Irrigation Management: Assumptions vs. Reality

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Bottom line: As water becomes scarcer and more expensive, water use patterns are under more intense scrutiny than ever. There are several commonly held, but not necessarily correct assumptions about irrigation management that can contribute to turf quality and water use problems if they are not addressed. These assumptions include: 1) ET drives irrigation demand; 2) The irrigation system delivers the amount of water that you program it to, and 3) It's not necessary to worry about nitrogen levels in water. Problems can be averted by avoiding over-reliance on ETs, developing a year-round soil moisture monitoring program and periodically checking irrigation water and soil for levels of plant available nitrogen.

Assumption 1: ET drives irrigation demand

While working with Dave Zahrte, CGCS, at Southern California's Santa Ana Country Club, we came across a water use problem that we believe is relatively widespread. It started during the spring of 2004 when Dave noticed that his water use was much higher than it had been in 2003 (Figure 1). This was at first unexpected, because the ETs (evapotranspiration rates, or the estimated amount of water lost from plants via transpiration and from soil through evaporation) at Santa Ana were very similar in 2003 and 2004. And it makes sense to assume that similar ETs should result in similar water use patterns. Or does it?

Figure 1. Water use vs. ETat Santa Ana Country Club: 2003 vs. 2004, Dave Zahrte CGCS, superintendent. Santa Ana, CA. Water use in the first half of 2004 was 50% higher than in 2003, despite the fact that ETs were similar in both years.

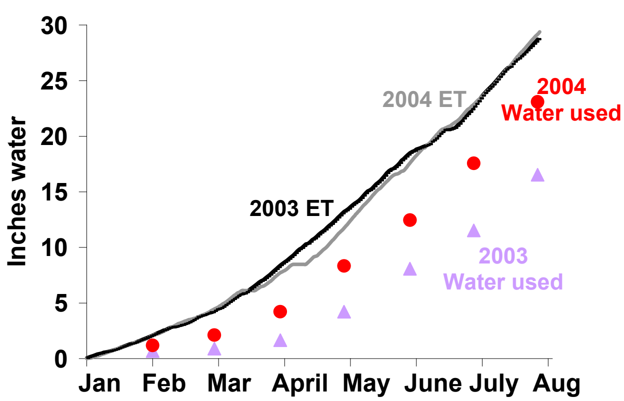
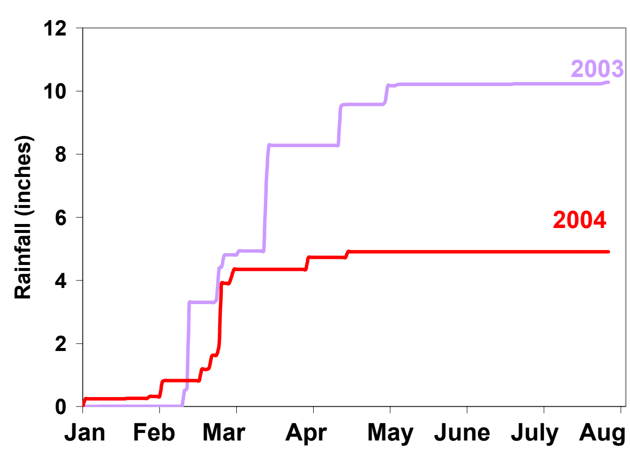


Table 1. Factors contributing to water demand on golf courses

Soil moisture holding capacity
Plant rooting depth
Irrigation distribution uniformity
Leaching activities
Onsite storage (lakes) capacities and volumes
Water meter calibration problems
Irrigation computer malfunctions
Rainfall amount and timing

As it turns out, the answer is "no" — similar ETs from one year to the next do not necessarily result in similar water use patterns. This is because although ET contributes to the amount of water used on a golf course, it is only one of many possible factors that contribute to overall water demand (Table 1). Given all of these options, what is the best way to start pinning the answer down? We always like to begin by looking at the weather station records for the location. When we did this, the answer became crystal clear — a 52% reduction in rainfall from 2003 to 2004 was the reason behind the increased demand for water (Figure 2). And not only was there less water in 2004, but it also was timed badly, coming all during the winter months (January – March) when it is least needed by the turf. In contrast, rainfall occurred through May during 2003.

Figure 2. Rainfall in 2003 vs. 2004 at Santa Ana Country Club. Santa Ana, CA. In 2004, the area received a total of only 4.9 inches, as compared to 10.2 inches in 2003 during the same time period. This represents a 52% reduction in rainfall from 2003 to 2004, and is the primary reason why irrigation demand was twice as high in 2004 as 2003.



Reality 1: ET is only one of many factors in calculating irrigation demand

Most modern irrigation systems use ETs to schedule irrigation so that they conform to changes in the weather. Since ET goes up as solar radiation, wind speed and temperature go up and as humidity goes down, a high ET is a good indicator that more water will be required to keep the plant healthy. While this is a good starting point for determination of your irrigation needs, complete reliance on ETs ignores the fact that there are many other factors involved in creating water demand (Table 1). For this reason, over-reliance on ETs can lead to inaccurate projections on water use. To avoid being surprised, under-budgeting water or being unjustly suspected of over-using water, keep in mind the following:

- There are many factors that contribute to irrigation demand in addition to ET (Table 1); these should all be taken into account when there are questions about variations in water use patterns
- Weather station records are invaluable for analyzing problems and explaining conditions; make sure that your weather station is properly calibrated, that records are readily accessible and that past records are stored properly.
- Lack of timely rainfall can have a devastating impact on budgets, as well as on turf performance; in arid environments this is particularly important. Given the length of the current drought in much of the U.S. and the fact that there is no obvious end in sight, it is better to be conservative and budget for a dry year rather than a wet one.
- It is a solid approach to use ET-based irrigation schedules as a starting point in estimating water demand, but your assessment of soil moisture is the ultimate test. Monitoring for soil moisture is described in more detail below.

Assumption 2: The irrigation system delivers the amount of water that you program it to.

In a previous issue of PACE Insights (Volume 6, Number 6), we talked about drought-related problems that are due to poor irrigation distribution uniformity. We have recently run across a different irrigation related problem which may unfortunately be more common than we would like — irrigation systems that are not delivering as much water as they are programmed to. Severe drought stress is the result (Figure 3) — a problem that no one can afford.

Figure 3. Failure of irrigation systems to deliver adequate water. The good quality rye/bermudagrass fairway turf in the photo on the left occurred next to the drought-stressed, poor quality turf on the right. Both areas were irrigated with recycled water. Catch-can tests (Figure 4) indicated that the poor quality turf was receiving only 0.14 inches of irrigation, even though the system had been programmed to deliver a desired 0.22 inches.

In addition to drought-stress, the poor quality turf was also afflicted with electrical conductivity (EC) and nitrogen levels that were high enough to cause turf damage (Figure 5). The accumulation of salts and nitrogen in the soil of the poor areas was due to the lack of leaching irrigation applied to the drought-stressed areas.

Figure 4. Lower than expected precipitation rate = poorer than expected turf quality. The irrigation system was programmed to deliver 110% of ET, or 0.22 inches of water. However, catch can tests showed that poor quality turf areas received less than 0.14 inches of water, or only 64% of the irrigation water that was desired. Even the good quality areas received an average of only 0.19 inches of water, indicating that the irrigation system programming was consistently delivering too little water to the turf. To deal with this problem, the base ET was adjusted to 128%. Once this change was implemented, the poor areas of the fairway received enough water to promote turf recovery. The vertical standard error bars represent the spread of values obtained for good vs. poor areas.

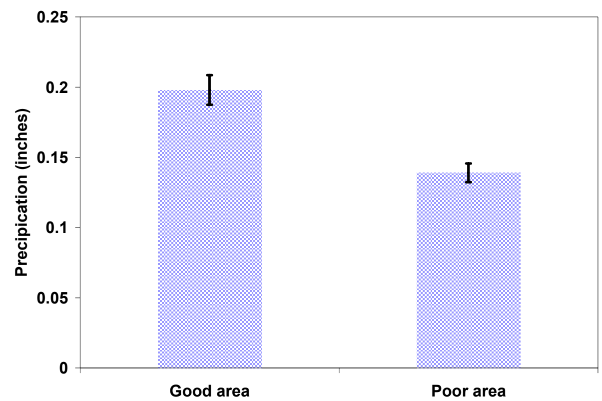


Figure 5. Indirect effects of drought stress. Due to lack of sufficient irrigation, the poor quality soil shown in Figure 3 was further stressed by high electrical conductivity (EC) in the soil. The nearby good area had sufficient soil moisture and acceptable ECs. (For good ryegrass growth, ECs should be less than 6.0 dS/m). The vertical standard error bars represent the spread of values obtained for good vs. poor areas.

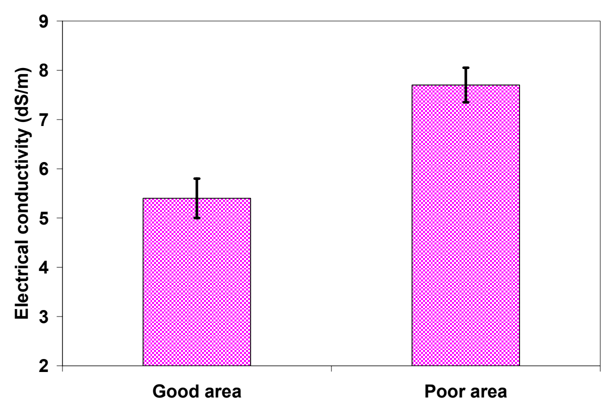
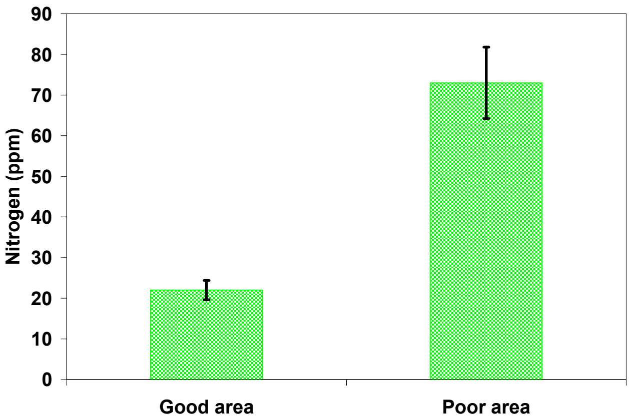


Figure 6. Indirect effects of drought stress. Due to lack of sufficient irrigation, the poor quality soil shown in Figure 3 was further stressed by high levels of total plant available nitrogen in the soil. The nearby good area had sufficient soil moisture and acceptable nitrogen (For good turf growth, total plant available nitrogen levels should be less than 20 ppm). The vertical standard error bars represent the spread of values obtained for good vs. poor areas.



Reality 2: Computerized irrigation systems need to be constantly monitored for accuracy

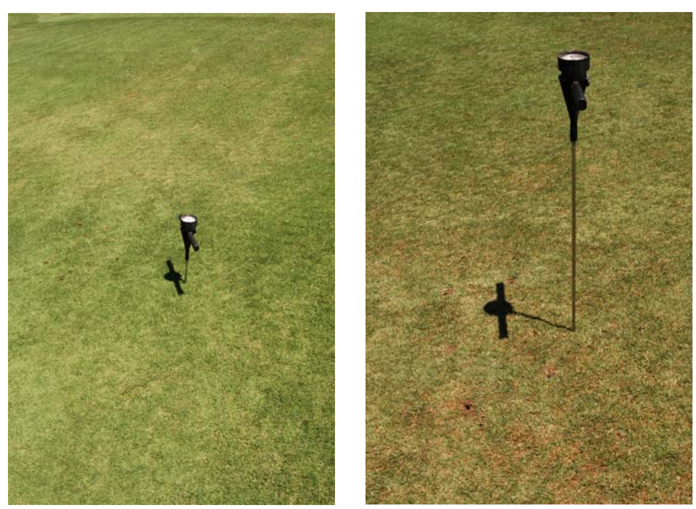
Computerized irrigation systems cannot be trusted to deliver a specific amount of water nor can it be expected to deliver it uniformly. Without constant monitoring, problems will develop — either drought stressed turf or the reverse, excessively wet turf. Some monitoring techniques that will help to avoid either situation are listed below:

- A cone penetrometer (Figure 6) may be the best method for rapidly evaluating soil moisture content. If it is difficult to push the penetrometer more than a few inches into the soil, the soil is too dry. These tools are available, usually for less than $200.00, from a variety of sources including Spectrum Technologies (Item 6100) at 800-248-8873 or www.specmeters.com. Various moisture meters are useful if more precise data is necessary.
- Periodic use of catch-cans in problem spots helps ensure that the correct amounts of water are being delivered. The procedure below can be used to check your irrigation system precipitation output to see if it matches up with the rates that SHOULD be delivered to the turf.

Precipitation check:

1. Order catch cans and metal stands The catch cans should collect 16 square surface inches of water and can be obtained from two sources: The Toolkit Company (Bakersfield, CA; 661-587-9854) OR the Irrigation Training and Research Center (ITRC) at Cal Poly State University. www.itrc.org/classes/CatchCanOrderForm.pdf
2. Set up at least two catch cans per test area — one catch can in good performing turf and another in an adjacent area of poor performing turf. Set them up in the late afternoon/early evening before the normally scheduled irrigation cycle begins.
3. Gather catch cans in the morning and record the volume of water collected in each of the good vs. poor performing areas.
4. To calculate the precipitation from your irrigation run, divide the volume from each catch can by 262. For example, a catch can that collects 60 ml overnight indicates precipitation of 0.23 inches per cycle (60/262 = 0.23). An area that collects 35 ml overnight indicates precipitation of 0.13 inches.
5. If you find that your poor performing turf is being irrigated with a lower precipitation than you desire, the system will have to be adjusted to compensate. To do this, divide the desired precipitation volume by the observed precipitation volume. The number that you obtain is the factor by which you will need to increase water delivery by. For example, if the desired precipitation is 0.18 inches per cycle, and you observe 0.15 inches, then you will need to increase the volume of water delivered by a factor of 1.2. (The calculation is**: 0.18 / 0.15 = 1.2 = scheduling coefficient**)

Figure 6. Using a cone penetrometer for rapid evaluation of soil moisture. In soil with adequate moisture, the penetrometer is easily inserted into the soil (photo on left) but in soil that is too dry, it is difficult to move the penetrometer to even a few inches below the soil surface. Make sure that the area you are testing is actually composed of soil, rather than of gravel or rocks. Interference from gravel or rocks may make it difficult to insert the penetrometer, but do not necessarily indicate that the soil is dry.



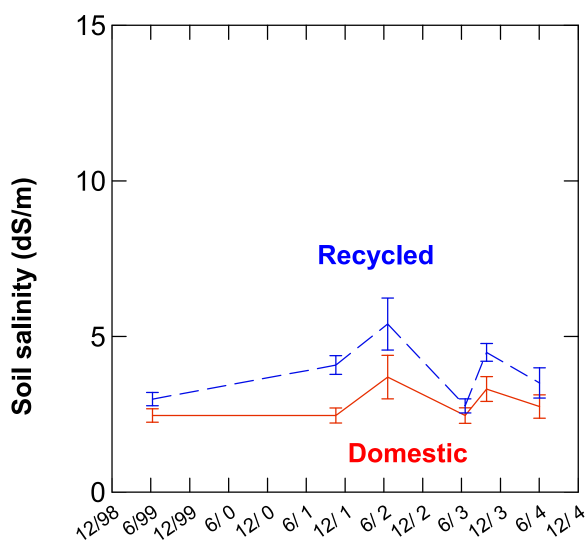
Assumption 3: It's not necessary to worry about nitrogen levels in water.

In recent years, we have worked with several clients whose irrigation water was responsible for declines in turf quality But these cases were unusual because the usual suspects such as high salinity and high bicarbonates were not involved (Figure 7). Instead, these problem waters had high levels of plant available nitrogen — so high, in fact (greater than 6 ppm), that the nitrogen levels in the soils that were being irrigated built up to plant-damaging levels over time (Figure 8).

Nitrogen is typically present at very low levels in irrigation water and is usually not a problem, and so the logical question is: where is all of this nitrogen coming from?

The answer is that it can come from a variety of sources. Some (though not all) recycled waters are high in nitrogen and some well waters are high in nitrogen as well, most usually as a result of contamination from livestock operations, fertilizer runoff; leaching from septic tanks, or even erosion of natural deposits of nitrogen.

Figure 7. Trends in soil salinity, **Big Canyon Country Club, Newport Beach, CA, Jeff Beardsley, superintendent**. In fairway soils irrigated with recycled (blue line) vs. domestic (red line) water over the period 12/98 – 6/04. Note that fairways irrigated with recycled water did not have dramatically higher soil salinities than fairways irrigated with domestic water. This is partly due to a successful leaching program instituted by the superintendent at this location. The desired EC level 6 dS/m or less.



Reality 3: High nitrogen levels in irrigation water can be involved in significant turf damage

Although it is still relatively rare to find high nitrogen levels in irrigation water, golf courses using recycled water or well water that is at risk from contamination are vulnerable.

Request that your irrigation water analysis include total plant available nitrogen. This is usually not evaluated, so you will have to make a special request. It should only cost a few extra dollars, and is well worth the expense. You are looking for no more than **6 ppm plant available nitrogen**. If water levels exceed 6 ppm, then it is possible that soil nitrogen levels will gradually exceed 20 ppm plant available nitrogen. To avoid reaching this threshold:

- Monitor soils for high nitrogen levels: take soil samples from good and poor performing areas and ship them to an analytical lab; you will have to request that the lab run total plant available nitrogen (a few dollars extra). Levels above 20 ppm can cause damage to turfgrass of all types.
- Reduce or stop nitrogen fertilizer applications until soil nitrogen levels fall below 20 ppm.
- Leach soils that are high in plant available nitrogen to move excessive nitrogen down below the root zone. Aerify and topdress with sand to allow leaching without loss of soil integrity.
- Consider removal of clippings
- If all of the above fail to decrease soil nitrogen levels below 20 ppm, consider a different water source. You may be able to alternate or blend with domestic water to dilute the nitrogen load, or completely switch to domestic water. Always confirm (via analytical testing) that the quality of the domestic water is acceptable — some domestic water sources can have problems as well.

Figure 8. **Effect of recycled water on fairway soil levels of plant available nitrogen** (NO3 + NH4) ppm over the period 12/98 to 6/04. Big Canyon Country Club, Newport Beach, CA. Note that fairways irrigated with domestic water (red line) had soils that mostly stayed below the limit of 20 ppm total plant available nitrogen, while fairway soils irrigated with recycled water (blue line) exceeded the limit of 20 ppm by three fold. The recycled water used contained 18 ppm plant available nitrogen. The domestic water contained 0.2 ppm plant available nitrogen.