04  0.5   67.5  32.5  203.9 24.1
ACIR   D09    2006  3     2     1.36  0.16  89.5  10.5  184.5 21.9
ACIR   D10    2006  4     2     1.09  0.03  97.3  2.7   173.2 18.1
ACIR   F04    2006  2     2     0.65  0.02  97.0  3.0   190.5 22.7
DWRS   B05    2006  2     2     1.25  0.49  71.8  28.2  180.7 20.6
DWRS   C01    2006  1     2     1.05  0.21  83.3  16.7  170.1 20.9
DWRS   C07    2006  3     2     1.11  0.29  79.3  20.7  164.7 20.2
DWRS   C11    2006  4     2     1.77  0.03  98.3  1.7   165.1 19.4
ET     E07    2006  3     2     0.65  0.06  91.5  8.5   258.4 32.2
ET     E10    2006  4     2     1.49  0.41  78.4  21.6  240.8 30.1
ET     F03    2006  1     2     0.57  0.04  93.4  6.6   271.3 33.9
ET     F05    2006  2     2     0.7   0     100.0 0.0   263.8 33.0
ETM    E01    2006  1     2     0.67  0.06  91.8  8.2   257.5 30.1
ETM    E09    2006  3     2     1.04  0.16  86.7  13.3  209.3 25.2
ETM    F06    2006  2     2     0.63  0     100.0 0.0   243.5 29.8
ETM    F10    2006  4     2     1.12  0.27  80.6  19.4  234.6 28.5
Llhigh       D02    2006  1     2     0.73  0.05  93.6  6.4   328.7 40.6
Llhigh       D06    2006  2     2     0.94  0.28  77.0  23.0  322.4 40.2
Llhigh       E12    2006  4     2     0.84  0     100.0 0.0   327.0 40.5
Llhigh       F09    2006  3     2     0.77  0.11  87.5  12.5  362.7 40.5
```

LLlow	D04	2006	2	2	0.82	0.26	75.9	24.1	116.4	12.3	
LLlow	D08	2006	3	2	1.02	0.32	76.1	23.9	115.4	12.4	
LLlow	E03	2006	1	2	0.85	0.03	96.6	3.4	116.2	12.5	
LLlow	F12	2006	4	2	0.45	0.09	83.3	16.7	113.7	11.9	
Llmed	D01	2006	1	2	1.41	0.18	88.7	11.3	225.4	26.4	
Llmed	D05	2006	2	2	0.62	0.08	88.6	11.4	226.4	26.4	
Llmed	D11	2006	4	2	1.07	0.21	83.6	16.4	223.3	25.5	
Llmed	F08	2006	3	2	0.98	0.25	79.7	20.3	228.1	26.8	
RS1-6mm	A02	2006	4	2	.	0.02	.	.	184.3	27.1	
RS1-6mm	B04	2006	1	2	0.31	0.2	60.8	39.2	171.5	26.4	
RS1-6mm	C08	2006	3	2	0.85	0.33	72.0	28.0	170.3	26.0	
RS1-6mm	C12	2006	2	2	0.8	0.11	87.9	12.1	173.2	26.0	
RS2-3mm	A06	2006	2	2	1.01	0.19	84.2	15.8	191.2	24.6	
RS2-3mm	B09	2006	3	2	0.67	0.14	82.7	17.3	178.4	22.8	
RS2-3mm	B10	2006	4	2	1.19	0.03	97.5	2.5	188.7	24.6	
RS2-3mm	C02	2006	1	2	1.02	0	100.0	0.0	187.4	24.2	
WORS	A03	2006	1	2	0.58	0.07	89.2	10.8	258.4	30.8	
WORS	A05	2006	2	2	0.97	0	100.0	0.0	223.7	29.7	
WORS	B12	2006	4	2	1.11	0	100.0	0.0	230.6	28.6	
WORS	C09	2006	3	2	1.15	0.14	89.1	10.9	235.4	29.7	
WRS	A04	2006	2	2	0.73	0.36	67.0	33.0	221.0	28.1	
WRS	A11	2006	4	2	0.81	0.07	92.0	8.0	220.8	27.8	
WRS	B07	2006	3	2	0.54	0	100.0	0.0	213.9	27.2	
WRS	C03	2006	1	2	1.24	0.32	79.5	20.5	220.0	28.1	
AC7	D12	2007	4	2	1.27	0.19	87.0	13.0	246.3	20.5	
AC7	E02	2007	1	2	1.03	0.42	71.0	29.0	252.5	21.0	
AC7	E04	2007	2	2	0.63	0.64	49.6	50.4	254.6	21.2	
AC7	F07	2007	3	2	1.3	0.5	72.2	27.8	271.3	22.6	
DWRS	B05	2007	2	2	1.03	0.8	56.3	43.7	252.5	21.0	
DWRS	C01	2007	1	2	1.53	0.29	84.1	15.9	257.7	21.5	
DWRS	C07	2007	3	2	0.74	0.7	51.4	48.6	252.5	21.0	
DWRS	C11	2007	4	2	2.11	0.47	81.8	18.2	250.4	20.9	
ETM	E01	2007	1	2	1	0.2	83.3	16.7	194.1	16.2	
ETM	E09	2007	3	2	1.12	0.27	80.6	19.4	212.1	17.7	
ETM	F10	2007	2	2	1.39	0.34	80.3	19.7	192.0	16.0	
ETM	F06	2007	4	2	1.29	0.34	79.1	20.9	190.9	15.9	
Llhigh	D02	2007	1	2	1.42	0.42	77.2	22.8	473.7	39.5	
Llhigh	D06	2007	2	2	1.21	1.36	47.1	52.9	471.6	39.3	
Llhigh	E12	2007	4	2	1.05	0.43	70.9	29.1	481.0	40.1	
Llhigh	F09	2007	3	2	1.18	0.2	85.5	14.5	486.2	40.5	
WORS	A03	2007	1	2	1.43	0.34	80.8	19.2	480.0	40.0	
WORS	A05	2007	2	2	0.83	0.66	55.7	44.3	477.9	39.8	
WORS	B12	2007	4	2	1.61	0.46	77.8	22.2	467.5	39.0	
WORS	C09	2007	3	2	0.79	0.46	63.2	36.8	423.6	35.3	
WRS	A04	2007	2	2	0.89	0.4	69.0	31.0	412.2	34.3	
WRS	A11	2007	4	2	1.16	0.12	90.6	9.4	411.1	34.3	
WRS	B07	2007	3	2	0.97	0.23	80.8	19.2	424.7	35.4	
WRS	C03	2007	1	2	1.13	1.16	49.3	50.7	411.1	34.3	
RS2-6mm	A07	2006	3	7	0.55	0.14	79.7	20.3	210.4	23.5	
RS2-6mm	B02	2006	1	7	0.62	0.3	67.4	32.6	207.9	23.2	
RS2-6mm	B11	2006	4	7	1.21	0.04	96.8	3.2	206.0	23.4	
RS2-6mm	C05	2006	2	7	0.91	0.1	90.1	9.9	211.4	22.7	
RS7-3mm	A08	2006	3	7	1	0.17	85.5	14.5	193.7	26.8	
RS7-3mm	A10	2006	4	7	1.72	0.03	98.3	1.7	192.2	26.5	
RS7-3mm	B03	2006	1	7	0.86	0.1	89.6	10.4	193.5	26.3	
RS7-3mm	C04	2006	2	7	0.99	0.07	93.4	6.6	201.2	27.1	
RS7-3mm	A08	2007	3	7	0.87	0.22	79.8	20.2	422.6	34.8	

```
RS7-3mm     A10   2007  4     7     0.75  0     100.0 0.0   401.7 33.1
RS7-3mm     B03   2007  1     7     0.89  0.08  91.8  8.2   404.9 33.4
RS7-3mm     C04   2007  2     7     1.2   0.75  61.5  38.5  352.7 28.9
run;

/*BY YEAR*/
proc sort;
      by year;
      run;
/*0 to 15 cm depth*/
proc glm; by year;
title 'Mass of Roots at 15 cm Frequency Analysis';
      class freq ;
      model mrootsA = freq ;
    means freq /duncan;
      run;
proc glm; by year;
title 'Mass of Roots at 15 cm Total Water Applied Analysis';
      class watertot ;
      model mrootsA = watertot ;
      run;
 proc glm; by year;
 title 'Mass of Roots at 15 cm Weekly Water Applied Analysis';
      class waterweekly ;
      model mrootsA = waterweekly ;
      run;
/*15 to 30 cm depth*/
proc glm; by year;
title 'Mass of Roots at 30 cm Frequency Analysis';
      class freq ;
      model mrootsB = freq ;
    means freq /duncan;
      run;
proc glm; by year;
title 'Mass of Roots at 30 cm Total Water Applied Analysis';
      class watertot ;
      model mrootsB = watertot ;
      run;

proc glm; by year;
title 'Mass of Roots at 30 cm Weekly Water Applied Analysis';
      class waterweekly ;
      model mrootsB = waterweekly ;
      run;
```

Rooting Depth 2006-2007 Comparisons

```
options nodate nonumber center formdlim="*" linesize=88;
data roots;
input tmt $ plot $ year block freq mrootsA mrootsB  waterapp;
cards;
RS1-3mm     A12   2006  1     1     1.29  0.08  94.2  5.8   212.7 22.7
RS1-3mm     B01   2006  2     1     1.54  0.42  78.6  21.4  208.1 22.5
RS1-3mm     B08   2006  3     1     0.78  0     100.0 0.0   204.7 21.4
RS1-3mm     C06   2006  4     1     1.38  0.44  75.8  24.2  204.7 22.5
RS1-3mm     A12   2007  4     1     0.71  0.12  85.5  14.5  480.0 40.0
RS1-3mm     B01   2007  1     1     1.02  0.27  79.1  20.9  474.8 39.6
RS1-3mm     B08   2007  3     1     0.91  0.23  79.8  20.2  481.0 40.1
RS1-3mm     C06   2007  2     1     1.03  0.52  66.5  33.5  472.7 39.4
AC10  E05   2006  2     2     0.9   0.1   90.0  10.0  216.2 27.2
AC10  E08   2006  3     2     0.75  0.25  75.0  25.0  221.4 28.2
AC10  E11   2006  4     2     0.81  0.02  97.6  2.4   218.7 27.6
AC10  F02   2006  1     2     1.48  0.15  90.8  9.2   216.0 27.4
AC13  D07   2006  3     2     1.19  0.16  88.1  11.9  246.7 30.5
AC13  E06   2006  2     2     1.94  0.85  69.5  30.5  259.6 31.9
AC13  F01   2006  1     2     0.78  0.09  89.7  10.3  261.1 32.1
AC13  F11   2006  4     2     0.84  0.26  76.4  23.6  254.0 31.2
AC7   D12   2006  4     2     0.46  0.15  75.4  24.6  157.4 19.0
AC7   E02   2006  1     2     0.83  0.32  72.2  27.8  163.8 19.7
AC7   E04   2006  2     2     0.82  0.2   80.4  19.6  163.8 19.7
AC7   F07   2006  3     2     0.75  0     100.0 0.0   167.6 20.6
ACIR  D03   2006  1     2     1.04  0.5   67.5  32.5  203.9 24.1
ACIR  D09   2006  3     2     1.36  0.16  89.5  10.5  184.5 21.9
ACIR  D10   2006  4     2     1.09  0.03  97.3  2.7   173.2 18.1
ACIR  F04   2006  2     2     0.65  0.02  97.0  3.0   190.5 22.7
DWRS  B05   2006  2     2     1.25  0.49  71.8  28.2  180.7 20.6
DWRS  C01   2006  1     2     1.05  0.21  83.3  16.7  170.1 20.9
DWRS  C07   2006  3     2     1.11  0.29  79.3  20.7  164.7 20.2
DWRS  C11   2006  4     2     1.77  0.03  98.3  1.7   165.1 19.4
ET    E07   2006  3     2     0.65  0.06  91.5  8.5   258.4 32.2
ET    E10   2006  4     2     1.49  0.41  78.4  21.6  240.8 30.1
ET    F03   2006  1     2     0.57  0.04  93.4  6.6   271.3 33.9
ET    F05   2006  2     2     0.7   0     100.0 0.0   263.8 33.0
ETM   E01   2006  1     2     0.67  0.06  91.8  8.2   257.5 30.1
ETM   E09   2006  3     2     1.04  0.16  86.7  13.3  209.3 25.2
ETM   F06   2006  2     2     0.63  0     100.0 0.0   243.5 29.8
ETM   F10   2006  4     2     1.12  0.27  80.6  19.4  234.6 28.5
Llhigh      D02   2006  1     2     0.73  0.05  93.6  6.4   328.7 40.6
Llhigh      D06   2006  2     2     0.94  0.28  77.0  23.0  322.4 40.2
Llhigh      E12   2006  4     2     0.84  0     100.0 0.0   327.0 40.5
Llhigh      F09   2006  3     2     0.77  0.11  87.5  12.5  362.7 40.5
LLlow D04   2006  2     2     0.82  0.26  75.9  24.1  116.4 12.3
LLlow D08   2006  3     2     1.02  0.32  76.1  23.9  115.4 12.4
LLlow E03   2006  1     2     0.85  0.03  96.6  3.4   116.2 12.5
LLlow F12   2006  4     2     0.45  0.09  83.3  16.7  113.7 11.9
Llmed D01   2006  1     2     1.41  0.18  88.7  11.3  225.4 26.4
Llmed D05   2006  2     2     0.62  0.08  88.6  11.4  226.4 26.4
Llmed D11   2006  4     2     1.07  0.21  83.6  16.4  223.3 25.5
Llmed F08   2006  3     2     0.98  0.25  79.7  20.3  228.1 26.8
RS1-6mm     A02   2006  4     2     .     0.02  .     .     184.3 27.1
RS1-6mm     B04   2006  1     2     0.31  0.2   60.8  39.2  171.5 26.4
RS1-6mm     C08   2006  3     2     0.85  0.33  72.0  28.0  170.3 26.0
RS1-6mm     C12   2006  2     2     0.8   0.11  87.9  12.1  173.2 26.0
```

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RS2-3mm     A06   2006  2     2     1.01  0.19  84.2  15.8  191.2 24.6
RS2-3mm     B09   2006  3     2     0.67  0.14  82.7  17.3  178.4 22.8
RS2-3mm     B10   2006  4     2     1.19  0.03  97.5  2.5   188.7 24.6
RS2-3mm     C02   2006  1     2     1.02  0     100.0 0.0   187.4 24.2
WORS  A03   2006  1     2     0.58  0.07  89.2  10.8  258.4 30.8
WORS  A05   2006  2     2     0.97  0     100.0 0.0   223.7 29.7
WORS  B12   2006  4     2     1.11  0     100.0 0.0   230.6 28.6
WORS  C09   2006  3     2     1.15  0.14  89.1  10.9  235.4 29.7
WRS   A04   2006  2     2     0.73  0.36  67.0  33.0  221.0 28.1
WRS   A11   2006  4     2     0.81  0.07  92.0  8.0   220.8 27.8
WRS   B07   2006  3     2     0.54  0     100.0 0.0   213.9 27.2
WRS   C03   2006  1     2     1.24  0.32  79.5  20.5  220.0 28.1
AC7   D12   2007  4     2     1.27  0.19  87.0  13.0  246.3 20.5
AC7   E02   2007  1     2     1.03  0.42  71.0  29.0  252.5 21.0
AC7   E04   2007  2     2     0.63  0.64  49.6  50.4  254.6 21.2
AC7   F07   2007  3     2     1.3   0.5   72.2  27.8  271.3 22.6
DWRS  B05   2007  2     2     1.03  0.8   56.3  43.7  252.5 21.0
DWRS  C01   2007  1     2     1.53  0.29  84.1  15.9  257.7 21.5
DWRS  C07   2007  3     2     0.74  0.7   51.4  48.6  252.5 21.0
DWRS  C11   2007  4     2     2.11  0.47  81.8  18.2  250.4 20.9
ETM   E01   2007  1     2     1     0.2   83.3  16.7  194.1 16.2
ETM   E09   2007  3     2     1.12  0.27  80.6  19.4  212.1 17.7
ETM   F10   2007  2     2     1.39  0.34  80.3  19.7  192.0 16.0
ETM   F06   2007  4     2     1.29  0.34  79.1  20.9  190.9 15.9
Llhigh      D02   2007  1     2     1.42  0.42  77.2  22.8  473.7 39.5
Llhigh      D06   2007  2     2     1.21  1.36  47.1  52.9  471.6 39.3
Llhigh      E12   2007  4     2     1.05  0.43  70.9  29.1  481.0 40.1
Llhigh      F09   2007  3     2     1.18  0.2   85.5  14.5  486.2 40.5
WORS  A03   2007  1     2     1.43  0.34  80.8  19.2  480.0 40.0
WORS  A05   2007  2     2     0.83  0.66  55.7  44.3  477.9 39.8
WORS  B12   2007  4     2     1.61  0.46  77.8  22.2  467.5 39.0
WORS  C09   2007  3     2     0.79  0.46  63.2  36.8  423.6 35.3
WRS   A04   2007  2     2     0.89  0.4   69.0  31.0  412.2 34.3
WRS   A11   2007  4     2     1.16  0.12  90.6  9.4   411.1 34.3
WRS   B07   2007  3     2     0.97  0.23  80.8  19.2  424.7 35.4
WRS   C03   2007  1     2     1.13  1.16  49.3  50.7  411.1 34.3
RS2-6mm     A07   2006  3     7     0.55  0.14  79.7  20.3  210.4 23.5
RS2-6mm     B02   2006  1     7     0.62  0.3   67.4  32.6  207.9 23.2
RS2-6mm     B11   2006  4     7     1.21  0.04  96.8  3.2   206.0 23.4
RS2-6mm     C05   2006  2     7     0.91  0.1   90.1  9.9   211.4 22.7
RS7-3mm     A08   2006  3     7     1     0.17  85.5  14.5  193.7 26.8
RS7-3mm     A10   2006  4     7     1.72  0.03  98.3  1.7   192.2 26.5
RS7-3mm     B03   2006  1     7     0.86  0.1   89.6  10.4  193.5 26.3
RS7-3mm     C04   2006  2     7     0.99  0.07  93.4  6.6   201.2 27.1
RS7-3mm     A08   2007  3     7     0.87  0.22  79.8  20.2  422.6 34.8
RS7-3mm     A10   2007  4     7     0.75  0     100.0 0.0   401.7 33.1
RS7-3mm     B03   2007  1     7     0.89  0.08  91.8  8.2   404.9 33.4
RS7-3mm     C04   2007  2     7     1.2   0.75  61.5  38.5  352.7 28.9
run;
proc glm;
title 'Roots at 15 cm - Frequency Analysis';
      class year ;
      model mrootsA = year ;
      means year /duncan;
      run;

proc glm;
```

```
title 'Roots at 30 cm - Frequency Analysis';
class year ;
model mrootsB = year ;
means year /duncan;
run;
```

Weekly Water Applied on Turf Quality

```
data TQ and weekly water;
input season$ month$ week$ tmt$ rep$ freq$ mm type$ TQ;
cards;
F06   Sep06 1     AC10  1     2     32    SMS   7
F06   Oct06 2     AC10  1     2     33    SMS   6
F06   Oct06 4     AC10  1     2     15    SMS   7
F06   Nov06 8     AC10  1     2     10    SMS   6
F06   Dec06 10    AC10  1     2     0     SMS   6
F06   Dec06 11    AC10  1     2     10    SMS   7
F06   Sep06 1     AC10  2     2     33    SMS   8
F06   Oct06 2     AC10  2     2     32    SMS   8
F06   Oct06 4     AC10  2     2     15    SMS   7
F06   Nov06 8     AC10  2     2     10    SMS   8
F06   Dec06 10    AC10  2     2     0     SMS   7
F06   Dec06 11    AC10  2     2     10    SMS   7
F06   Sep06 1     AC10  3     2     33    SMS   8
F06   Oct06 2     AC10  3     2     34    SMS   8
F06   Oct06 4     AC10  3     2     15    SMS   7
F06   Nov06 8     AC10  3     2     10    SMS   7
F06   Dec06 10    AC10  3     2     0     SMS   7
F06   Dec06 11    AC10  3     2     10    SMS   7
F06   Sep06 1     AC10  4     2     33    SMS   7
F06   Oct06 2     AC10  4     2     33    SMS   7
F06   Oct06 4     AC10  4     2     15    SMS   7
F06   Nov06 8     AC10  4     2     10    SMS   7
F06   Dec06 10    AC10  4     2     0     SMS   6
F06   Dec06 11    AC10  4     2     10    SMS   7
F06   Sep06 1     AC13  1     2     34    SMS   4
F06   Oct06 2     AC13  1     2     34    SMS   4
F06   Oct06 4     AC13  1     2     29    SMS   4
F06   Nov06 8     AC13  1     2     10    SMS   6
F06   Dec06 10    AC13  1     2     10    SMS   6
F06   Dec06 11    AC13  1     2     21    SMS   6
F06   Sep06 1     AC13  2     2     33    SMS   8
F06   Oct06 2     AC13  2     2     33    SMS   7
F06   Oct06 4     AC13  2     2     28    SMS   8
F06   Nov06 8     AC13  2     2     10    SMS   8
F06   Dec06 10    AC13  2     2     10    SMS   7
F06   Dec06 11    AC13  2     2     21    SMS   7
F06   Sep06 1     AC13  3     2     32    SMS   8
F06   Oct06 2     AC13  3     2     32    SMS   8
F06   Oct06 4     AC13  3     2     28    SMS   8
F06   Nov06 8     AC13  3     2     9     SMS   7
F06   Dec06 10    AC13  3     2     9     SMS   8
F06   Dec06 11    AC13  3     2     21    SMS   8
F06   Sep06 1     AC13  4     2     33    SMS   7
F06   Oct06 2     AC13  4     2     33    SMS   7
F06   Oct06 4     AC13  4     2     29    SMS   7
F06   Nov06 8     AC13  4     2     10    SMS   7
F06   Dec06 10    AC13  4     2     10    SMS   6
F06   Dec06 11    AC13  4     2     20    SMS   7
F06   Sep06 1     ACIR  1     2     17    SMS   8
F06   Oct06 2     ACIR  1     2     17    SMS   7
F06   Oct06 4     ACIR  1     2     15    SMS   7
F06   Nov06 8     ACIR  1     2     0     SMS   7
```

F06	Dec06	10	ACIR	1	2	10	SMS	6
F06	Dec06	11	ACIR	1	2	0	SMS	7
F06	Sep06	1	ACIR	2	2	34	SMS	5
F06	Oct06	2	ACIR	2	2	33	SMS	5
F06	Oct06	4	ACIR	2	2	29	SMS	5
F06	Nov06	8	ACIR	2	2	10	SMS	5
F06	Dec06	10	ACIR	2	2	0	SMS	4
F06	Dec06	11	ACIR	2	2	10	SMS	5
F06	Sep06	1	ACIR	3	2	17	SMS	7
F06	Oct06	2	ACIR	3	2	17	SMS	6
F06	Oct06	4	ACIR	3	2	15	SMS	7
F06	Nov06	8	ACIR	3	2	0	SMS	8
F06	Dec06	10	ACIR	3	2	10	SMS	7
F06	Dec06	11	ACIR	3	2	0	SMS	8
F06	Sep06	1	ACIR	4	2	0	SMS	8
F06	Oct06	2	ACIR	4	2	16	SMS	7
F06	Oct06	4	ACIR	4	2	13	SMS	7
F06	Nov06	8	ACIR	4	2	0	SMS	8
F06	Dec06	10	ACIR	4	2	0	SMS	7
F06	Dec06	11	ACIR	4	2	0	SMS	7
F06	Sep06	1	DWRS	1	2	21	RS	7
F06	Oct06	2	DWRS	1	2	21	RS	7
F06	Oct06	4	DWRS	1	2	18	RS	7
F06	Nov06	8	DWRS	1	2	7	RS	7
F06	Dec06	10	DWRS	1	2	7	RS	7
F06	Dec06	11	DWRS	1	2	13	RS	7
F06	Sep06	1	DWRS	2	2	21	RS	7
F06	Oct06	2	DWRS	2	2	21	RS	7
F06	Oct06	4	DWRS	2	2	17	RS	7
F06	Nov06	8	DWRS	2	2	6	RS	7
F06	Dec06	10	DWRS	2	2	6	RS	6
F06	Dec06	11	DWRS	2	2	13	RS	7
F06	Sep06	1	DWRS	3	2	22	RS	8
F06	Oct06	2	DWRS	3	2	21	RS	8
F06	Oct06	4	DWRS	3	2	18	RS	8
F06	Nov06	8	DWRS	3	2	6	RS	8
F06	Dec06	10	DWRS	3	2	7	RS	8
F06	Dec06	11	DWRS	3	2	13	RS	8
F06	Sep06	1	DWRS	4	2	21	RS	7
F06	Oct06	2	DWRS	4	2	21	RS	7
F06	Oct06	4	DWRS	4	2	18	RS	7
F06	Nov06	8	DWRS	4	2	6	RS	7
F06	Dec06	10	DWRS	4	2	6	RS	6
F06	Dec06	11	DWRS	4	2	14	RS	6
F06	Sep06	1	ETM	1	2	35	ET	8
F06	Oct06	2	ETM	1	2	35	ET	8
F06	Oct06	4	ETM	1	2	33	ET	8
F06	Nov06	8	ETM	1	2	0	ET	8
F06	Dec06	10	ETM	1	2	13	ET	8
F06	Dec06	11	ETM	1	2	10	ET	8
F06	Sep06	1	ETM	2	2	33	ET	6
F06	Oct06	2	ETM	2	2	35	ET	6
F06	Oct06	4	ETM	2	2	31	ET	6
F06	Nov06	8	ETM	2	2	0	ET	4
F06	Dec06	10	ETM	2	2	10	ET	4
F06	Dec06	11	ETM	2	2	10	ET	4
F06	Sep06	1	ETM	3	2	29	ET	7

F06	Oct06	2	ETM	3	2	34	ET	7
F06	Oct06	4	ETM	3	2	31	ET	7
F06	Nov06	8	ETM	3	2	0	ET	8
F06	Dec06	10	ETM	3	2	10	ET	7
F06	Dec06	11	ETM	3	2	10	ET	8
F06	Sep06	1	ETM	4	2	33	ET	8
F06	Oct06	2	ETM	4	2	35	ET	8
F06	Oct06	4	ETM	4	2	31	ET	8
F06	Nov06	8	ETM	4	2	0	ET	8
F06	Dec06	10	ETM	4	2	10	ET	8
F06	Dec06	11	ETM	4	2	10	ET	8
F06	Sep06	1	LL5	1	2	32	SMS	7
F06	Oct06	2	LL5	1	2	33	SMS	7
F06	Oct06	4	LL5	1	2	14	SMS	7
F06	Nov06	8	LL5	1	2	10	SMS	7
F06	Dec06	10	LL5	1	2	10	SMS	7
F06	Dec06	11	LL5	1	2	21	SMS	7
F06	Sep06	1	LL5	2	2	33	SMS	8
F06	Oct06	2	LL5	2	2	33	SMS	7
F06	Oct06	4	LL5	2	2	15	SMS	7
F06	Nov06	8	LL5	2	2	10	SMS	8
F06	Dec06	10	LL5	2	2	10	SMS	7
F06	Dec06	11	LL5	2	2	20	SMS	7
F06	Sep06	1	LL5	3	2	32	SMS	7
F06	Oct06	2	LL5	3	2	33	SMS	7
F06	Oct06	4	LL5	3	2	15	SMS	7
F06	Nov06	8	LL5	3	2	10	SMS	7
F06	Dec06	10	LL5	3	2	10	SMS	6
F06	Dec06	11	LL5	3	2	21	SMS	7
F06	Sep06	1	LL5	4	2	32	SMS	8
F06	Oct06	2	LL5	4	2	32	SMS	8
F06	Oct06	4	LL5	4	2	14	SMS	8
F06	Nov06	8	LL5	4	2	10	SMS	8
F06	Dec06	10	LL5	4	2	10	SMS	6
F06	Dec06	11	LL5	4	2	20	SMS	7
F06	Sep06	1	RS2-3mm	1	2	32	RS	6
F06	Oct06	2	RS2-3mm	1	2	33	RS	7
F06	Oct06	4	RS2-3mm	1	2	28	RS	7
F06	Nov06	8	RS2-3mm	1	2	9	RS	5
F06	Dec06	10	RS2-3mm	1	2	10	RS	5
F06	Dec06	11	RS2-3mm	1	2	21	RS	5
F06	Sep06	1	RS2-3mm	2	2	33	RS	8
F06	Oct06	2	RS2-3mm	2	2	33	RS	8
F06	Oct06	4	RS2-3mm	2	2	28	RS	8
F06	Nov06	8	RS2-3mm	2	2	10	RS	8
F06	Dec06	10	RS2-3mm	2	2	10	RS	6
F06	Dec06	11	RS2-3mm	2	2	21	RS	7
F06	Sep06	1	RS2-3mm	3	2	32	RS	7
F06	Oct06	2	RS2-3mm	3	2	29	RS	7
F06	Oct06	4	RS2-3mm	3	2	29	RS	7
F06	Nov06	8	RS2-3mm	3	2	10	RS	7
F06	Dec06	10	RS2-3mm	3	2	9	RS	6
F06	Dec06	11	RS2-3mm	3	2	21	RS	7
F06	Sep06	1	RS2-3mm	4	2	33	RS	7
F06	Oct06	2	RS2-3mm	4	2	33	RS	7
F06	Oct06	4	RS2-3mm	4	2	28	RS	7
F06	Nov06	8	RS2-3mm	4	2	10	RS	6

F06	Dec06	10	RS2-3mm	4	2	10	RS	5
F06	Dec06	11	RS2-3mm	4	2	21	RS	5
F06	Sep06	1	RS2-6mm	1	2	33	RS	8
F06	Oct06	2	RS2-6mm	1	2	33	RS	8
F06	Oct06	4	RS2-6mm	1	2	28	RS	7
F06	Nov06	8	RS2-6mm	1	2	10	RS	7
F06	Dec06	10	RS2-6mm	1	2	10	RS	6
F06	Dec06	11	RS2-6mm	1	2	21	RS	6
F06	Sep06	1	RS2-6mm	2	2	33	RS	5
F06	Oct06	2	RS2-6mm	2	2	32	RS	5
F06	Oct06	4	RS2-6mm	2	2	28	RS	5
F06	Nov06	8	RS2-6mm	2	2	10	RS	5
F06	Dec06	10	RS2-6mm	2	2	10	RS	4
F06	Dec06	11	RS2-6mm	2	2	21	RS	4
F06	Sep06	1	RS2-6mm	3	2	34	RS	4
F06	Oct06	2	RS2-6mm	3	2	33	RS	4
F06	Oct06	4	RS2-6mm	3	2	29	RS	4
F06	Nov06	8	RS2-6mm	3	2	10	RS	5
F06	Dec06	10	RS2-6mm	3	2	10	RS	4
F06	Dec06	11	RS2-6mm	3	2	21	RS	5
F06	Sep06	1	RS2-6mm	4	2	33	RS	7
F06	Oct06	2	RS2-6mm	4	2	32	RS	7
F06	Oct06	4	RS2-6mm	4	2	29	RS	8
F06	Nov06	8	RS2-6mm	4	2	10	RS	7
F06	Dec06	10	RS2-6mm	4	2	10	RS	6
F06	Dec06	11	RS2-6mm	4	2	21	RS	7
F06	Sep06	1	RS7-6mm	1	7	3	RS	8
F06	Oct06	2	RS7-6mm	1	7	51	RS	7
F06	Oct06	4	RS7-6mm	1	7	28	RS	7
F06	Nov06	8	RS7-6mm	1	7	20	RS	7
F06	Dec06	10	RS7-6mm	1	7	17	RS	6
F06	Dec06	11	RS7-6mm	1	7	19	RS	6
F06	Sep06	1	RS7-6mm	2	7	3	RS	8
F06	Oct06	2	RS7-6mm	2	7	52	RS	8
F06	Oct06	4	RS7-6mm	2	7	28	RS	8
F06	Nov06	8	RS7-6mm	2	7	20	RS	8
F06	Dec06	10	RS7-6mm	2	7	16	RS	8
F06	Dec06	11	RS7-6mm	2	7	20	RS	8
F06	Sep06	1	RS7-6mm	3	7	3	RS	5
F06	Oct06	2	RS7-6mm	3	7	52	RS	4
F06	Oct06	4	RS7-6mm	3	7	28	RS	6
F06	Nov06	8	RS7-6mm	3	7	20	RS	5
F06	Dec06	10	RS7-6mm	3	7	17	RS	4
F06	Dec06	11	RS7-6mm	3	7	20	RS	5
F06	Sep06	1	RS7-6mm	4	7	3	RS	6
F06	Oct06	2	RS7-6mm	4	7	51	RS	6
F06	Oct06	4	RS7-6mm	4	7	28	RS	6
F06	Nov06	8	RS7-6mm	4	7	19	RS	7
F06	Dec06	10	RS7-6mm	4	7	16	RS	6
F06	Dec06	11	RS7-6mm	4	7	19	RS	6
F06	Sep06	1	TORO 1	2	6	ET	5	
F06	Oct06	2	TORO 1	2	30	ET	5	
F06	Oct06	4	TORO 1	2	8	ET	5	
F06	Nov06	8	TORO 1	2	0	ET	5	
F06	Dec06	10	TORO 1	2	5	ET	4	
F06	Dec06	11	TORO 1	2	10	ET	6	
F06	Sep06	1	TORO 2	2	5	ET	6	

F06	Oct06	2	TORO	2	2	30	ET	6
F06	Oct06	4	TORO	2	2	8	ET	6
F06	Nov06	8	TORO	2	2	0	ET	6
F06	Dec06	10	TORO	2	2	4	ET	5
F06	Dec06	11	TORO	2	2	11	ET	6
F06	Sep06	1	TORO	3	2	6	ET	8
F06	Oct06	2	TORO	3	2	29	ET	8
F06	Oct06	4	TORO	3	2	8	ET	8
F06	Nov06	8	TORO	3	2	0	ET	7
F06	Dec06	10	TORO	3	2	4	ET	8
F06	Dec06	11	TORO	3	2	11	ET	8
F06	Sep06	1	TORO	4	2	6	ET	7
F06	Oct06	2	TORO	4	2	29	ET	8
F06	Oct06	4	TORO	4	2	8	ET	7
F06	Nov06	8	TORO	4	2	0	ET	8
F06	Dec06	10	TORO	4	2	4	ET	7
F06	Dec06	11	TORO	4	2	10	ET	8
F06	Sep06	1	WOS	1	2	33	WOS	4
F06	Oct06	2	WOS	1	2	33	WOS	4
F06	Oct06	4	WOS	1	2	29	WOS	4
F06	Nov06	8	WOS	1	2	23	WOS	4
F06	Dec06	10	WOS	1	2	21	WOS	3
F06	Dec06	11	WOS	1	2	21	WOS	4
F06	Sep06	1	WOS	2	2	31	WOS	6
F06	Oct06	2	WOS	2	2	33	WOS	7
F06	Oct06	4	WOS	2	2	28	WOS	7
F06	Nov06	8	WOS	2	2	21	WOS	6
F06	Dec06	10	WOS	2	2	20	WOS	5
F06	Dec06	11	WOS	2	2	21	WOS	5
F06	Sep06	1	WOS	3	2	32	WOS	8
F06	Oct06	2	WOS	3	2	32	WOS	8
F06	Oct06	4	WOS	3	2	28	WOS	8
F06	Nov06	8	WOS	3	2	20	WOS	8
F06	Dec06	10	WOS	3	2	21	WOS	8
F06	Dec06	11	WOS	3	2	20	WOS	8
F06	Sep06	1	WOS	4	2	32	WOS	7
F06	Oct06	2	WOS	4	2	33	WOS	6
F06	Oct06	4	WOS	4	2	28	WOS	7
F06	Nov06	8	WOS	4	2	21	WOS	7
F06	Dec06	10	WOS	4	2	20	WOS	6
F06	Dec06	11	WOS	4	2	21	WOS	6
F07	Sep07	20	AC10	1	2	16	SMS	7
F07	Oct07	24	AC10	1	2	29	SMS	7
F07	Nov07	28	AC10	1	2	10	SMS	6
F07	Sep07	20	AC10	2	2	16	SMS	7
F07	Oct07	24	AC10	2	2	28	SMS	6
F07	Nov07	28	AC10	2	2	10	SMS	5
F07	Sep07	20	AC10	3	2	16	SMS	7
F07	Oct07	24	AC10	3	2	31	SMS	7
F07	Nov07	28	AC10	3	2	14	SMS	7
F07	Sep07	20	AC10	4	2	16	SMS	7
F07	Oct07	24	AC10	4	2	28	SMS	7
F07	Nov07	28	AC10	4	2	10	SMS	6
F07	Sep07	20	AC13	1	2	33	SMS	7
F07	Oct07	24	AC13	1	2	29	SMS	6
F07	Nov07	28	AC13	1	2	26	SMS	6
F07	Sep07	20	AC13	2	2	30	SMS	7

F07	Oct07	24	AC13	2	2	27	SMS	7
F07	Nov07	28	AC13	2	2	24	SMS	6
F07	Sep07	20	AC13	3	2	31	SMS	7
F07	Oct07	24	AC13	3	2	63	SMS	7
F07	Nov07	28	AC13	3	2	25	SMS	6
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F07	Oct07	24	AC13	4	2	28	SMS	7
F07	Nov07	28	AC13	4	2	25	SMS	6
F07	Sep07	20	AC7	1	2	17	SMS	7
F07	Oct07	24	AC7	1	2	15	SMS	7
F07	Nov07	28	AC7	1	2	15	SMS	6
F07	Sep07	20	AC7	2	2	16	SMS	6
F07	Oct07	24	AC7	2	2	14	SMS	7
F07	Nov07	28	AC7	2	2	15	SMS	5
F07	Sep07	20	AC7	3	2	19	SMS	6
F07	Oct07	24	AC7	3	2	17	SMS	5
F07	Nov07	28	AC7	3	2	21	SMS	5
F07	Sep07	20	AC7	4	2	16	SMS	6
F07	Oct07	24	AC7	4	2	15	SMS	6
F07	Nov07	28	AC7	4	2	15	SMS	5
F07	Sep07	20	ACIR	1	2	15	SMS	6
F07	Oct07	24	ACIR	1	2	14	SMS	6
F07	Nov07	28	ACIR	1	2	10	SMS	5
F07	Sep07	20	ACIR	2	2	17	SMS	6
F07	Oct07	24	ACIR	2	2	15	SMS	6
F07	Nov07	28	ACIR	2	2	10	SMS	4
F07	Sep07	20	ACIR	3	2	0	SMS	6
F07	Oct07	24	ACIR	3	2	15	SMS	7
F07	Nov07	28	ACIR	3	2	15	SMS	7
F07	Sep07	20	ACIR	4	2	17	SMS	7
F07	Oct07	24	ACIR	4	2	14	SMS	7
F07	Nov07	28	ACIR	4	2	10	SMS	7
F07	Sep07	20	DWRS	1	2	20	RS	6
F07	Oct07	24	DWRS	1	2	19	RS	7
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F07	Sep07	20	DWRS	2	2	21	RS	8
F07	Oct07	24	DWRS	2	2	17	RS	8
F07	Nov07	28	DWRS	2	2	17	RS	8
F07	Sep07	20	DWRS	3	2	13	RS	8
F07	Oct07	24	DWRS	3	2	16	RS	8
F07	Nov07	28	DWRS	3	2	14	RS	8
F07	Sep07	20	DWRS	4	2	20	RS	6
F07	Oct07	24	DWRS	4	2	20	RS	6
F07	Nov07	28	DWRS	4	2	17	RS	6
F07	Sep07	20	ETM	1	2	15	ET	8
F07	Oct07	24	ETM	1	2	17	ET	6
F07	Nov07	28	ETM	1	2	10	ET	6
F07	Sep07	20	ETM	2	2	16	ET	4
F07	Oct07	24	ETM	2	2	16	ET	4
F07	Nov07	28	ETM	2	2	11	ET	4
F07	Sep07	20	ETM	3	2	16	ET	6
F07	Oct07	24	ETM	3	2	16	ET	7
F07	Nov07	28	ETM	3	2	11	ET	6
F07	Sep07	20	ETM	4	2	16	ET	5
F07	Oct07	24	ETM	4	2	15	ET	6
F07	Nov07	28	ETM	4	2	10	ET	6
F07	Sep07	20	LL4	1	2	32	SMS	5

F07	Oct07	24	LL4	1	2	29	SMS	7
F07	Nov07	28	LL4	1	2	26	SMS	6
F07	Sep07	20	LL4	2	2	31	SMS	5
F07	Oct07	24	LL4	2	2	27	SMS	6
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F07	Sep07	20	LL4	3	2	31	SMS	7
F07	Oct07	24	LL4	3	2	28	SMS	7
F07	Nov07	28	LL4	3	2	24	SMS	7
F07	Sep07	20	LL4	4	2	31	SMS	6
F07	Oct07	24	LL4	4	2	27	SMS	7
F07	Nov07	28	LL4	4	2	24	SMS	6
F07	Sep07	20	LL5	1	2	33	SMS	6
F07	Oct07	24	LL5	1	2	29	SMS	5
F07	Nov07	28	LL5	1	2	26	SMS	5
F07	Sep07	20	LL5	2	2	30	SMS	7
F07	Oct07	24	LL5	2	2	26	SMS	7
F07	Nov07	28	LL5	2	2	24	SMS	6
F07	Sep07	20	LL5	3	2	31	SMS	7
F07	Oct07	24	LL5	3	2	28	SMS	7
F07	Nov07	28	LL5	3	2	25	SMS	7
F07	Sep07	20	LL5	4	2	30	SMS	6
F07	Oct07	24	LL5	4	2	27	SMS	7
F07	Nov07	28	LL5	4	2	24	SMS	6
F07	Sep07	20	LL6	1	2	31	SMS	7
F07	Oct07	24	LL6	1	2	29	SMS	6
F07	Nov07	28	LL6	1	2	24	SMS	5
F07	Sep07	20	LL6	2	2	32	SMS	7
F07	Oct07	24	LL6	2	2	30	SMS	7
F07	Nov07	28	LL6	2	2	26	SMS	6
F07	Sep07	20	LL6	3	2	32	SMS	8
F07	Oct07	24	LL6	3	2	29	SMS	8
F07	Nov07	28	LL6	3	2	24	SMS	7
F07	Sep07	20	LL6	4	2	31	SMS	7
F07	Oct07	24	LL6	4	2	28	SMS	7
F07	Nov07	28	LL6	4	2	25	SMS	6
F07	Sep07	20	NON	1	0	0	.	5
F07	Oct07	24	NON	1	0	0	.	4
F07	Nov07	28	NON	1	0	0	.	3
F07	Sep07	20	NON	2	0	0	.	5
F07	Oct07	24	NON	2	0	0	.	6
F07	Nov07	28	NON	2	0	0	.	5
F07	Sep07	20	NON	3	0	0	.	6
F07	Oct07	24	NON	3	0	0	.	7
F07	Nov07	28	NON	3	0	0	.	6
F07	Sep07	20	NON	4	0	0	.	3
F07	Oct07	24	NON	4	0	0	.	5
F07	Nov07	28	NON	4	0	0	.	5
F07	Sep07	20	RS1-3mm	1	1	32	RS	6
F07	Oct07	24	RS1-3mm	1	1	29	RS	5
F07	Nov07	28	RS1-3mm	1	1	29	RS	4
F07	Sep07	20	RS1-3mm	2	1	32	RS	8
F07	Oct07	24	RS1-3mm	2	1	29	RS	8
F07	Nov07	28	RS1-3mm	2	1	30	RS	7
F07	Sep07	20	RS1-3mm	3	1	31	RS	7
F07	Oct07	24	RS1-3mm	3	1	29	RS	7
F07	Nov07	28	RS1-3mm	3	1	29	RS	7
F07	Sep07	20	RS1-3mm	4	1	33	RS	6

F07	Oct07	24	RS1-3mm	4	1	29	RS	5
F07	Nov07	28	RS1-3mm	4	1	29	RS	5
F07	Sep07	20	RS1-6mm	1	1	32	RS	8
F07	Oct07	24	RS1-6mm	1	1	29	RS	8
F07	Nov07	28	RS1-6mm	1	1	29	RS	8
F07	Sep07	20	RS1-6mm	2	1	31	RS	6
F07	Oct07	24	RS1-6mm	2	1	31	RS	6
F07	Nov07	28	RS1-6mm	2	1	32	RS	5
F07	Sep07	20	RS1-6mm	3	1	30	RS	6
F07	Oct07	24	RS1-6mm	3	1	27	RS	4
F07	Nov07	28	RS1-6mm	3	1	28	RS	4
F07	Sep07	20	RS1-6mm	4	1	31	RS	7
F07	Oct07	24	RS1-6mm	4	1	29	RS	6
F07	Nov07	28	RS1-6mm	4	1	29	RS	6
F07	Sep07	20	RS2-3mm	1	2	31	RS	7
F07	Oct07	24	RS2-3mm	1	2	28	RS	7
F07	Nov07	28	RS2-3mm	1	2	25	RS	6
F07	Sep07	20	RS2-3mm	2	2	32	RS	8
F07	Oct07	24	RS2-3mm	2	2	29	RS	8
F07	Nov07	28	RS2-3mm	2	2	25	RS	8
F07	Sep07	20	RS2-3mm	3	2	31	RS	7
F07	Oct07	24	RS2-3mm	3	2	28	RS	7
F07	Nov07	28	RS2-3mm	3	2	24	RS	6
F07	Sep07	20	RS2-3mm	4	2	31	RS	7
F07	Oct07	24	RS2-3mm	4	2	28	RS	6
F07	Nov07	28	RS2-3mm	4	2	24	RS	5
F07	Sep07	20	RS2-6mm	1	2	31	RS	6
F07	Oct07	24	RS2-6mm	1	2	30	RS	6
F07	Nov07	28	RS2-6mm	1	2	27	RS	4
F07	Sep07	20	RS2-6mm	2	2	32	RS	7
F07	Oct07	24	RS2-6mm	2	2	28	RS	6
F07	Nov07	28	RS2-6mm	2	2	25	RS	5
F07	Sep07	20	RS2-6mm	3	2	33	RS	8
F07	Oct07	24	RS2-6mm	3	2	30	RS	8
F07	Nov07	28	RS2-6mm	3	2	26	RS	7
F07	Sep07	20	RS2-6mm	4	2	31	RS	7
F07	Oct07	24	RS2-6mm	4	2	28	RS	6
F07	Nov07	28	RS2-6mm	4	2	26	RS	6
F07	Sep07	20	RS7-3mm	1	7	29	RS	8
F07	Oct07	24	RS7-3mm	1	7	29	RS	8
F07	Nov07	28	RS7-3mm	1	7	25	RS	8
F07	Sep07	20	RS7-3mm	2	7	29	RS	7
F07	Oct07	24	RS7-3mm	2	7	27	RS	8
F07	Nov07	28	RS7-3mm	2	7	25	RS	7
F07	Sep07	20	RS7-3mm	3	7	31	RS	7
F07	Oct07	24	RS7-3mm	3	7	30	RS	7
F07	Nov07	28	RS7-3mm	3	7	27	RS	6
F07	Sep07	20	RS7-3mm	4	7	29	RS	6
F07	Oct07	24	RS7-3mm	4	7	29	RS	5
F07	Nov07	28	RS7-3mm	4	7	27	RS	4
F07	Sep07	20	RS7-6mm	1	7	28	RS	6
F07	Oct07	24	RS7-6mm	1	7	27	RS	6
F07	Nov07	28	RS7-6mm	1	7	25	RS	5
F07	Sep07	20	RS7-6mm	2	7	30	RS	8
F07	Oct07	24	RS7-6mm	2	7	29	RS	8
F07	Nov07	28	RS7-6mm	2	7	26	RS	9
F07	Sep07	20	RS7-6mm	3	7	29	RS	8

F07	Oct07	24	RS7-6mm	3	7	28	RS	8
F07	Nov07	28	RS7-6mm	3	7	25	RS	6
F07	Sep07	20	RS7-6mm	4	7	30	RS	7
F07	Oct07	24	RS7-6mm	4	7	28	RS	6
F07	Nov07	28	RS7-6mm	4	7	25	RS	6
F07	Sep07	20	TORO	1	2	21	ET	6
F07	Oct07	24	TORO	1	2	17	ET	6
F07	Nov07	28	TORO	1	2	13	ET	5
F07	Sep07	20	TORO	2	2	21	ET	6
F07	Oct07	24	TORO	2	2	18	ET	6
F07	Nov07	28	TORO	2	2	11	ET	4
F07	Sep07	20	TORO	3	2	22	ET	7
F07	Oct07	24	TORO	3	2	19	ET	7
F07	Nov07	28	TORO	3	2	13	ET	6
F07	Sep07	20	TORO	4	2	20	ET	8
F07	Oct07	24	TORO	4	2	17	ET	8
F07	Nov07	28	TORO	4	2	11	ET	8
F07	Sep07	20	WOS	1	2	33	WOS	6
F07	Oct07	24	WOS	1	2	31	WOS	5
F07	Nov07	28	WOS	1	2	25	WOS	4
F07	Sep07	20	WOS	2	2	33	WOS	7
F07	Oct07	24	WOS	2	2	29	WOS	6
F07	Nov07	28	WOS	2	2	25	WOS	5
F07	Sep07	20	WOS	3	2	28	WOS	8
F07	Oct07	24	WOS	3	2	28	WOS	8
F07	Nov07	28	WOS	3	2	25	WOS	8
F07	Sep07	20	WOS	4	2	31	WOS	7
F07	Oct07	24	WOS	4	2	28	WOS	6
F07	Nov07	28	WOS	4	2	26	WOS	6
S06	May06	3	AC10	1	2	27	SMS	7
S06	May06	4	AC10	1	2	40	SMS	6
S06	May06	5	AC10	1	2	27	SMS	6
S06	June06	7	AC10	1	2	17	SMS	5
S06	June06	9	AC10	1	2	32	SMS	5
S06	May06	3	AC10	2	2	27	SMS	6
S06	May06	4	AC10	2	2	40	SMS	6
S06	May06	5	AC10	2	2	27	SMS	5
S06	June06	7	AC10	2	2	16	SMS	5
S06	June06	9	AC10	2	2	32	SMS	5
S06	May06	3	AC10	3	2	28	SMS	7
S06	May06	4	AC10	3	2	40	SMS	7
S06	May06	5	AC10	3	2	28	SMS	7
S06	June06	7	AC10	3	2	17	SMS	7
S06	June06	9	AC10	3	2	34	SMS	7
S06	May06	3	AC10	4	2	27	SMS	6
S06	May06	4	AC10	4	2	40	SMS	7
S06	May06	5	AC10	4	2	27	SMS	6
S06	June06	7	AC10	4	2	17	SMS	7
S06	June06	9	AC10	4	2	33	SMS	6
S06	May06	3	AC13	1	2	28	SMS	6
S06	May06	4	AC13	1	2	41	SMS	5
S06	May06	5	AC13	1	2	28	SMS	5
S06	June06	7	AC13	1	2	33	SMS	5
S06	June06	9	AC13	1	2	34	SMS	4
S06	May06	3	AC13	2	2	27	SMS	7
S06	May06	4	AC13	2	2	39	SMS	6
S06	May06	5	AC13	2	2	28	SMS	6

S06	June06	7	AC13	2	2	34	SMS	6
S06	June06	9	AC13	2	2	34	SMS	6
S06	May06 3	AC13	3	2	27	SMS	6	
S06	May06 4	AC13	3	2	37	SMS	7	
S06	May06 5	AC13	3	2	27	SMS	7	
S06	June06	7	AC13	3	2	32	SMS	7
S06	June06	9	AC13	3	2	32	SMS	7
S06	May06 3	AC13	4	2	27	SMS	7	
S06	May06 4	AC13	4	2	40	SMS	7	
S06	May06 5	AC13	4	2	27	SMS	7	
S06	June06	7	AC13	4	2	33	SMS	7
S06	June06	9	AC13	4	2	33	SMS	7
S06	May06 3	AC7	1	2	14	SMS	8	
S06	May06 4	AC7	1	2	26	SMS	7	
S06	May06 5	AC7	1	2	27	SMS	4	
S06	June06	7	AC7	1	2	17	SMS	6
S06	June06	9	AC7	1	2	17	SMS	5
S06	May06 3	AC7	2	2	14	SMS	4	
S06	May06 4	AC7	2	2	24	SMS	5	
S06	May06 5	AC7	2	2	27	SMS	3	
S06	June06	7	AC7	2	2	17	SMS	3
S06	June06	9	AC7	2	2	18	SMS	3
S06	May06 3	AC7	3	2	15	SMS	7	
S06	May06 4	AC7	3	2	27	SMS	6	
S06	May06 5	AC7	3	2	29	SMS	5	
S06	June06	7	AC7	3	2	17	SMS	5
S06	June06	9	AC7	3	2	17	SMS	4
S06	May06 3	AC7	4	2	14	SMS	6	
S06	May06 4	AC7	4	2	24	SMS	6	
S06	May06 5	AC7	4	2	26	SMS	5	
S06	June06	7	AC7	4	2	17	SMS	4
S06	June06	9	AC7	4	2	17	SMS	5
S06	May06 3	ACIR	1	2	27	SMS	7	
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S06	May06 5	ACIR	1	2	27	SMS	6	
S06	June06	7	ACIR	1	2	17	SMS	5
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S06	May06 4	ACIR	2	2	41	SMS	5	
S06	May06 5	ACIR	2	2	27	SMS	4	
S06	June06	7	ACIR	2	2	18	SMS	3
S06	June06	9	ACIR	2	2	17	SMS	3
S06	May06 3	ACIR	3	2	24	SMS	6	
S06	May06 4	ACIR	3	2	30	SMS	7	
S06	May06 5	ACIR	3	2	23	SMS	5	
S06	June06	7	ACIR	3	2	34	SMS	7
S06	June06	9	ACIR	3	2	17	SMS	7
S06	May06 3	ACIR	4	2	24	SMS	7	
S06	May06 4	ACIR	4	2	18	SMS	6	
S06	May06 5	ACIR	4	2	27	SMS	6	
S06	June06	7	ACIR	4	2	8	SMS	7
S06	June06	9	ACIR	4	2	17	SMS	7
S06	May06 3	DWRS	1	2	27	RS	5	
S06	May06 4	DWRS	1	2	28	RS	6	
S06	May06 5	DWRS	1	2	22	RS	5	
S06	June06	7	DWRS	1	2	20	RS	5
S06	June06	9	DWRS	1	2	20	RS	5

S06	May06	3	DWRS	2	2	27	RS	8
S06	May06	4	DWRS	2	2	27	RS	6
S06	May06	5	DWRS	2	2	23	RS	7
S06	June06	7	DWRS	2	2	21	RS	5
S06	June06	9	DWRS	2	2	19	RS	5
S06	May06	3	DWRS	3	2	27	RS	8
S06	May06	4	DWRS	3	2	27	RS	8
S06	May06	5	DWRS	3	2	22	RS	8
S06	June06	7	DWRS	3	2	19	RS	7
S06	June06	9	DWRS	3	2	18	RS	7
S06	May06	3	DWRS	4	2	25	RS	7
S06	May06	4	DWRS	4	2	24	RS	7
S06	May06	5	DWRS	4	2	22	RS	7
S06	June06	7	DWRS	4	2	19	RS	6
S06	June06	9	DWRS	4	2	20	RS	7
S06	May06	3	LL2	1	2	27	SMS	5
S06	May06	4	LL2	1	2	28	SMS	7
S06	May06	5	LL2	1	2	14	SMS	6
S06	June06	7	LL2	1	2	0	SMS	4
S06	June06	9	LL2	1	2	0	SMS	4
S06	May06	3	LL2	2	2	27	SMS	4
S06	May06	4	LL2	2	2	27	SMS	5
S06	May06	5	LL2	2	2	14	SMS	5
S06	June06	7	LL2	2	2	0	SMS	4
S06	June06	9	LL2	2	2	0	SMS	4
S06	May06	3	LL2	3	2	27	SMS	4
S06	May06	4	LL2	3	2	27	SMS	7
S06	May06	5	LL2	3	2	14	SMS	5
S06	June06	7	LL2	3	2	0	SMS	3
S06	June06	9	LL2	3	2	0	SMS	4
S06	May06	3	LL2	4	2	26	SMS	2
S06	May06	4	LL2	4	2	27	SMS	4
S06	May06	5	LL2	4	2	13	SMS	3
S06	June06	7	LL2	4	2	0	SMS	2
S06	June06	9	LL2	4	2	0	SMS	2
S06	May06	3	LL5	1	2	41	SMS	4
S06	May06	4	LL5	1	2	40	SMS	6
S06	May06	5	LL5	1	2	40	SMS	7
S06	June06	7	LL5	1	2	45	SMS	7
S06	June06	9	LL5	1	2	17	SMS	6
S06	May06	3	LL5	2	2	41	SMS	5
S06	May06	4	LL5	2	2	40	SMS	7
S06	May06	5	LL5	2	2	40	SMS	8
S06	June06	7	LL5	2	2	46	SMS	6
S06	June06	9	LL5	2	2	17	SMS	7
S06	May06	3	LL5	3	2	41	SMS	4
S06	May06	4	LL5	3	2	40	SMS	7
S06	May06	5	LL5	3	2	41	SMS	7
S06	June06	7	LL5	3	2	46	SMS	7
S06	June06	9	LL5	3	2	17	SMS	6
S06	May06	3	LL5	4	2	38	SMS	5
S06	May06	4	LL5	4	2	38	SMS	7
S06	May06	5	LL5	4	2	40	SMS	8
S06	June06	7	LL5	4	2	45	SMS	8
S06	June06	9	LL5	4	2	16	SMS	8
S06	May06	3	LL8	1	2	48	SMS	6
S06	May06	4	LL8	1	2	55	SMS	7

S06	May06 5	LL8	1	2	51	SMS	8		
S06	June06	7	LL8	1	2	72	SMS	7	
S06	June06	9	LL8	1	2	17	SMS	7	
S06	May06 3	LL8	2	2	47	SMS	6		
S06	May06 4	LL8	2	2	55	SMS	7		
S06	May06 5	LL8	2	2	51	SMS	8		
S06	June06	7	LL8	2	2	72	SMS	8	
S06	June06	9	LL8	2	2	16	SMS	8	
S06	May06 3	LL8	3	2	48	SMS	6		
S06	May06 4	LL8	3	2	54	SMS	8		
S06	May06 5	LL8	3	2	51	SMS	8		
S06	June06	7	LL8	3	2	73	SMS	8	
S06	June06	9	LL8	3	2	17	SMS	7	
S06	May06 3	LL8	4	2	49	SMS	4		
S06	May06 4	LL8	4	2	53	SMS	5		
S06	May06 5	LL8	4	2	51	SMS	6		
S06	June06	7	LL8	4	2	72	SMS	5	
S06	June06	9	LL8	4	2	17	SMS	5	
S06	May06 3	NON	1	0	0	.	1		
S06	May06 4	NON	1	0	0	.	1		
S06	May06 5	NON	1	0	0	.	1		
S06	June06	7	NON	1	0	0	.	1	
S06	June06	9	NON	1	0	0	.	1	
S06	May06 3	NON	2	0	0	.	2		
S06	May06 4	NON	2	0	0	.	1		
S06	May06 5	NON	2	0	0	.	1		
S06	June06	7	NON	2	0	0	.	1	
S06	June06	9	NON	2	0	0	.	1	
S06	May06 3	NON	3	0	0	.	3		
S06	May06 4	NON	3	0	0	.	1		
S06	May06 5	NON	3	0	0	.	1		
S06	June06	7	NON	3	0	0	.	1	
S06	June06	9	NON	3	0	0	.	2	
S06	May06 3	NON	4	0	0	.	4		
S06	May06 4	NON	4	0	0	.	1		
S06	May06 5	NON	4	0	0	.	1		
S06	June06	7	NON	4	0	0	.	1	
S06	June06	9	NON	4	0	0	.	2	
S06	May06 3	RS1-3mm	1	1	27	RS	4		
S06	May06 4	RS1-3mm	1	1	27	RS	6		
S06	May06 5	RS1-3mm	1	1	27	RS	6		
S06	June06	7	RS1-3mm	1	1	33	RS	4	
S06	June06	9	RS1-3mm	1	1	33	RS	4	
S06	May06 3	RS1-3mm	2	1	27	RS	5		
S06	May06 4	RS1-3mm	2	1	27	RS	8		
S06	May06 5	RS1-3mm	2	1	27	RS	8		
S06	June06	7	RS1-3mm	2	1	33	RS	8	
S06	June06	9	RS1-3mm	2	1	33	RS	8	
S06	May06 3	RS1-3mm	3	1	24	RS	2		
S06	May06 4	RS1-3mm	3	1	24	RS	4		
S06	May06 5	RS1-3mm	3	1	27	RS	4		
S06	June06	7	RS1-3mm	3	1	34	RS	3	
S06	June06	9	RS1-3mm	3	1	33	RS	2	
S06	May06 3	RS1-3mm	4	1	29	RS	2		
S06	May06 4	RS1-3mm	4	1	27	RS	4		
S06	May06 5	RS1-3mm	4	1	27	RS	3		
S06	June06	7	RS1-3mm	4	1	33	RS	3	

S06	June06	9	RS1-3mm	4	1	33	RS	3
S06	May06 3	RS1-6mm	1	1	28	RS	2	
S06	May06 4	RS1-6mm	1	1	28	RS	4	
S06	May06 5	RS1-6mm	1	1	28	RS	3	
S06	June06	7	RS1-6mm	1	1	34	RS	3
S06	June06	9	RS1-6mm	1	1	34	RS	3
S06	May06 3	RS1-6mm	2	1	27	RS	5	
S06	May06 4	RS1-6mm	2	1	27	RS	7	
S06	May06 5	RS1-6mm	2	1	28	RS	7	
S06	June06	7	RS1-6mm	2	1	33	RS	6
S06	June06	9	RS1-6mm	2	1	33	RS	6
S06	May06 3	RS1-6mm	3	1	27	RS	4	
S06	May06 4	RS1-6mm	3	1	26	RS	8	
S06	May06 5	RS1-6mm	3	1	27	RS	8	
S06	June06	7	RS1-6mm	3	1	33	RS	8
S06	June06	9	RS1-6mm	3	1	33	RS	7
S06	May06 3	RS1-6mm	4	1	26	RS	4	
S06	May06 4	RS1-6mm	4	1	27	RS	7	
S06	May06 5	RS1-6mm	4	1	27	RS	6	
S06	June06	7	RS1-6mm	4	1	32	RS	4
S06	June06	9	RS1-6mm	4	1	33	RS	4
S06	May06 3	RS2-3mm	1	2	26	RS	7	
S06	May06 4	RS2-3mm	1	2	27	RS	5	
S06	May06 5	RS2-3mm	1	2	26	RS	4	
S06	June06	7	RS2-3mm	1	2	32	RS	4
S06	June06	9	RS2-3mm	1	2	32	RS	4
S06	May06 3	RS2-3mm	2	2	27	RS	7	
S06	May06 4	RS2-3mm	2	2	27	RS	7	
S06	May06 5	RS2-3mm	2	2	26	RS	6	
S06	June06	7	RS2-3mm	2	2	33	RS	6
S06	June06	9	RS2-3mm	2	2	33	RS	6
S06	May06 3	RS2-3mm	3	2	25	RS	6	
S06	May06 4	RS2-3mm	3	2	25	RS	7	
S06	May06 5	RS2-3mm	3	2	25	RS	6	
S06	June06	7	RS2-3mm	3	2	31	RS	6
S06	June06	9	RS2-3mm	3	2	30	RS	6
S06	May06 3	RS2-3mm	4	2	26	RS	8	
S06	May06 4	RS2-3mm	4	2	27	RS	7	
S06	May06 5	RS2-3mm	4	2	27	RS	6	
S06	June06	7	RS2-3mm	4	2	33	RS	6
S06	June06	9	RS2-3mm	4	2	33	RS	5
S06	May06 3	RS2-6mm	1	2	27	RS	7	
S06	May06 4	RS2-6mm	1	2	27	RS	7	
S06	May06 5	RS2-6mm	1	2	27	RS	6	
S06	June06	7	RS2-6mm	1	2	33	RS	5
S06	June06	9	RS2-6mm	1	2	33	RS	6
S06	May06 3	RS2-6mm	2	2	28	RS	8	
S06	May06 4	RS2-6mm	2	2	27	RS	7	
S06	May06 5	RS2-6mm	2	2	28	RS	7	
S06	June06	7	RS2-6mm	2	2	34	RS	7
S06	June06	9	RS2-6mm	2	2	34	RS	8
S06	May06 3	RS2-6mm	3	2	27	RS	3	
S06	May06 4	RS2-6mm	3	2	27	RS	4	
S06	May06 5	RS2-6mm	3	2	27	RS	3	
S06	June06	7	RS2-6mm	3	2	33	RS	3
S06	June06	9	RS2-6mm	3	2	33	RS	3
S06	May06 3	RS2-6mm	4	2	26	RS	8	

S06	May06	4	RS2-6mm	4	2	27	RS	7
S06	May06	5	RS2-6mm	4	2	27	RS	6
S06	June06	7	RS2-6mm	4	2	32	RS	8
S06	June06	9	RS2-6mm	4	2	33	RS	8
S06	May06	3	RS7-3mm	1	7	17	RS	7
S06	May06	4	RS7-3mm	1	7	28	RS	6
S06	May06	5	RS7-3mm	1	7	28	RS	6
S06	June06	7	RS7-3mm	1	7	25	RS	5
S06	June06	9	RS7-3mm	1	7	20	RS	6
S06	May06	3	RS7-3mm	2	7	17	RS	8
S06	May06	4	RS7-3mm	2	7	27	RS	7
S06	May06	5	RS7-3mm	2	7	29	RS	7
S06	June06	7	RS7-3mm	2	7	23	RS	7
S06	June06	9	RS7-3mm	2	7	19	RS	8
S06	May06	3	RS7-3mm	3	7	16	RS	6
S06	May06	4	RS7-3mm	3	7	29	RS	6
S06	May06	5	RS7-3mm	3	7	28	RS	5
S06	June06	7	RS7-3mm	3	7	24	RS	4
S06	June06	9	RS7-3mm	3	7	20	RS	5
S06	May06	3	RS7-3mm	4	7	16	RS	6
S06	May06	4	RS7-3mm	4	7	28	RS	6
S06	May06	5	RS7-3mm	4	7	28	RS	5
S06	June06	7	RS7-3mm	4	7	23	RS	7
S06	June06	9	RS7-3mm	4	7	19	RS	6
S06	May06	3	WOS	1	2	27	WOS	4
S06	May06	4	WOS	1	2	29	WOS	3
S06	May06	5	WOS	1	2	27	WOS	3
S06	June06	7	WOS	1	2	33	WOS	3
S06	June06	9	WOS	1	2	33	WOS	3
S06	May06	3	WOS	2	2	27	WOS	6
S06	May06	4	WOS	2	2	25	WOS	5
S06	May06	5	WOS	2	2	27	WOS	4
S06	June06	7	WOS	2	2	33	WOS	4
S06	June06	9	WOS	2	2	33	WOS	5
S06	May06	3	WOS	3	2	27	WOS	8
S06	May06	4	WOS	3	2	25	WOS	8
S06	May06	5	WOS	3	2	26	WOS	7
S06	June06	7	WOS	3	2	31	WOS	8
S06	June06	9	WOS	3	2	31	WOS	8
S06	May06	3	WOS	4	2	27	WOS	8
S06	May06	4	WOS	4	2	27	WOS	7
S06	May06	5	WOS	4	2	27	WOS	6
S06	June06	7	WOS	4	2	32	WOS	6
S06	June06	9	WOS	4	2	33	WOS	6
S07	May07	1	AC10	1	2	43	SMS	7
S07	May07	3	AC10	1	2	50	SMS	7
S07	May07	4	AC10	1	2	43	SMS	7
S07	Jun07	7	AC10	1	2	17	SMS	6
S07	Jul07	9	AC10	1	2	17	SMS	7
S07	Jul07	12	AC10	1	2	31	SMS	6
S07	Aug07	14	AC10	1	2	20	SMS	8
S07	Aug07	17	AC10	1	2	41	SMS	8
S07	May07	1	AC10	2	2	42	SMS	7
S07	May07	3	AC10	2	2	49	SMS	6
S07	May07	4	AC10	2	2	43	SMS	6
S07	Jun07	7	AC10	2	2	16	SMS	5
S07	Jul07	9	AC10	2	2	17	SMS	6

S07	Jul07	12	AC10	2	2	31	SMS	6
S07	Aug07	14	AC10	2	2	20	SMS	7
S07	Aug07	17	AC10	2	2	41	SMS	7
S07	May07	1	AC10	3	2	43	SMS	6
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S07	May07	4	AC10	3	2	44	SMS	6
S07	Jun07	7	AC10	3	2	17	SMS	6
S07	Jul07	9	AC10	3	2	18	SMS	7
S07	Jul07	12	AC10	3	2	32	SMS	7
S07	Aug07	14	AC10	3	2	21	SMS	7
S07	Aug07	17	AC10	3	2	42	SMS	8
S07	May07	1	AC10	4	2	43	SMS	6
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S07	May07	4	AC10	4	2	43	SMS	6
S07	Jun07	7	AC10	4	2	17	SMS	6
S07	Jul07	9	AC10	4	2	17	SMS	6
S07	Jul07	12	AC10	4	2	32	SMS	6
S07	Aug07	14	AC10	4	2	21	SMS	7
S07	Aug07	17	AC10	4	2	42	SMS	7
S07	May07	1	AC13	1	2	44	SMS	6
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S07	Aug07	14	AC13	1	2	22	SMS	7
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S07	May07	1	AC13	2	2	43	SMS	6
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S07	May07	4	AC13	2	2	43	SMS	7
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S07	Jul07	12	AC13	4	2	31	SMS	6
S07	Aug07	14	AC13	4	2	21	SMS	7
S07	Aug07	17	AC13	4	2	41	SMS	7
S07	May07	1	AC7	1	2	28	SMS	7
S07	May07	3	AC7	1	2	28	SMS	6
S07	May07	4	AC7	1	2	21	SMS	6
S07	Jun07	7	AC7	1	2	17	SMS	6
S07	Jul07	9	AC7	1	2	17	SMS	7
S07	Jul07	12	AC7	1	2	16	SMS	6

S07	Aug07	14	AC7	1	2	0	SMS	8
S07	Aug07	17	AC7	1	2	21	SMS	8
S07	May07	1	AC7	2	2	29	SMS	5
S07	May07	3	AC7	2	2	28	SMS	5
S07	May07	4	AC7	2	2	22	SMS	5
S07	Jun07	7	AC7	2	2	16	SMS	5
S07	Jul07	9	AC7	2	2	17	SMS	4
S07	Jul07	12	AC7	2	2	16	SMS	5
S07	Aug07	14	AC7	2	2	0	SMS	7
S07	Aug07	17	AC7	2	2	20	SMS	7
S07	May07	1	AC7	3	2	31	SMS	5
S07	May07	3	AC7	3	2	31	SMS	5
S07	May07	4	AC7	3	2	23	SMS	5
S07	Jun07	7	AC7	3	2	17	SMS	5
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S07	Aug07	17	AC7	3	2	23	SMS	6
S07	May07	1	AC7	4	2	27	SMS	5
S07	May07	3	AC7	4	2	28	SMS	5
S07	May07	4	AC7	4	2	21	SMS	6
S07	Jun07	7	AC7	4	2	17	SMS	6
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S07	Jul07	12	AC7	4	2	16	SMS	6
S07	Aug07	14	AC7	4	2	0	SMS	6
S07	Aug07	17	AC7	4	2	20	SMS	7
S07	May07	1	ACIR	1	2	42	SMS	6
S07	May07	3	ACIR	1	2	50	SMS	6
S07	May07	4	ACIR	1	2	21	SMS	6
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S07	Aug07	14	ACIR	1	2	20	SMS	7
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S07	May07	1	ACIR	2	2	44	SMS	4
S07	May07	3	ACIR	2	2	29	SMS	4
S07	May07	4	ACIR	2	2	43	SMS	4
S07	Jun07	7	ACIR	2	2	17	SMS	4
S07	Jul07	9	ACIR	2	2	17	SMS	4
S07	Jul07	12	ACIR	2	2	17	SMS	4
S07	Aug07	14	ACIR	2	2	21	SMS	6
S07	Aug07	17	ACIR	2	2	22	SMS	7
S07	May07	1	ACIR	3	2	22	SMS	6
S07	May07	3	ACIR	3	2	28	SMS	4
S07	May07	4	ACIR	3	2	44	SMS	6
S07	Jun07	7	ACIR	3	2	17	SMS	6
S07	Jul07	9	ACIR	3	2	17	SMS	6
S07	Jul07	12	ACIR	3	2	16	SMS	6
S07	Aug07	14	ACIR	3	2	0	SMS	7
S07	Aug07	17	ACIR	3	2	21	SMS	7
S07	May07	1	ACIR	4	2	11	SMS	6
S07	May07	3	ACIR	4	2	29	SMS	6
S07	May07	4	ACIR	4	2	21	SMS	6
S07	Jun07	7	ACIR	4	2	17	SMS	6
S07	Jul07	9	ACIR	4	2	17	SMS	6
S07	Jul07	12	ACIR	4	2	17	SMS	6
S07	Aug07	14	ACIR	4	2	0	SMS	6

S07	Aug07	17	ACIR	4	2	20	SMS	7
S07	May07	1	DWRS	1	2	26	RS	6
S07	May07	3	DWRS	1	2	34	RS	6
S07	May07	4	DWRS	1	2	26	RS	7
S07	Jun07	7	DWRS	1	2	20	RS	7
S07	Jul07	9	DWRS	1	2	10	RS	6
S07	Jul07	12	DWRS	1	2	20	RS	6
S07	Aug07	14	DWRS	1	2	14	RS	7
S07	Aug07	17	DWRS	1	2	26	RS	7
S07	May07	1	DWRS	2	2	25	RS	7
S07	May07	3	DWRS	2	2	33	RS	7
S07	May07	4	DWRS	2	2	25	RS	7
S07	Jun07	7	DWRS	2	2	19	RS	7
S07	Jul07	9	DWRS	2	2	10	RS	8
S07	Jul07	12	DWRS	2	2	19	RS	8
S07	Aug07	14	DWRS	2	2	13	RS	8
S07	Aug07	17	DWRS	2	2	25	RS	8
S07	May07	1	DWRS	3	2	26	RS	6
S07	May07	3	DWRS	3	2	33	RS	7
S07	May07	4	DWRS	3	2	26	RS	6
S07	Jun07	7	DWRS	3	2	19	RS	7
S07	Jul07	9	DWRS	3	2	10	RS	8
S07	Jul07	12	DWRS	3	2	20	RS	8
S07	Aug07	14	DWRS	3	2	13	RS	8
S07	Aug07	17	DWRS	3	2	22	RS	8
S07	May07	1	DWRS	4	2	26	RS	6
S07	May07	3	DWRS	4	2	33	RS	6
S07	May07	4	DWRS	4	2	25	RS	6
S07	Jun07	7	DWRS	4	2	19	RS	6
S07	Jul07	9	DWRS	4	2	9	RS	6
S07	Jul07	12	DWRS	4	2	21	RS	6
S07	Aug07	14	DWRS	4	2	14	RS	7
S07	Aug07	17	DWRS	4	2	26	RS	7
S07	May07	1	ETM	1	2	21	ET	8
S07	May07	3	ETM	1	2	29	ET	6
S07	May07	4	ETM	1	2	23	ET	4
S07	Jun07	7	ETM	1	2	17	ET	7
S07	Jul07	9	ETM	1	2	17	ET	6
S07	Jul07	12	ETM	1	2	0	ET	5
S07	Aug07	14	ETM	1	2	0	ET	6
S07	Aug07	17	ETM	1	2	4	ET	6
S07	May07	1	ETM	2	2	21	ET	5
S07	May07	3	ETM	2	2	29	ET	3
S07	May07	4	ETM	2	2	22	ET	2
S07	Jun07	7	ETM	2	2	17	ET	3
S07	Jul07	9	ETM	2	2	17	ET	3
S07	Jul07	12	ETM	2	2	0	ET	3
S07	Aug07	14	ETM	2	2	0	ET	4
S07	Aug07	17	ETM	2	2	5	ET	3
S07	May07	1	ETM	3	2	22	ET	6
S07	May07	3	ETM	3	2	45	ET	4
S07	May07	4	ETM	3	2	22	ET	3
S07	Jun07	7	ETM	3	2	16	ET	4
S07	Jul07	9	ETM	3	2	19	ET	4
S07	Jul07	12	ETM	3	2	0	ET	5
S07	Aug07	14	ETM	3	2	0	ET	6
S07	Aug07	17	ETM	3	2	5	ET	5

S07	May07	1	ETM	4	2	21	ET	6
S07	May07	3	ETM	4	2	29	ET	4
S07	May07	4	ETM	4	2	21	ET	3
S07	Jun07	7	ETM	4	2	17	ET	3
S07	Jul07	9	ETM	4	2	17	ET	4
S07	Jul07	12	ETM	4	2	0	ET	4
S07	Aug07	14	ETM	4	2	0	ET	5
S07	Aug07	17	ETM	4	2	5	ET	4
S07	May07	1	LL5	1	2	67	SMS	6
S07	May07	3	LL5	1	2	50	SMS	6
S07	May07	4	LL5	1	2	43	SMS	6
S07	Jun07	7	LL5	1	2	33	SMS	6
S07	Jul07	9	LL5	1	2	17	SMS	6
S07	Jul07	12	LL5	1	2	0	SMS	6
S07	Aug07	14	LL5	1	2	21	SMS	6
S07	Aug07	17	LL5	1	2	42	SMS	7
S07	May07	1	LL5	2	2	66	SMS	6
S07	May07	3	LL5	2	2	50	SMS	7
S07	May07	4	LL5	2	2	42	SMS	6
S07	Jun07	7	LL5	2	2	32	SMS	7
S07	Jul07	9	LL5	2	2	17	SMS	7
S07	Jul07	12	LL5	2	2	0	SMS	7
S07	Aug07	14	LL5	2	2	19	SMS	7
S07	Aug07	17	LL5	2	2	40	SMS	8
S07	May07	1	LL5	3	2	67	SMS	6
S07	May07	3	LL5	3	2	50	SMS	5
S07	May07	4	LL5	3	2	42	SMS	6
S07	Jun07	7	LL5	3	2	32	SMS	6
S07	Jul07	9	LL5	3	2	17	SMS	6
S07	Jul07	12	LL5	3	2	0	SMS	7
S07	Aug07	14	LL5	3	2	20	SMS	7
S07	Aug07	17	LL5	3	2	41	SMS	7
S07	May07	1	LL5	4	2	65	SMS	6
S07	May07	3	LL5	4	2	49	SMS	6
S07	May07	4	LL5	4	2	42	SMS	7
S07	Jun07	7	LL5	4	2	33	SMS	7
S07	Jul07	9	LL5	4	2	16	SMS	7
S07	Jul07	12	LL5	4	2	0	SMS	7
S07	Aug07	14	LL5	4	2	20	SMS	7
S07	Aug07	17	LL5	4	2	41	SMS	8
S07	May07	1	LL6	1	2	66	SMS	6
S07	May07	3	LL6	1	2	50	SMS	6
S07	May07	4	LL6	1	2	42	SMS	6
S07	Jun07	7	LL6	1	2	33	SMS	6
S07	Jul07	9	LL6	1	2	32	SMS	7
S07	Jul07	12	LL6	1	2	31	SMS	6
S07	Aug07	14	LL6	1	2	40	SMS	7
S07	Aug07	17	LL6	1	2	41	SMS	7
S07	May07	1	LL6	2	2	66	SMS	6
S07	May07	3	LL6	2	2	49	SMS	6
S07	May07	4	LL6	2	2	43	SMS	7
S07	Jun07	7	LL6	2	2	33	SMS	7
S07	Jul07	9	LL6	2	2	31	SMS	7
S07	Jul07	12	LL6	2	2	28	SMS	7
S07	Aug07	14	LL6	2	2	35	SMS	7
S07	Aug07	17	LL6	2	2	43	SMS	8
S07	May07	1	LL6	3	2	67	SMS	7

S07	May07	3	LL6	3	2	50	SMS	6	
S07	May07	4	LL6	3	2	43	SMS	7	
S07	Jun07	7	LL6	3	2	33	SMS	7	
S07	Jul07	9	LL6	3	2	32	SMS	7	
S07	Jul07	12	LL6	3	2	31	SMS	7	
S07	Aug07	14	LL6	3	2	42	SMS	8	
S07	Aug07	17	LL6	3	2	42	SMS	8	
S07	May07	1	LL6	4	2	66	SMS	6	
S07	May07	3	LL6	4	2	49	SMS	7	
S07	May07	4	LL6	4	2	42	SMS	6	
S07	Jun07	7	LL6	4	2	33	SMS	7	
S07	Jul07	9	LL6	4	2	31	SMS	7	
S07	Jul07	12	LL6	4	2	31	SMS	7	
S07	Aug07	14	LL6	4	2	41	SMS	7	
S07	Aug07	17	LL6	4	2	41	SMS	7	
S07	May07	1	RS1-6mm	1	1	44	RS	7	
S07	May07	3	RS1-6mm	1	1	52	RS	6	
S07	May07	4	RS1-6mm	1	1	44	RS	7	
S07	Jun07	7	RS1-6mm	1	1	34	RS	8	
S07	Jul07	9	RS1-6mm	1	1	33	RS	8	
S07	Jul07	12	RS1-6mm	1	1	33	RS	7	
S07	Aug07	14	RS1-6mm	1	1	0	RS	8	
S07	Aug07	17	RS1-6mm	1	1	42	RS	8	
S07	May07	1	RS1-6mm	2	1	43	RS	4	
S07	May07	3	RS1-6mm	2	1	51	RS	5	
S07	May07	4	RS1-6mm	2	1	43	RS	4	
S07	Jun07	7	RS1-6mm	2	1	33	RS	5	
S07	Jul07	9	RS1-6mm	2	1	33	RS	5	
S07	Jul07	12	RS1-6mm	2	1	32	RS	6	
S07	Aug07	14	RS1-6mm	2	1	0	RS	6	
S07	Aug07	17	RS1-6mm	2	1	41	RS	7	
S07	May07	1	RS1-6mm	3	1	42	RS	4	
S07	May07	3	RS1-6mm	3	1	50	RS	4	
S07	May07	4	RS1-6mm	3	1	42	RS	4	
S07	Jun07	7	RS1-6mm	3	1	33	RS	4	
S07	Jul07	9	RS1-6mm	3	1	32	RS	5	
S07	Jul07	12	RS1-6mm	3	1	31	RS	4	
S07	Aug07	14	RS1-6mm	3	1	0	RS	6	
S07	Aug07	17	RS1-6mm	3	1	40	RS	6	
S07	May07	1	RS1-6mm	4	1	42	RS	5	
S07	May07	3	RS1-6mm	4	1	50	RS	6	
S07	May07	4	RS1-6mm	4	1	42	RS	5	
S07	Jun07	7	RS1-6mm	4	1	33	RS	6	
S07	Jul07	9	RS1-6mm	4	1	32	RS	6	
S07	Jul07	12	RS1-6mm	4	1	32	RS	6	
S07	Aug07	14	RS1-6mm	4	1	0	RS	7	
S07	Aug07	17	RS1-6mm	4	1	41	RS	7	
S07	May07	1	RS2-3mm	1	2	43	RS	6	
S07	May07	3	RS2-3mm	1	2	51	RS	7	
S07	May07	4	RS2-3mm	1	2	21	RS	7	
S07	Jun07	7	RS2-3mm	1	2	33	RS	7	
S07	Jul07	9	RS2-3mm	1	2	16	RS	7	
S07	Jul07	12	RS2-3mm	1	2	31	RS	7	
S07	Aug07	14	RS2-3mm	1	2	20	RS	8	
S07	Aug07	17	RS2-3mm	1	2	40	RS	8	
S07	May07	1	RS2-3mm	2	2	43	RS	7	
S07	May07	3	RS2-3mm	2	2	51	RS	7	

S07	May07	4	RS2-3mm	2	2	22	RS	6
S07	Jun07	7	RS2-3mm	2	2	33	RS	7
S07	Jul07	9	RS2-3mm	2	2	18	RS	7
S07	Jul07	12	RS2-3mm	2	2	31	RS	7
S07	Aug07	14	RS2-3mm	2	2	20	RS	8
S07	Aug07	17	RS2-3mm	2	2	42	RS	8
S07	May07	1	RS2-3mm	3	2	43	RS	5
S07	May07	3	RS2-3mm	3	2	50	RS	6
S07	May07	4	RS2-3mm	3	2	21	RS	6
S07	Jun07	7	RS2-3mm	3	2	32	RS	6
S07	Jul07	9	RS2-3mm	3	2	16	RS	6
S07	Jul07	12	RS2-3mm	3	2	31	RS	7
S07	Aug07	14	RS2-3mm	3	2	20	RS	7
S07	Aug07	17	RS2-3mm	3	2	41	RS	7
S07	May07	1	RS2-3mm	4	2	42	RS	6
S07	May07	3	RS2-3mm	4	2	50	RS	6
S07	May07	4	RS2-3mm	4	2	21	RS	6
S07	Jun07	7	RS2-3mm	4	2	33	RS	6
S07	Jul07	9	RS2-3mm	4	2	17	RS	7
S07	Jul07	12	RS2-3mm	4	2	31	RS	6
S07	Aug07	14	RS2-3mm	4	2	21	RS	7
S07	Aug07	17	RS2-3mm	4	2	41	RS	7
S07	May07	1	RS2-6mm	1	2	43	RS	5
S07	May07	3	RS2-6mm	1	2	50	RS	6
S07	May07	4	RS2-6mm	1	2	43	RS	5
S07	Jun07	7	RS2-6mm	1	2	32	RS	5
S07	Jul07	9	RS2-6mm	1	2	17	RS	6
S07	Jul07	12	RS2-6mm	1	2	32	RS	5
S07	Aug07	14	RS2-6mm	1	2	20	RS	6
S07	Aug07	17	RS2-6mm	1	2	42	RS	7
S07	May07	1	RS2-6mm	2	2	43	RS	4
S07	May07	3	RS2-6mm	2	2	50	RS	5
S07	May07	4	RS2-6mm	2	2	43	RS	5
S07	Jun07	7	RS2-6mm	2	2	33	RS	4
S07	Jul07	9	RS2-6mm	2	2	17	RS	6
S07	Jul07	12	RS2-6mm	2	2	31	RS	7
S07	Aug07	14	RS2-6mm	2	2	20	RS	7
S07	Aug07	17	RS2-6mm	2	2	41	RS	7
S07	May07	1	RS2-6mm	3	2	44	RS	4
S07	May07	3	RS2-6mm	3	2	50	RS	5
S07	May07	4	RS2-6mm	3	2	42	RS	5
S07	Jun07	7	RS2-6mm	3	2	33	RS	5
S07	Jul07	9	RS2-6mm	3	2	17	RS	6
S07	Jul07	12	RS2-6mm	3	2	32	RS	7
S07	Aug07	14	RS2-6mm	3	2	22	RS	8
S07	Aug07	17	RS2-6mm	3	2	43	RS	8
S07	May07	1	RS2-6mm	4	2	43	RS	7
S07	May07	3	RS2-6mm	4	2	50	RS	6
S07	May07	4	RS2-6mm	4	2	42	RS	7
S07	Jun07	7	RS2-6mm	4	2	33	RS	7
S07	Jul07	9	RS2-6mm	4	2	17	RS	7
S07	Jul07	12	RS2-6mm	4	2	32	RS	7
S07	Aug07	14	RS2-6mm	4	2	21	RS	7
S07	Aug07	17	RS2-6mm	4	2	42	RS	6
S07	May07	1	RS7-3mm	1	7	46	RS	6
S07	May07	3	RS7-3mm	1	7	53	RS	6
S07	May07	4	RS7-3mm	1	7	39	RS	7

S07	Jun07	7	RS7-3mm	1	7	28	RS	8
S07	Jul07	9	RS7-3mm	1	7	24	RS	7
S07	Jul07	12	RS7-3mm	1	7	24	RS	8
S07	Aug07	14	RS7-3mm	1	7	17	RS	8
S07	Aug07	17	RS7-3mm	1	7	28	RS	8
S07	May07	1	RS7-3mm	2	7	33	RS	7
S07	May07	3	RS7-3mm	2	7	42	RS	7
S07	May07	4	RS7-3mm	2	7	35	RS	6
S07	Jun07	7	RS7-3mm	2	7	27	RS	7
S07	Jul07	9	RS7-3mm	2	7	23	RS	7
S07	Jul07	12	RS7-3mm	2	7	23	RS	8
S07	Aug07	14	RS7-3mm	2	7	17	RS	6
S07	Aug07	17	RS7-3mm	2	7	27	RS	8
S07	May07	1	RS7-3mm	3	7	48	RS	6
S07	May07	3	RS7-3mm	3	7	55	RS	7
S07	May07	4	RS7-3mm	3	7	40	RS	7
S07	Jun07	7	RS7-3mm	3	7	30	RS	6
S07	Jul07	9	RS7-3mm	3	7	26	RS	7
S07	Jul07	12	RS7-3mm	3	7	25	RS	7
S07	Aug07	14	RS7-3mm	3	7	18	RS	7
S07	Aug07	17	RS7-3mm	3	7	30	RS	7
S07	May07	1	RS7-3mm	4	7	45	RS	4
S07	May07	3	RS7-3mm	4	7	49	RS	5
S07	May07	4	RS7-3mm	4	7	39	RS	4
S07	Jun07	7	RS7-3mm	4	7	29	RS	5
S07	Jul07	9	RS7-3mm	4	7	25	RS	5
S07	Jul07	12	RS7-3mm	4	7	25	RS	5
S07	Aug07	14	RS7-3mm	4	7	17	RS	5
S07	Aug07	17	RS7-3mm	4	7	29	RS	6
S07	May07	1	RS7-6mm	1	7	45	RS	6
S07	May07	3	RS7-6mm	1	7	51	RS	6
S07	May07	4	RS7-6mm	1	7	44	RS	6
S07	Jun07	7	RS7-6mm	1	7	28	RS	6
S07	Jul07	9	RS7-6mm	1	7	24	RS	6
S07	Jul07	12	RS7-6mm	1	7	24	RS	6
S07	Aug07	14	RS7-6mm	1	7	17	RS	6
S07	Aug07	17	RS7-6mm	1	7	33	RS	7
S07	May07	1	RS7-6mm	2	7	46	RS	8
S07	May07	3	RS7-6mm	2	7	55	RS	8
S07	May07	4	RS7-6mm	2	7	46	RS	8
S07	Jun07	7	RS7-6mm	2	7	29	RS	8
S07	Jul07	9	RS7-6mm	2	7	25	RS	8
S07	Jul07	12	RS7-6mm	2	7	25	RS	8
S07	Aug07	14	RS7-6mm	2	7	17	RS	8
S07	Aug07	17	RS7-6mm	2	7	35	RS	9
S07	May07	1	RS7-6mm	3	7	45	RS	5
S07	May07	3	RS7-6mm	3	7	53	RS	7
S07	May07	4	RS7-6mm	3	7	45	RS	7
S07	Jun07	7	RS7-6mm	3	7	29	RS	7
S07	Jul07	9	RS7-6mm	3	7	24	RS	7
S07	Jul07	12	RS7-6mm	3	7	24	RS	7
S07	Aug07	14	RS7-6mm	3	7	17	RS	8
S07	Aug07	17	RS7-6mm	3	7	33	RS	8
S07	May07	1	RS7-6mm	4	7	45	RS	5
S07	May07	3	RS7-6mm	4	7	52	RS	5
S07	May07	4	RS7-6mm	4	7	44	RS	6
S07	Jun07	7	RS7-6mm	4	7	29	RS	6

S07	Jul07	9	RS7-6mm	4	7	24	RS	6
S07	Jul07	12	RS7-6mm	4	7	23	RS	7
S07	Aug07	14	RS7-6mm	4	7	17	RS	7
S07	Aug07	17	RS7-6mm	4	7	33	RS	7
S07	May07	1	TORO	1	2	53	ET	5
S07	May07	3	TORO	1	2	39	ET	5
S07	May07	4	TORO	1	2	35	ET	5
S07	Jun07	7	TORO	1	2	29	ET	4
S07	Jul07	9	TORO	1	2	23	ET	5
S07	Jul07	12	TORO	1	2	8	ET	5
S07	Aug07	14	TORO	1	2	28	ET	7
S07	Aug07	17	TORO	1	2	27	ET	7
S07	May07	1	TORO	2	2	52	ET	4
S07	May07	3	TORO	2	2	39	ET	4
S07	May07	4	TORO	2	2	35	ET	5
S07	Jun07	7	TORO	2	2	30	ET	4
S07	Jul07	9	TORO	2	2	24	ET	5
S07	Jul07	12	TORO	2	2	8	ET	6
S07	Aug07	14	TORO	2	2	27	ET	6
S07	Aug07	17	TORO	2	2	28	ET	7
S07	May07	1	TORO	3	2	56	ET	5
S07	May07	3	TORO	3	2	42	ET	6
S07	May07	4	TORO	3	2	37	ET	6
S07	Jun07	7	TORO	3	2	30	ET	6
S07	Jul07	9	TORO	3	2	25	ET	6
S07	Jul07	12	TORO	3	2	8	ET	7
S07	Aug07	14	TORO	3	2	31	ET	7
S07	Aug07	17	TORO	3	2	30	ET	8
S07	May07	1	TORO	4	2	52	ET	6
S07	May07	3	TORO	4	2	39	ET	7
S07	May07	4	TORO	4	2	35	ET	8
S07	Jun07	7	TORO	4	2	29	ET	8
S07	Jul07	9	TORO	4	2	23	ET	8
S07	Jul07	12	TORO	4	2	7	ET	8
S07	Aug07	14	TORO	4	2	27	ET	8
S07	Aug07	17	TORO	4	2	27	ET	8
S07	May07	1	WOS	1	2	42	WOS	4
S07	May07	3	WOS	1	2	52	WOS	4
S07	May07	4	WOS	1	2	44	WOS	5
S07	Jun07	7	WOS	1	2	33	WOS	5
S07	Jul07	9	WOS	1	2	40	WOS	5
S07	Jul07	12	WOS	1	2	33	WOS	6
S07	Aug07	14	WOS	1	2	42	WOS	6
S07	Aug07	17	WOS	1	2	44	WOS	7
S07	May07	1	WOS	2	2	43	WOS	6
S07	May07	3	WOS	2	2	50	WOS	6
S07	May07	4	WOS	2	2	43	WOS	7
S07	Jun07	7	WOS	2	2	32	WOS	6
S07	Jul07	9	WOS	2	2	40	WOS	6
S07	Jul07	12	WOS	2	2	32	WOS	7
S07	Aug07	14	WOS	2	2	41	WOS	7
S07	Aug07	17	WOS	2	2	42	WOS	7
S07	May07	1	WOS	3	2	40	WOS	8
S07	May07	3	WOS	3	2	45	WOS	8
S07	May07	4	WOS	3	2	38	WOS	8
S07	Jun07	7	WOS	3	2	30	WOS	8
S07	Jul07	9	WOS	3	2	35	WOS	8

```
S07   Jul07 12    WOS   3     2     29    WOS   7
S07   Aug07 14    WOS   3     2     39    WOS   8
S07   Aug07 17    WOS   3     2     38    WOS   9
S07   May07 1     WOS   4     2     43    WOS   6
S07   May07 3     WOS   4     2     50    WOS   6
S07   May07 4     WOS   4     2     43    WOS   6
S07   Jun07 7     WOS   4     2     33    WOS   6
S07   Jul07 9     WOS   4     2     40    WOS   6
S07   Jul07 12    WOS   4     2     32    WOS   7
S07   Aug07 14    WOS   4     2     41    WOS   7
S07   Aug07 17    WOS   4     2     41    WOS   7
run;
proc glm;
title 'TQ and Weekly Water';
      class mm;
      model TQ = mm;
      means mm/Duncan;
      run;
proc glm;
title 'TQ and Frequency';
      class freq;
      model TQ = freq;
      means freq/Duncan;
      run;
proc glm;
title 'TQ and Frequency';
      class rep;
      model TQ = rep;
      means rep/Duncan;
      run;
proc glm;
title 'TQ and Season';
      class season;
      model TQ = season;
      means season/Duncan;
      run;

proc sort;
by season;
run;
proc glm; by season;
title 'TQ and Weekly Water';
      class mm;
      model TQ = mm;
      means mm/Duncan;
      run;
proc glm; by season;
title 'TQ and Frequency';
      class freq;
      model TQ = freq;
      means freq/Duncan;
      run;
proc mixed; by season;
      class freq rep;
      model TQ = freq; random rep;
      lsmeans freq/pdiff;
      run;
```

Weekly Water Applied on Turf Quality by Season

```
data TQ and TotalWater;
input season$ plot$ tmt$ rep$  TQ mm;
cards;
F06   E05   AC10  1     7     199
F06   E08   AC10  3     7     203
F06   E11   AC10  2     7     200
F06   F02   AC10  4     7     198
F06   D07   AC13  1     8     250
F06   E06   AC13  3     7     258
F06   F01   AC13  2     6     263
F06   F11   AC13  4     7     256
F06   D12   AC7   1     7     253
F06   E02   AC7   3     7     264
F06   E04   AC7   2     7     268
F06   F07   AC7   4     6     294
F06   D03   ACIR  1     7     124
F06   D09   ACIR  3     8     109
F06   D10   ACIR  2     7     75
F06   F04   ACIR  4     5     218
F06   B05   DWRS  1     7     165
F06   C01   DWRS  3     7     168
F06   C07   DWRS  2     8     167
F06   C11   DWRS  4     6     166
F06   E01   ETM   1     8     177
F06   E09   ETM   3     8     169
F06   F06   ETM   2     4     174
F06   F10   ETM   4     8     173
F06   D02   Llhigh      1     7     458
F06   D06   Llhigh      3     7     456
F06   E12   Llhigh      2     7     456
F06   F09   Llhigh      4     8     460
F06   D01   Llmed 1     7     235
F06   D05   Llmed 3     7     236
F06   D11   Llmed 2     7     233
F06   F08   Llmed 4     7     236
F06   A08   RS2-3mm     1     5     267
F06   A10   RS2-3mm     3     7     259
F06   B03   RS2-3mm     2     5     265
F06   C04   RS2-3mm     4     7     264
F06   A07   RS7-6mm     1     5     264
F06   B02   RS7-6mm     3     6     261
F06   B11   RS7-6mm     2     6     259
F06   C05   RS7-6mm     4     8     264
F06   E07   TORO  1     8     106
F06   E10   TORO  3     8     105
F06   F03   TORO  2     6     108
F06   F05   TORO  4     6     106
F06   A03   WORS  1     4     296
F06   A05   WORS  3     5     286
F06   B12   WORS  2     6     285
F06   C09   WORS  4     8     283
F06   A04   WRS   1     4     266
F06   A11   WRS   3     7     266
F06   B07   WRS   2     5     271
F06   C03   WRS   4     6     266
F07   E05   AC10  1     5     173
```

F07	E08	AC10	3	7	185	
F07	E11	AC10	2	6	177	
F07	F02	AC10	4	6	173	
F07	D07	AC13	1	6	382	
F07	E06	AC13	3	6	292	
F07	F01	AC13	2	6	315	
F07	F11	AC13	4	6	304	
F07	D12	AC7	1	5	89	
F07	E02	AC7	3	6	93	
F07	E04	AC7	2	5	91	
F07	F07	AC7	4	5	111	
F07	D03	ACIR	1	5	70	
F07	D09	ACIR	3	7	73	
F07	D10	ACIR	2	7	93	
F07	F04	ACIR	4	4	135	
F07	B05	DWRS	1	8	184	
F07	C01	DWRS	3	5	188	
F07	C07	DWRS	2	8	147	
F07	C11	DWRS	4	6	194	
F07	E01	ETM	1	6	154	
F07	E09	ETM	3	6	159	
F07	F06	ETM	2	4	154	
F07	F10	ETM	4	6	150	
F07	D02	Llhigh	1	5	327	
F07	D06	Llhigh	3	6	343	
F07	E12	Llhigh	2	6	329	
F07	F09	Llhigh	4	7	333	
F07	D04	LLlow	1	5	206	
F07	D08	LLlow	3	7	210	
F07	E03	LLlow	2	6	221	
F07	F12	LLlow	4	6	209	
F07	D01	Llmed	1	5	271	
F07	D05	Llmed	3	6	251	
F07	D11	Llmed	2	6	255	
F07	F08	Llmed	4	7	261	
F07	A01	NON	1	3	0	
F07	A09	NON	3	6	0	
F07	B06	NON	2	5	0	
F07	C10	NON	4	5	0	
F07	A12	RS1-3mm	1	5	267	
F07	B01	RS1-3mm	3	4	264	
F07	B08	RS1-3mm	2	7	264	
F07	C06	RS1-3mm	4	7	270	
F07	A02	RS1-6mm	1	4	270	
F07	B04	RS1-6mm	3	6	271	
F07	C08	RS1-6mm	2	8	255	
F07	C12	RS1-6mm	4	5	260	
F07	A06	RS2-3mm	1	6	274	
F07	B09	RS2-3mm	3	8	268	
F07	B10	RS2-3mm	2	6	270	
F07	C02	RS2-3mm	4	5	271	
F07	A08	RS7-3mm	1	8	264	
F07	A10	RS7-3mm	3	6	267	
F07	B03	RS7-3mm	2	4	262	
F07	C04	RS7-3mm	4	7	255	
F07	A07	RS7-6mm	1	6	290	
F07	B02	RS7-6mm	3	5	285	

F07	B11	RS7-6mm	2	6	290
F07	C05	RS7-6mm	4	9	295
F07	E07	TORO	1	6	152
F07	E10	TORO	3	8	137
F07	F03	TORO	2	5	141
F07	F05	TORO	4	4	140
F07	A03	WORS	1	4	386
F07	A05	WORS	3	5	383
F07	B12	WORS	2	6	374
F07	C09	WORS	4	8	363
F07	A04	WRS	1	5	288
F07	A11	WRS	3	6	290
F07	B07	WRS	2	7	303
F07	C03	WRS	4	4	296
S06	E05	AC10	1	5	261
S06	E08	AC10	3	7	270
S06	E11	AC10	2	6	264
S06	F02	AC10	4	5	263
S06	D07	AC13	1	7	307
S06	E06	AC13	3	6	321
S06	F01	AC13	2	4	322
S06	F11	AC13	4	7	313
S06	D12	AC7	1	5	171
S06	E02	AC7	3	5	177
S06	E04	AC7	2	3	177
S06	F07	AC7	4	4	186
S06	D03	ACIR	1	5	233
S06	D09	ACIR	3	7	197
S06	D10	ACIR	2	7	163
S06	F04	ACIR	4	3	221
S06	B05	DWRS	1	5	196
S06	C01	DWRS	3	5	198
S06	C07	DWRS	2	7	191
S06	C11	DWRS	4	7	184
S06	E01	ETM	1	6	305
S06	E09	ETM	3	6	259
S06	F06	ETM	2	3	302
S06	F10	ETM	4	7	288
S06	D02	Llhigh	1	7	398
S06	D06	Llhigh	3	8	393
S06	E12	Llhigh	2	5	397
S06	F09	Llhigh	4	7	397
S06	D04	LLlow	1	4	111
S06	D08	LLlow	3	4	112
S06	E03	LLlow	2	4	113
S06	F12	LLlow	4	2	107
S06	D01	Llmed	1	6	238
S06	D05	Llmed	3	7	238
S06	D11	Llmed	2	8	230
S06	F08	Llmed	4	6	241
S06	A01	NON	1	1	0
S06	A09	NON	3	2	0
S06	B06	NON	2	1	0
S06	C10	NON	4	2	0
S06	A12	RS1-3mm	1	3	204
S06	B01	RS1-3mm	3	4	202
S06	B08	RS1-3mm	2	2	193

S06	C06	RS1-3mm	4	8	202
S06	A02	RS1-6mm	1	3	244
S06	B04	RS1-6mm	3	6	238
S06	C08	RS1-6mm	2	7	234
S06	C12	RS1-6mm	4	4	234
S06	A06	RS2-3mm	1	4	237
S06	B09	RS2-3mm	3	6	220
S06	B10	RS2-3mm	2	5	237
S06	C02	RS2-3mm	4	6	235
S06	A07	RS2-6mm	1	3	241
S06	B02	RS2-6mm	3	6	239
S06	B11	RS2-6mm	2	8	237
S06	C05	RS2-6mm	4	8	244
S06	A08	RS7-3mm	1	5	231
S06	A10	RS7-3mm	3	6	227
S06	B03	RS7-3mm	2	6	231
S06	C04	RS7-3mm	4	8	223
S06	E07	TORO	1	8	307
S06	E10	TORO	3	6	286
S06	F03	TORO	2	2	321
S06	F05	TORO	4	2	314
S06	A03	WORS	1	3	311
S06	A05	WORS	3	5	300
S06	B12	WORS	2	6	287
S06	C09	WORS	4	8	299
S06	A04	WRS	1	4	268
S06	A11	WRS	3	5	267
S06	B07	WRS	2	3	262
S06	C03	WRS	4	7	268
S07	E05	AC10	1	7	553
S07	E08	AC10	3	8	563
S07	E11	AC10	2	7	566
S07	F02	AC10	4	8	559
S07	D07	AC13	1	8	567
S07	E06	AC13	3	8	610
S07	F01	AC13	2	7	631
S07	F11	AC13	4	7	607
S07	D12	AC7	1	7	342
S07	E02	AC7	3	8	351
S07	E04	AC7	2	7	353
S07	F07	AC7	4	6	378
S07	D03	ACIR	1	7	357
S07	D09	ACIR	3	7	342
S07	D10	ACIR	2	7	355
S07	F04	ACIR	4	7	459
S07	B05	DWRS	1	8	376
S07	C01	DWRS	3	7	385
S07	C07	DWRS	2	8	363
S07	C11	DWRS	4	7	377
S07	E01	ETM	1	6	271
S07	E09	ETM	3	5	289
S07	F06	ETM	2	3	269
S07	F10	ETM	4	4	268
S07	D02	Llhigh	1	7	684
S07	D06	Llhigh	3	8	671
S07	E12	Llhigh	2	7	695
S07	F09	Llhigh	4	8	703

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S07   D01   Llmed 1     7     586
S07   D05   Llmed 3     8     560
S07   D11   Llmed 2     8     566
S07   F08   Llmed 4     7     575
S07   A02   RS1-6mm     1     6     649
S07   B04   RS1-6mm     3     7     632
S07   C08   RS1-6mm     2     8     612
S07   C12   RS1-6mm     4     7     619
S07   A06   RS2-3mm     1     8     591
S07   B09   RS2-3mm     3     8     579
S07   B10   RS2-3mm     2     7     581
S07   C02   RS2-3mm     4     7     580
S07   A08   RS7-3mm     1     8     575
S07   A10   RS7-3mm     3     7     553
S07   B03   RS7-3mm     2     6     554
S07   C04   RS7-3mm     4     8     495
S07   A07   RS7-6mm     1     8     579
S07   B02   RS7-6mm     3     7     571
S07   B11   RS7-6mm     2     7     572
S07   C05   RS7-6mm     4     9     597
S07   E07   TORO  1     8     530
S07   E10   TORO  3     8     495
S07   F03   TORO  2     7     502
S07   F05   TORO  4     7     499
S07   A03   WORS  1     7     703
S07   A05   WORS  3     7     702
S07   B12   WORS  2     7     683
S07   C09   WORS  4     9     622
S07   A04   WRS   1     7     608
S07   A11   WRS   3     6     608
S07   B07   WRS   2     8     629
S07   C03   WRS   4     7     606
run;
proc sort;
by season;
run;
 proc glm; by season;
 title 'Water Applied';
      class mm;
      model TQ = mm;
      means mm/Duncan;
      run;
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BIOGRAPHICAL SKETCH

Mary L. Shedd received her Bachelor of Science in Agricultural and Biological Engineering at the University of Florida. During her undergraduate studies she focused on land and water resources and assisted on several university research projects. In 2005, she accepted a graduate assistantship position from the Agricultural and Biological Engineering department at the University of Florida.

While working on her graduate studies, she presented research results at both state and national conferences. Mary won second place in a student paper competition at a state-level scientific conference. Also during her graduate studies, she had the opportunity to work on a research project with students from EARTH University in Costa Rica. She spent several weeks researching the uniformity of irrigation at a golf course in Guanacaste.

Mary has traveled to eight countries and has lived in four US. states. She travels once a year to backpack small sections of the Appalachian Trail with friends.