To the LAST DROP...

Las Vegas superintendent Tim Cloninger has made a career out of knowing how to use his water resources. by Brian Vinchesi

Tim Cloninger has been the superintendent at Shadow Creek since July of 2011. He was also the assistant superintendent from late 2005 to the end of 2007. Tim has an interesting background for a golf course superintendent, which includes positions in Australia, Mexico and the Cayman Islands. In addition to obtaining a turf degree, he has done graduate work in Water Policy and Geographical Information Systems (GIS). Given his background working with water policy and state of the art technologies, I interviewed Tim about maintaining an exclusive golf course in the Las Vegas heat with a limited water supply.

How old is the irrigation system at Shadow Creek, and what type of system is it? The irrigation system at Shadow Creek was originally installed with the construction of the golf course in 1990. The fairways and rough irrigation systems were redone in 2003 and the greens and tees in 2004. In 2008 the golf course was renovated and adjustments were made to the irrigation system. The native area irrigation systems are all still original. A new 7,200-gallon-per minute (gpm) Watertronics pump station was installed in 2011. The system is primarily Rain Bird with some miscellaneous equipment in the native areas.

What don't you like about your irrigation system? The native areas – which are native for the golf course, but not native to Las Vegas – are all block controlled and waste a lot of water. They need major improvements as there is not enough control and they have poor sprinkler spacing as well as aging equipment. There is also a large amount of drip irrigation installed and I do not have a good handle on how much water it is using and I feel if we can improve the scheduling of the drip irrigation we can save a lot of water.

Is there anything you like about your irrigation system? There are a lot of quick couplers on the course and they are spaced in such a way that we can water any turf area on the golf course with a 100-foot hose, which we do a lot. I also like that we have two-part circle sprinklers on the edge of the fairways to separate the rough and fairway watering which is nice if you don't over seed, but also because our fairways are sand capped and the rough isn't so they have very different watering requirements.

How does your irrigation system waste water? The block system in the native areas is wasteful on many levels. The spacing is not ideal and the system is old. The zones cover a lot of area with different soils and different plant material as well as widely varying topography. There is a very large amount of drip irrigation installed on the perimeter of the property and the plantings along the golf course. We do not have a very good handle on the size of the drip zones and I think could do a better job of scheduling the drip zones. We also have a large amount of surface water with a high evaporation rate.

If money was no object, what would your No. 1 irrigation improvement be? I would work on the native areas which in Las Vegas are not native with only 4 inches of rainfall a year they are irrigation dependent. I would fix the spacing's and get more control of the operation by having single sprinkler control or much smaller zones. Given our plant height, many of the sprinklers need to be above grade to provide more uniform coverage.

Water policy is starting to influence golf course watering and will continue to in the fu-

ERIC JAMISON

Cloninger: "Water is an area where I can reduce cost and improve conditions at the same time."

ture. How does your educational background in water policy help you as a golf course superintendent? It helps to have knowledge of the water situation in the region and in the country. It gives you a better understanding of where golf courses fit in the realm of water use and understanding the need for water conservation. Having an understanding of local/regional water policy when talking to policy makers can be used to represent golf courses in a better way. If gives me the ability to communicate with regulators before policy is made, not after. If you show concern that you are trying to do the right thing you end up with better policy in the long run. I provide facts that compare golf with other water use sectors.

When I worked at the University of Arizona Water Resources Research Center I noticed that there is a lot of misinformation about golf course water use. It is important to have someone from golf who understands water use and water policy and is not just representing one side.

Describe your water supply. We have a 4-acre irrigation storage pond between holes No. 3 and No. 4. The water supply is made up of approximately half permitted groundwater from three wells and half from a 10-inch potable city water feed. Two of the wells discharge directly into the pond and the city water and the newest well into the pump house wet well. Since the irrigation pond is very much in play, the level needs to be carefully managed. The wells also have to be managed to make sure their individual permit amounts are not exceeded on a monthly and yearly basis. Golf courses in Las Vegas use large amounts of water (annual ET rates are 90 inches) and the supply needs to be carefully managed. Shadow Creek is no exception.

How do you determine the amount of water to apply? The green, tees and approaches are sand based bent grass and I use a TDR 3000 soil moisture meter daily to gauge the amount of water to apply. We have cal-

By mapping all the dead spots late last summer, Cloninger was able to sod those areas earlier this year to give the Bermuda a chance to grow.

culated very specific precipitation rates for each area and water deeply and infrequently to a specified depth and not based on time. There is also a small sample (four greens) of in ground sensors that report the soil moisture and salinity. The in ground sensors assist me with determining when to flush the greens. I lean to the dry side and try to stay consistent throughout the week and usually hit watering hard on Fridays.

The fairways, rough and native areas run off of the reference ET produced by our two on-site weather stations. Each zone is assigned to one of the weather stations. The turf ET is then calculated based off of the crop coefficient for the type of turf. Our crop coefficient changes throughout the year as our turf type changes from ryegrass to Bermuda grass during over seeding. We start with an 80 percent crop coefficient and do a global adjust based on what the course is doing. Because our summer water window is not very flexible we can't move around our schedule too much, but do during the rest of the year. We don't throw water out just to water based on ET. Every day is a game-time decision as to what to water and how much.

Do you pay for water? Yes. Water costs account for a large part of the annual budget and the cost of water is only going to continue to increase in Las Vegas and most other areas. The electricity to pump that water is also expensive and is significant, but not as large a part of the budget.

In addition to Water Policy you also have a GIS background. What is GIS and how to you utilize it in your irrigation practices? Geographical Information Sciences is the background and Geographical Information Systems is the practical use of the science. I am in the process of using a soil moisture meter to create soil moisture profile distribution uniformity maps on a GIS platform. I am concentrating on fairways and rough because they are the larger water users and larger areas. Mapping something as small as a green requires a very fine scale and very good equipment. There is too much hand watering and very subtle differences in the topography of greens, so the data is too inconsistent. Fairways and roughs are more normalized and it is easier to see trends.

I will use these maps to adjust stations and reduce runtimes. I map hot spots also. I am also mapping irrigation components and trouble areas and creating plans to fix the trouble spots. This will include adjusting sprinkler heads, maybe amending the soils and changing nozzles.

By mapping all the dead spots late last summer, I was able to sod those areas earlier this year to give the Bermuda a chance to grow all summer. It also provides a data and a record for historical perspective. I will also map the electrical conductivity and generate soil type maps and use those to create management zones. For each of the management zones I hope to develop specific irrigation and fertility schedules. I am expecting very good results from the GIS efforts I am undertaking.

ERIC JAMISON

At Shadow Creek, the soils are very different due to so much earth moving.

At Shadow Creek, the soils are very different due to so much earth moving. The site was originally flat and now has some 80 feet of elevation change. That along with the remodel has resulted in a very diverse soil profile depending where you are on the golf course.

From a superintendent's perspective, what is the easiest way to save water? What is the hardest? The easiest way is to promote most drought tolerant turf grasses. You need to be diligent on your scheduling and use weather and all other information available to make the irrigation system as efficient as possible. You need to have buy-in from your staff to do a lot of hand watering. Also, keeping things lean and not watering hot spots with irrigation but by hand watering is essential.

Do you consider yourself an efficient irrigator? How are you efficient? Yes, all measures are taken when scheduling irrigation to ensure the most efficient watering window. In Las Vegas there are frequently strong winds and I mange the water window to avoid irrigation in high winds as nothing gets accomplished from a watering standpoint when it is windy. We try to water when the winds are calm but don't have that much flexibility in the summer due to water window constraints.

Is your water quality a concern? The water quality at Shadow Creek is excellent when compared to other golf courses in the Las Vegas area. However, the accumulation of sodium is always an issue in a climate that receives only 1 to 4 inches of annual rainfall and the salinity has to be managed.

Are you under pressure to save water? In this economic climate I think every golf course is looking for innovative ways to save money while producing a quality product and Shadow Creek is no exception. Water is an area where I can reduce cost and improve conditions at the same time. Also management would like to see additional water savings due to the economics. One way to do that is to eliminate or reduce the amount of area we over seed which could save up to 20 percent, but it is a tough sell.

Have you been able to decrease water use at Shadow Creek, if so how? So far I have reduced water use by 15 percent. The majority of the water reduction has been accomplished by changing the crop coefficients on a monthly basis. Rather than keeping the crop ET at a constant, it changes based on the variety of turf that is growing (ryegrass or Bermuda) and where.

An increase in hand watering has also saved significant amounts of water while producing a more uniform turf. I have stressed the importance of hand watering to our section workers and have allotted them more time to hand water. **GCI**

Brian Vinchesi writes GCI's irrigation column.

ERIC JAMISON

How you're using water

Superintendents explain how they're utilizing water resources and their prevailing attitudes toward water consumption.

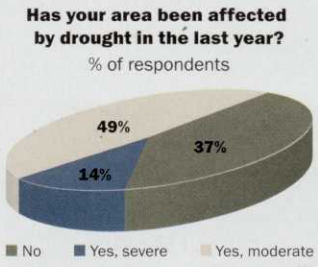
In conjunction with GCI, Trone Brand Energy conducted research to gain an appreciation for the differing attitudes and behaviors resulting from the variety of recent drought levels.

As Figure 1 shows, only 37 percent of the respondents reported not having to deal with any drought conditions at all and 14 percent noted they had experienced a severe drought in the last year. Despite these problems, most courses continue to operate at their own volition. Among those experiencing severe drought conditions less than half (42 percent) have had an outside authority intercede and put restrictions on their water consumption. And, most of those who had restrictions enforced felt the limitations were minor despite the fact that more than half (54 percent) reported their water use would be 20 to 50 percent higher if consumption was not controlled.

Consumption levels, cost and budget impact did not vary substantially based on the weather conditions experienced. As expected, expenditure levels were driven primarily by the number of holes maintained. As a percentage of the course's non-capital goods operating budget water remained remarkably consistent across the sample. For the overall sample the budget impact was 5 percent. That was also the case for those experiencing no or moderate drought conditions. Among those with severe drought conditions the number increased marginally to 6 percent.

The application of water by course part was also consistent regardless of the level of drought conditions experienced. Overall, courses are putting 21 percent of their water on greens 16 percent on tee boxes, a little over a third (35 percent) on the fairways, 15 percent on the rough and 14 percent elsewhere. The only disparity of note that surfaced was that those experiencing severe drought conditions are putting slightly more water on the rough (18 percent) and slightly less on the fairways (33 percent). This phenomenon may be the result of the need for a minimum amount of water being necessary to keep from losing the rough completely.

Figure 1: Drought impact



Lakes/ponds (39 percent) and wells (30 percent) are the most common sources of water followed by municipalities (17 percent) and rivers and streams (14 percent). Among those experiencing severe drought conditions the municipality number jumps to 29 percent. This disparity is likely the result of an increased desire or requirement to use effluent or reclaimed water which is, in fact, much higher among those being short changed by Mother Nature. Overall, 13 percent of

Key observations

- The majority of superintendents believe an environmental obligation to conserve and/or recognize the risk of outside intervention (77 percent top three box agreement) if they don't conserve water.
- There is no silver bullet – success is a function of doing a lot of things right. As a result, most courses are continually striving to save.
- Some popular and productive saving practices have other positive financial implications. More natural areas require less water and fewer chemicals as well as less fertilizer and maintenance.
- Other productive savings practices (hand watering, wetting agents) have an adverse impact on the budget.
- Irrigation enhancements, which are an opportunity for some, have clearly been impacted by the financial downturn.
- Many don't feel they have the tools or trained staff they need to be effective.
- There isn't a lot of concern about water testing (effluent or reclaimed and ground water testing)
- Major outside influences are less than supportive. For example, management doesn't get it; players are demanding; "fast and firm" doesn't have great traction; lush continues to be the desired state by many.

Figure 2: Reduce Annual Consumption

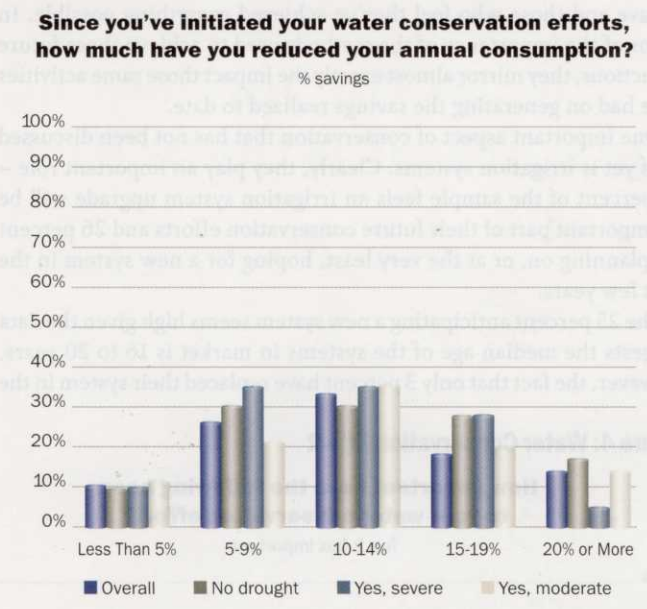
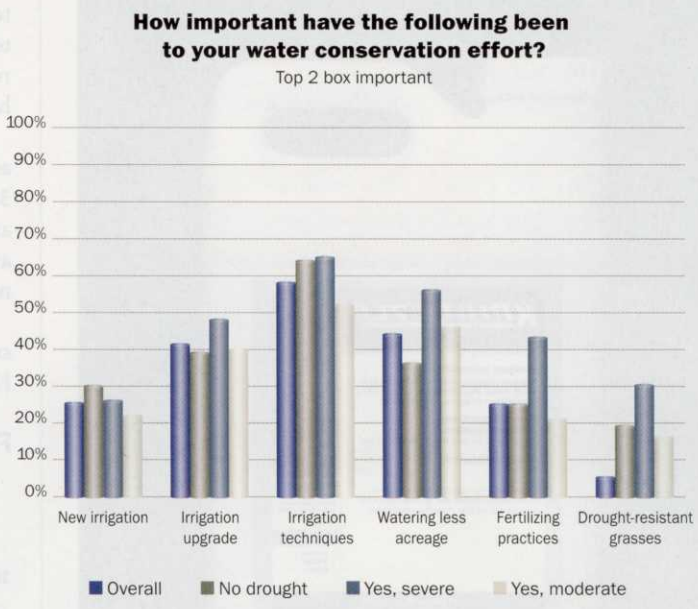


Figure 3: Water Conservation Effort



the water being used is effluent and 11 percent is reclaimed. Those numbers more than double to 26 percent and 25 percent for the courses being hardest hit by the drought. In keeping with the earlier findings few courses are having restrictions placed on their consumption by outside agencies. Only a third using effluent or reclaimed water are required to do so.

An interesting side note is that only half (51 percent) of courses using effluent or reclaimed water are bothering to test it and the same limited number (51 percent) are using additives. Among those treating the water wetting agents (78 percent) are by far the most popular followed by gypsum (35 percent), acids (31 percent) and all other (24 percent).

Ninety-plus percent have taken some measures to reduce consumption. And, it is consistent across all the groups analyzed. The overall sample was at 91 percent with those experiencing no drought at 90 percent, moderate drought conditions at 91 percent and severe drought at 88 percent. Given the consistency of these numbers there are forces at work other than the simple availability of water. As noted, water has significant cost implications and that is likely a motivation.

To support the concept that the economic impact is a significant motivation for water conservation efforts, it is noteworthy that half of the courses have initiated their activities since the economic downturn of 2008. It is also worth pointing out that among those in the areas most heavily impacted by the drought 43 percent of the courses began their reductions prior to 2005 as opposed to 26 percent of the overall sample having started that long ago.

As Figure 2 shows, the savings generated varies substantially but, in most cases it's significant with 60 percent or more of the sample realizing annual reductions in excess of 10 percent. Accomplishing those savings, however, is a big effort. There is no "silver bullet." As Figure 3 shows, supers are implementing numerous and varied changes to achieve the results. Of note is how much more aggressive those in the heavily drought stricken areas have been than their those elsewhere. Equally noteworthy is that while water conservation brings with it a cost savings many of the steps being taken to reduce consumption (upgrades, wetting agents, hand-watering) have their own adverse cost implications.

Across the sample the most important (top 2 box) activities in their conservation efforts have been the implementation of new irrigation techniques (48 percent), addition of wetting agents (48 percent) and hand watering (48 percent). These same activities have been most critical for those achieving reductions in excess of 10 percent annually. The notable difference between the overall respondent base and those achieving the highest levels of savings (>15 percent) is the importance of a maintaining a drier course which jumps from 40 percent to 70 percent.

Another significant conservation technique is the watering of less acreage which 37 percent of the sample indicated had top 2 box importance. Far and away the increase of natural areas (73 percent) was the most popular way to reduce the acreage irrigated followed by not watering the rough (34 percent) and narrowing of fairways (21 percent).

Despite the extensive conservation efforts put in place to date, the industry is far from finished. 83 percent of courses have goals to further reduce their water consumption over the next three years. And many of those goals are significant. Forty percent are planning to save 10 percent or more with ten percent striving for reductions

Implications

- **There is an industry-wide obligation to create new conservation opportunities.**
- **There is a need for more education: superintendents/staff; management on the benefits; and players on the need**
- **How big a role should water quality versus water consumption play?**
- **An improving economy bodes well for the irrigation companies.**
- **There appears to be pent up demand but, how are they positioning themselves today for tomorrow's sale?**

in excess of 20 percent. Among the 17 percent planning no reduction there is undoubtedly a mix of those who have no particular motivation to save and those who feel they've achieved everything possible. In terms of the importance of the methods used to achieve those future reductions, they mirror almost exactly the impact those same activities have had on generating the savings realized to date.

One important aspect of conservation that has not been discussed as of yet is irrigation systems. Clearly, they play an important role – 38 percent of the sample feels an irrigation system upgrade will be an important part of their future conservation efforts and 26 percent are planning on, or at the very least, hoping for a new system in the next few years.

The 25 percent anticipating a new system seems high given the data suggests the median age of the systems in market is 16 to 20 years. However, the fact that only 3 percent have replaced their system in the

Figure 4: Water Conservation Effort

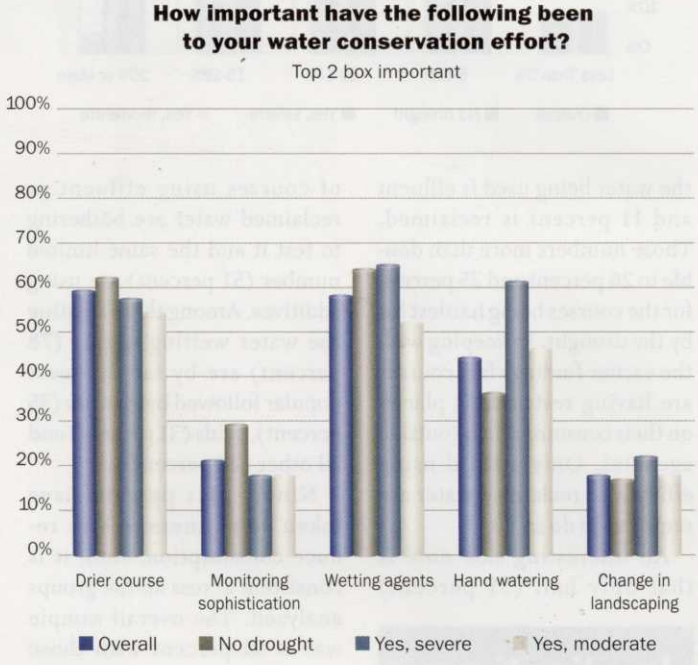
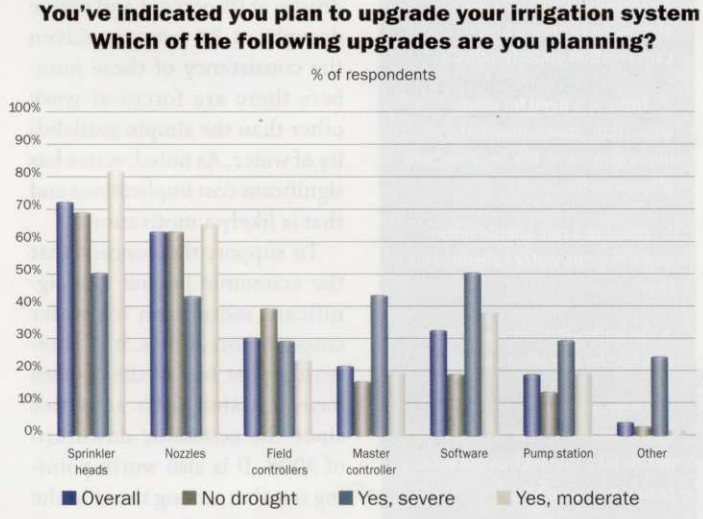


Figure 5: Water Conservation Effort



last three years and only 7 percent replaced in the three years prior would suggest the economic downturn has had a significant impact and the market is experiencing significant demand. This phenomenon is true of major irrigation system upgrades where more than half of courses have not had one in the past decade and 38 percent are anticipating one in the next few years.

As Figure 4 shows, of those planning an upgrade, the more sophisticated components will be most popular with those experiencing severe drought conditions.

In addition to the behavioral information, one of the study's goal was to understand superintendents' attitudes about water, as well as the attitudes of those who influence them.

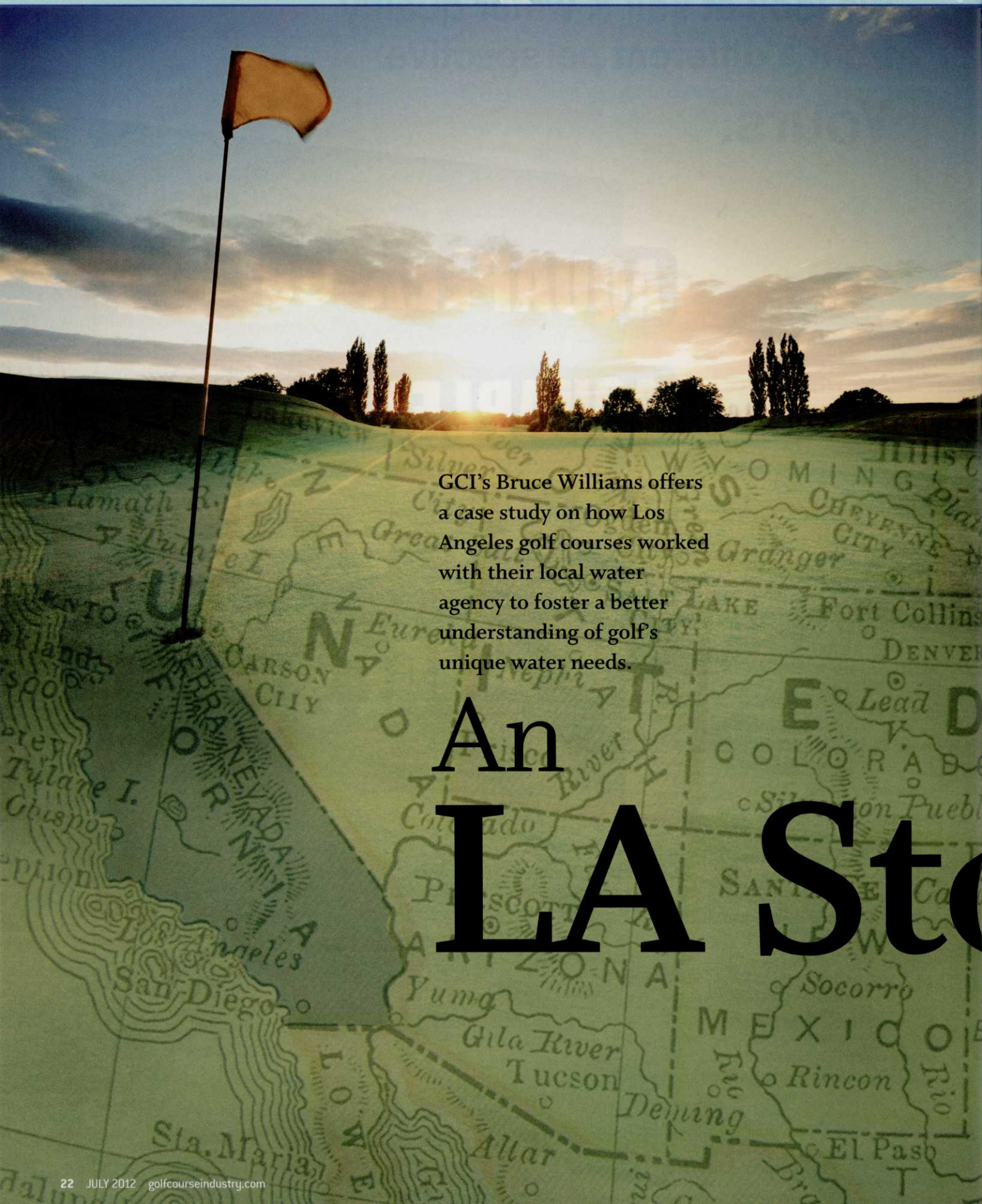
Clearly, supers understand the dilemma. Over half (54 percent) top 2 box agreed they have an environmental obligation to conserve water. They are also very pragmatic with 62 percent recognizing there is a significant possibility of outside intervention if the industry does not act responsibly. With that said, less than half (48 percent) agreed they were well versed in conservation techniques and only a third felt there employees were trained to save water. Most disappointingly, only 14 percent indicated they are using the most sophisticated water management techniques. This number is tempered somewhat by the fact that 34 percent feel hampered by antiquated systems.

And throughout it all, the super remains the man in the middle. On the one side they are dealing with management that still doesn't appreciate the issue. Only 38 percent were in top two box agreement that management understands the environmental impact of water use and even fewer (36 percent) feel management understands the financial impact. The other side is comprised of players who will always want a lush, green course (46 percent top 2 box) and for whom the concept of a faster, firmer course has not taken hold (only 31 percent top 2 box agreement). GCI

Methodology and notes

The median age of the respondents was 45 and they have an average of 11 years in their position. The courses were geographically dispersed and represented an appropriate mix of private, semi-private and daily fee facilities. As expected the majority (73 percent) were 18-hole layouts.

The study was fielded in May 2012 to the GCI circulation database. 192 responses were collected yielding a 95 percent confidence level with a margin of error of +/-7.04 points. The survey was programmed in Perseus and the analysis was conducted using SAS software.The reference to "top 2 box" is based on a six-point Likert scale. Trone Brand Energy prefers this to the more common five-point scale in that it eliminates the default neutral position (box 3 in a five-point scale) and adds meaning to the findings by not including those indicating marginal agreement (box 4 in the six-point scale).



GCI's Bruce Williams offers a case study on how Los Angeles golf courses worked with their local water agency to foster a better understanding of golf's unique water needs.

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Key points

- An irrigation audit might be the best money you ever spent at your golf course.
- With the increasing cost of water it may soon be called liquid gold.
- The days of lush and green are long gone as golf courses strive for even greater water conservation.
- In Southern California it is not unusual for water budgets to be the second highest cost of maintenance with average annual cost in the $300K to $600K range for an 18-hole golf course.
- Sit down and discuss the scientific requirements for a grass plant to survive rather than having a water agency pick an arbitrary set of reduction percentages and establish poorly supported regulations.

All across the United States water shortages are applying pressure on golf courses to conserve more water than ever before. Recent droughts in Texas, Georgia and other states have made headlines, while other states like Arizona, Nevada, New Mexico and California have dealt with these issues for years.

In 2009, successive drought years jeopardized Los Angeles' water supply. LA receives its water from the Sacramento Delta and also from the Colorado River via a lengthy set of aqueducts. Much of that water is stored in reservoirs near LA because usage is higher during the summer months due to reduced rainfall and increasing temperatures.

Snowpack in the Sierras is a major source of water that enters the delta. Much of Southern California is dependent on a solid snow season to provide the melting off that feeds the rivers. Up until 2012 we have experienced successive below normal snow years, which resulted in lower-than-normal reservoirs are much and it would take several years of above average precipitation to get out of the drought situation.

Water is such a precious commodity the city council passed an Emergency Water Conservation Ordinance in June 2009 mandating immediate compliance with an onerous set of irrigation regulations that would have had a dismal impact on golf courses. The original set of regulations allowed for irrigation only on Mondays and Thursdays and no irrigation between 9 a.m. and 4 p.m. Those regulations were for all turf irrigation including, lawns, parks, sports fields and, of course, golf courses.

Originally the request was for a 15 percent reduction in water usage for each golf course facility but the regulations did not allow for well-trained and highly educated golf course superintendents to manage their water. The new stipulations could have potentially led to mismanagement of a precious resource. There became a need to develop a group of golf course water users – who had water provided to them by the Los Angeles Department of Water and Power (LADWP) – to engage in a process of education and understanding.

DEVELOPING PARTNERSHIP. LA's golf community organized and approached the LADWP with the idea of having a set of meetings that would evolve into the "Golf Industry Water Conservation Task Force." The purpose of the group was to:

- Open a dialogue regarding water usage and conservation
- Discuss methodology for golf courses to best manage irrigation
- Be involved in the formation of any new regulations via recommendations by the task force to LADWP
- Have ongoing meetings to chart the progress of the conservation efforts
- Educate the LADWP as to the Better Management Practices for golf course irrigation
- Educate golf course representatives on the requirements of the LADWP and its sister agencies
- Provide annual educational workshops to educate superintendents on new programs and methods for water conservation.

This task force has been working well for over 3 years now and the outcomes would not have been possible without all the powers sitting at the same table. I imagine this group will still be working on water issues with mutually agreeable outcomes for many years to come.

Through tracking of water usage and staff member education, the most satisfying moment was when golf course representatives were told that golf courses were some of the most efficient of all the outdoor irrigation users.

OPTIONS FOR WATER CONSERVATION. During the dialogue for water conservation it was felt that the first step would be to reduce golf irrigation water usage by 15 percent. The governor of California had developed a plan that was referred to as 20 by 2020 and included a 20 percent reduction in water usage by the year 2020. The restrictions as to days of irrigation and timing of irrigation were not suitable to the golf community so an offer was made to reduce the irrigation water by 20 percent immediately and not wait until 2020

Through tracking of water usage and staff member education, the most satisfying moment was when golf course representatives were told that golf courses were some of the most efficient of all the outdoor irrigation users.

but lift all restrictions as to how individual golf courses would accomplish this.

A win-win deal was struck for both the golf community and the people of LA. Within the first year all of the 35 golf course were in compliance as tracked by the LADWP and the meters used to monitor water usage.

Prior to the mandates the city, through the LADWP, had provided a variety of incentives to reduce water usage. Among those were:

- Replacement of irrigation nozzles to improve uniformity of distribution
- Turf removal program that would reward properties taking acreage out of irrigation
- Rebates for approved control systems
- Adjusted water rates for golf courses following a set of requirements including the use of weather stations and computerized control systems to best apply water to the turf

Water can wear things out after many years of usage. Most nozzles, on the irrigation heads, are made of either plastic or brass and subject to wear. When those orifices wear out the volume, trajectory and uniformity of the irrigation water can be dramatically affected. I have seen irrigation audits that resulted in only about 60 percent efficiency of systems. By changing the nozzles an increase of up to 25 percent can be expected. From personal experience I utilized a rebate program that allowed our golf courses to receive all new nozzles and all we had to do was supply the labor to install them. This is a great program that the LADWP has had in place for a number of years. It does require some paperwork but it is well worth the effort.

Steve Sinclair, CGCS, Woodland Hills Country Club, is one of several superintendents who opted to remove turf as a part of his conservation program. Don Johnson, superintendent at Porter Ranch GC, also undertook a major improvement project involving turf removal. The premise of meeting a 20 percent reduction in irrigation water becomes much simpler when you have 10-20 percent less turf to water. These projects are not simply undertaken and they are not inexpensive. However, with a rebate of $1 per square foot, it does make such projects doable for many properties. You not only have the reduction in irrigation costs but sustained cost reduction via savings on fertilizer, mowing and weed control.

Turf reduction requires a plan designed by a qualified golf course architect and the golf course superintendent. Simply ceasing to irrigate does not work and the turf will need to be cut and removed. Once the turf is removed it is often replaced by decomposed granite, pine straw or bark mulch. This requires installation costs but those are normally offset by the rebate. Upkeep will be required as well.

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Xeriscaping is often added with the use of drought tolerant plants and the installation of subsurface emitters for drip irrigation.

Several golf courses have opted to install new irrigation systems. A typical irrigation system should last 20 years in Southern California. Newer systems are much more efficient than those designed several decades ago. Variable speed pumps save on energy costs and also keep optimal pressure in the lines. Although new irrigation systems can cost between $1 million and $2 million if you calculate the cost per year it is less than the cost of water that many courses would pay in a 4-year to 8-year period.

IMPORTANCE OF WORKING TOGETHER. With the LA area receiving an average of less than 12 inches of rainfall per year it is easy to understand that golf course turf would not exist without irrigation. Water is a precious resource and it is also a huge line item in most golf course budgets.

The golf course industry was very proactive in working with the local water agency to develop a sound strategy to turn a problem into a solution. That takes teamwork. Without both parties coming to the table it would not have happened.

Drought is a serious trend in California. Even with an above-normal snow pack and above-average rainfall I doubt we will see any improvement for the rest of this decade and beyond. Treaties concerning water were originated back in the 1950's. At that time California was in a growth boom and transporting water to places like LA and San Diego made that possible. At the same time, Northern California and Las Vegas grew, and both of those locations were supplying water.

There is a lot of pressure to reduce water transport to Southern California as Las Vegas and the Sacramento Delta want to keep their water and also the many agricultural farms that feed the nation along the aqueducts. Debates over endangered species and reduced fish populations have added fuel to the fire.

One thing you can count on is that potable water is a finite commodity and we are not making any more. The availability is less and often the quality is marginal at best. Yet the cost continues to rise as golf course superintendents walk the tight rope with their daily decisions for irrigation management.

MIRRORING LA'S GOLF COURSE WATER PLAN

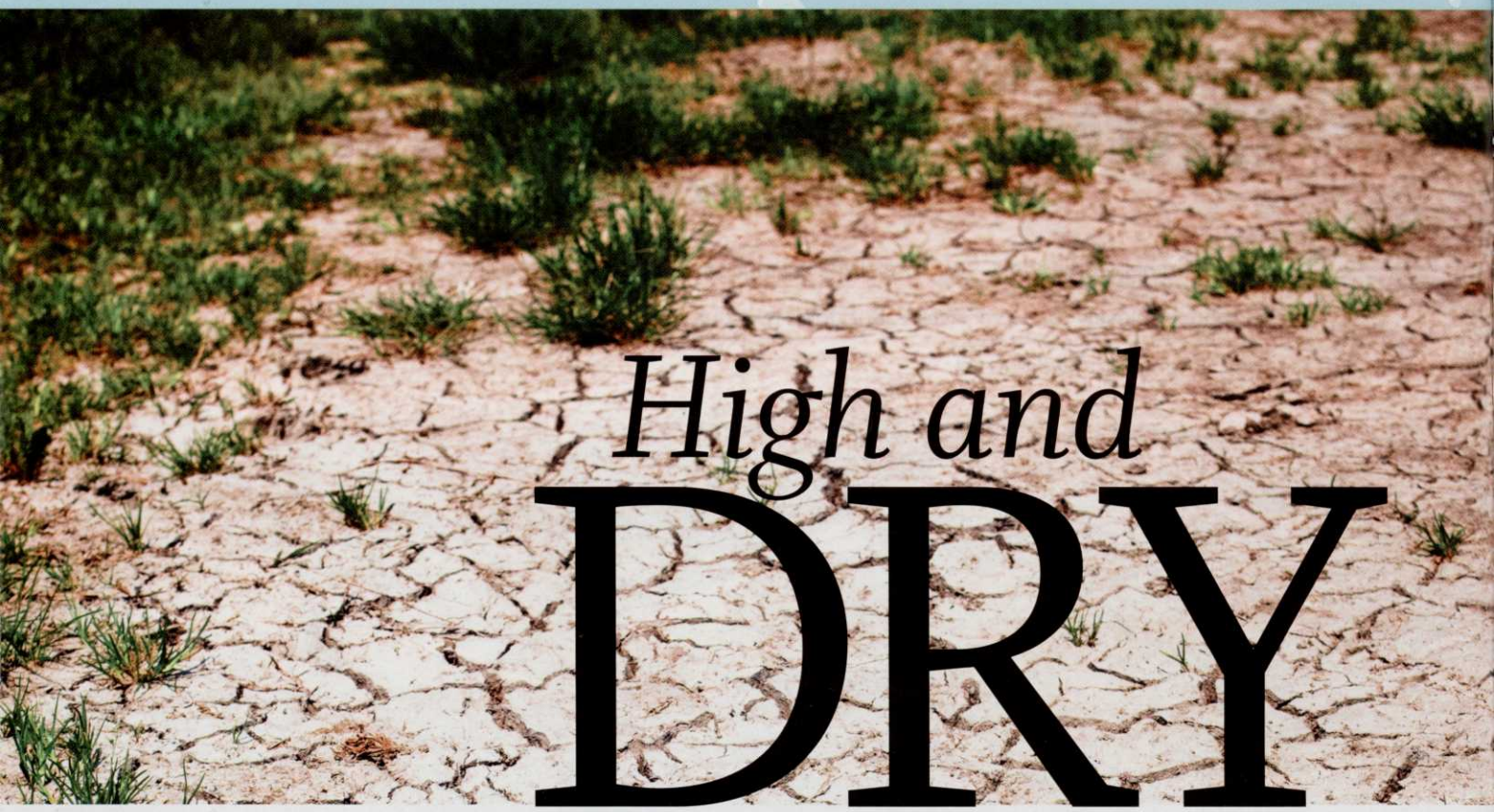
Several other nearby water agencies have taken notice of the collaborative efforts of LADWP and the Golf Industry Water Conservation Task Force. As regulations are being developed we have heard from many other water agencies and also golf course superintendents. As the old saying goes "it may not be necessary to reinvent the wheel."

Ironically, a few other regions are experiencing new water regulations that you would think had adequate supplies. Florida has quite a few water management districts and they monitor any and all usage for golf irrigation. A few years ago there was a severe drought up through Georgia. The Georgia Golf Course Superintendents rose to the occasion and worked with agencies to develop better management practices still utilized.

Even cities like Chicago are starting to question who has rights to Lake Michigan water. Many collar cities that border other cities on Lake Michigan utilize that water for irrigation. As lake water levels go down plenty of eyebrows raise in Michigan and Wisconsin as to who has those water rights.

THE FUTURE. No matter how we look at it there will be less water to irrigate with, so we must manage it well. By working with local water agencies it is possible to develop positive outcomes that satisfy everyone. We must continue to be strong stewards of the environment and our resources. **GCI**

Bruce R. Williams, CGCS, is principal for both Bruce Williams Golf Consulting and Executive Golf Search. He is a frequent GCI contributor.



High and DRY

A crippling drought is helping superintendents discover if their irrigation systems are up to snuff. But it's also putting pressure on their budgets as they're starting to feel the effects of having had to turn their systems on earlier this year. *By Jason Stahl*

Golf course superintendents no doubt will agree that this year has been one to remember so far in terms of its weather conditions. They might even go so far as to file it under "weird" – a very mild winter that almost transitioned directly into summer with no spring.

Some superintendents might dismiss the meteorological abnormalities as freakish and not likely to ever happen again, but the smart ones are no doubt documenting the bizarre temperatures and noting the various tweaks to their maintenance programs that produced the optimal results.

One of the things superintendents had to do this year that went against the norm is turn on their irrigation systems earlier than usual. Now, it could have a huge impact on their budgets, especially if they use city water.

"I had guys who started filling their ponds with city water in April who usually wouldn't do that till August," says irrigation consultant Brian Vinchesi. "Even if you're not paying for your water, your electric bill will go up. Depending where you're located, it won't be that bad, but it's still going to go up."

"I had guys who started filling their ponds with city water in April who usually wouldn't do that till August."

— Brian Vinchesi

Bradley Anderson of Bittersweet Golf Club in Gurnee, Ill., is one superintendent who is feeling the pain of a depleted water supply. His irrigation reservoir, which holds six million gallons and is fed exclusively by run-off, began running out of water in mid-June, and his crews started transferring water from the ponds on the golf course to the reservoir. They shut the irrigation system off during the day, then hook up a pump and reverse the flow of water backwards through the system to the reservoir.

"Eventually, we may need to buy water from the village, but if we can hold out until the rain replenishes our supply, the water savings will be applied to better use," says Anderson. "You hate to have to pay for water. I would rather apply that money to topdressing and other projects." The rain, however, has been hard to come by with, according to Anderson, only two inches in the 60 days prior to June 20.

Another challenge Anderson is facing is that his irrigation system is antiquated. The solenoids and gear drives are failing, and every day, he runs as many heads as he can ahead of play to identify which ones are broken.

"On any given day, we're fixing 10 to 12 sprinklers," he says.

Anderson is currently taking quotes from several consultants on a new system but admits that spending $1 million on such a system right now is not feasible.

"Yes, we're wasting man hours taking care of things but we're still spending less money than you would on a new system – and in this

THINKSTOCK

economy, you have to make do with what you have until things improve," he says.

Vinchesi says that's one of the blessings of having such a strange season that is warmer and drier than normal: realizing the shortcomings of your irrigation system and being able to make the case for an upgrade.

"The thing about years like this one is that it shows you the deficiencies in your system which, in a normal year, you would never see. You might discover there is more wrong with it than you thought, or that it's not as good as you thought," says Vinchesi. "It's a good year to document what's wrong with your system and why."

Greg Shaffer of Elcona Country Club in Briston, Ind., has no problems with water supply as he has his own wells. However, he is feeling the pinch from increased electricity costs from running the pumps more. Those costs could be higher, though, if the pumps didn't have a variable frequency drive (VFD).

"The VFD ensures that they're only putting out what they need to put out," says Shaffer.

ELCONA COUNTRY CLUB

Water wasn't the major concern at Elcona Country Club, it was electricity use related to irrigation.

"They slowly ramp up and slowly wind down so that there's no water hammer, which leads to significant savings in the electrical department."

Even so, more use equals higher bills. Check out these numbers: in May 2011, Shaffer used 1.5 million gallons of water. This May, he used 8.7 million gallons. Through late June 2011, usage was at 5.1 million gallons, compared to 11.2 million this year.

"For the entire year last year, we used 21 million gallons of water, so we're already at half of what we used all last year," says Shaffer.

Fortunately, Shaffer is reaping the benefits of a newer irrigation system installed in 2009 that features a weather station that enables him to monitor evapotranspiration (ET) rates. He will look at the ET rates for a three-day period, and if the ET rate each day was .15, he will irrigate the cumulative total of .45. Sometimes he will stretch it to a four-day period, but if he has two high ET days and the course really needs some water, he will stack two days together and water every other night.

Elcona Country Club has been enjoying the benefits of a newer irrigation system.

ELCONA COUNTRY CLUB

"The theory is that we're putting back out what we used and therefore we're not overwatering," he says.

To minimize wear and tear on the irrigation system, Shaffer divides the course into sections and waters on a deep and infrequent basis. For example, one night he will water fairways and greens heavily, about a half inch. The next night, he might put the same amount of water on the tees and rough. On the third night, he waters the practice facility and clubhouse.

Vinchesi believes the early start-up of irrigation systems for most supers was a good

thing as the longer these systems sit idle, the more problems they tend to have. Still, Shaffer worries that the intense use of his system so far this year might lead to problems.

"You still have pumps turning off and on, pressure fluctuation in the lines, and more water running through the nozzles and rotors," he says. "Since we have a new system, we're not really seeing any side effects to this point, but you still have to account for the wear and tear over a period of time."

While Shaffer normally does his preventive maintenance program in May, he still had not done it by late June because he has been using his irrigation system so much.

Chris Tritabaugh of Northland Country Club in Duluth, Minn., doesn't have to worry about running out of water this year or overtaxing his irrigation system. He has gotten plenty of rain through spring up till mid-June. But, like with a lot of superintendents, the wacko weather has put everything ahead of schedule.

"Everything has been a month ahead al-

BITTERSWEET GOLF CLUB

Get flexible

Bittersweet Golf Club

So, with many areas of the country experiencing moderate to severe drought conditions, are there any steps superintendents can take to use less water in the future and possibly avoid a budget crunch?

Irrigation consultant Brian Vinchesi believes a more flexible irrigation system might be one answer. He uses the example of a straight double row system of one that is not flexible.

"It's watering the rough and fairway with the same sprinkler, and there's nothing you can do about it. If you don't turn it on, your fairway doesn't get watered," he says. "It's the same thing on the greens. If your greens have only full-circle sprinklers, you're watering the greens and around the greens. Those are all things that could be avoided by having a different irrigation system or even an updated control system."

Bradley Anderson of Bittersweet Golf Club is getting with the program by converting his full-circle sprinklers to part-circle sprinklers so that he's only watering the playing surface.

"We have some areas where we have full-circle sprinklers and we don't need them there," says Anderson. "We're watering a certain amount of rough, not an excessive amount, but we're converting those areas to part-circle sprinklers so we can conserve water. And at $40 per sprinkler to do that, it's not a big cost. I think we're already following the most conservative practices we can, although we're constantly tweaking them."

BITTERSWEET GOLF CLUB

Courses must diversify their water sources.

most to the day," says Tritabaugh. "It has been pretty amazing to watch. We started to see disease in June that we normally don't see till July 4."

Tritabaugh's biggest concern is for his labor budget. This year was the second in the last three years where they had to open early due to the mild weather. He typically plans his budget for opening in the third week of April and brings in some workers the first week of April. But this year, they were a good month ahead of that schedule.

"And being a private course, it doesn't really result in a lot more revenue when you open early," Tritabaugh says. "It's tough when you're on as tight a budget as we are. You almost have to try to make it up at some point during the season. It's a little bit disheartening when the weather allows you to open early but you end up cutting back to make it work at the end of the year."

When all is said and done, Vinchesi feels the biggest issue relating to irrigation this summer will have been the water supply. He feels that those courses on city water might be better off than those that are not, unless the city enacts a water ban.

"I would be more concerned about the guys who are on a pond or groundwater well where, as it gets drier, it gets lower and stops giving the amount of water it used to or the pond dries up and they have no way to fill it," he says. "On the other hand, the guys who are using city water may not be able to hugely supplement it if it gets too dry and the city cuts them off. So it's important to be cognizant of what's going on with your water." **GCI**

Jason Stahl is a Cleveland-based freelance writer and frequent GCI contributor.

DROUGHT UPDATE

As of mid-June, although most parts of the country were dry, the notable drought was in Florida and Georgia. Most of the country was dry except for Oregon, Washington, Pennsylvania, West Virginia and Virginia. The Midwest was abnormally dry. New Mexico was in a pretty severe drought, as were parts of western Texas. The Southeast was dry, and Northern Ohio and Indiana were, too. Massachusetts was in a slight drought, as was Connecticut, although New York was faring pretty well.

Minnesota has been deluged with rain. Just ask Chris Tritabaugh of Northland Country Club in Duluth. In one 10-day stretch in the spring, they received 6.7 inches, and in an eight-day stretch in mid-June received three-plus inches with more forecasted to come.

innovative IRRIGATION

by Shawn Emerson

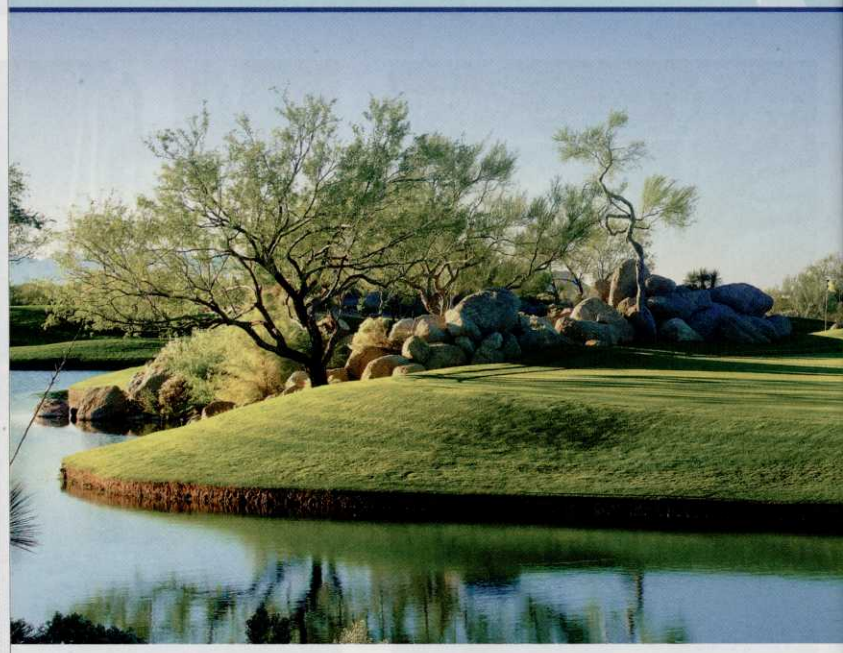
Data, collected from on-site telemetry systems, including water flow, electricity usage and lake levels is captured, analyzed and displayed by the system in a single, unified view of usage across the property.

DESERT MOUNTAIN

Desert Mount Club turns to technology to halt costs and conserve water.

It was six years ago that the agronomy team at the Desert Mountain Club in Scottsdale, Ariz., realized that the pricing on our commodities – reclaimed water, fertilizer, seed – was on the rise. That's always cause for concern for any club but especially so at Desert Mountain with six Jack Nicklaus Signature courses on 550 acres of turf. Comprised of six turf types, the courses accommodate 150,000 rounds of golf annually.

Typically we use 400,000 pounds of seed and 600,000 pounds of fertilizer in a year. In addition, we're located in the Sonoran desert where water is one of our most precious, and expensive, resources. Desert Mountain partnered with the city of Scottsdale and the state to utilize treated effluent, or reclaimed water, to reduce our water footprint. Using 1 billion gallons annually makes us the largest user of reclaimed water in the metro



Dessert Mountain employed a comprehensive records system to track how much water they were using and just how much we really needed.

Phoenix-Scottsdale area. We move that water through 11 on-site pump stations and eight reclaimed water lakes.

Dealing with the sheer volume of running an operation of this size and the cost it entails, I recognized the need for a comprehensive records system to keep track of just how much water we were using and just how much we really needed. Reducing energy and operating costs while continuing to maintain the greens in championship condition to provide a golf experience the members have come to expect on these award-winning courses also became a goal. In addition, reaching these goals would reduce our footprint on the land as no decision is made here without considering the indigenous plants and the wildlife that make this property home.

One of the areas I thought we could reduce our use of reclaimed water as well as fertilizer was in our leaching schedule. We had been flushing the salts and alkali out of the soil 20 times per year, requiring a significant output of water and power. It was at that time that I enlisted the help of Walt Norley at UgMo, a leader in advanced soil moisture monitoring, to create a wireless ground sensor that would tell me the TDS (total dissolved salts) in the soil which I could compare to the industry standard. Sensors installed, we monitored and waited for the TDS level to rise. It didn't, and we were able to eliminate the guess work and reduce the flushing to six times per year for a savings of 3-4 million gallons of water and a 10-15 percent reduction in our greens fertilization.

The sensors also captured moisture level, soil temperature and other variables. But what good was all this disparate data if we couldn't integrate it into our existing software that would help us monitor our peak water and energy usage, our storage lake levels and, most importantly, pinpoint how much water (and the energy to pump it to the courses) and fertilizer were actually needed in order to become better stewards of the land and save money?

TWEAKING THE TECHNOLOGY. In my two decades in the agronomy industry, the best words of wisdom I can give are these: It's okay to have problems but it's even better to ask for help. The agronomy department utilizes four separate softwares: Rainbird, Microcom, Arizona Public

DESERT MOUNTAIN

Service and UgMo. But together they're incompatible and we needed them to communicate in real time so that if our weather station tells us the courses received rain the night before, we could adjust the irrigation to water less that day, among other situations that require fine tuning on a daily basis. The agronomy budget could not withstand the purchase of all new software so once again I turned to experts in the business.

Through UgMo's partnership with IBM, I learned that IBM's Intelligent Operations Center (IOC) and Water Information Hub (WIH) systems could unite the four softwares into one platform to help us gather analytics while continuing to utilize our existing software. This became IBM's first application of analytics software on a golf course.

A key partner in this effort is Element Blue, an IBM Premier business partner responsible for the installation and management of the IOC and WIH systems. The IOC is an expandable platform designed to provide operational insight across one or multiple domains. The WIH allows users to have a system-wide view of operational and infrastructure performance. Together they create a common platform for information flow across the entire property. The software solution is hosted on the IBM Smart Cloud and managed by Element Blue.

With a customized dashboard and mobile notification capability, we can capture and visualize measurement data from monitors and the wireless ground sensors with which to base our decisions. Data, collected from onsite telemetry systems, including water flow, electricity usage and lake levels is captured, analyzed and displayed by the system in a single unified view of usage across the property. In addition soil moisture, salinity and temperature data is gathered from sensors across the course and combined with the telemetry data to provide an integrated view of course conditions and direct feedback on water and power usage.

In other words, instead of taking 30 days to gather and verify data, we can gather information up to six times per hour, 24 hours per day, allowing us to make decisions within 15 minutes. We can maximize response times to changing course conditions, and to minimize water usage, power consumption, personnel time and other direct costs. Course supervisors can adjust the system to respond to preset thresholds for every measurement collected and can be alerted in real time when thresholds are exceeded. We no longer need to rely on "sneaker net," meaning that we're running back and forth to gather updates on course and soil conditions.

THE PAYBACK. The software installation on the Cochise course will be completed by the end of July and we are projecting a 5-10 percent energy savings, a 20 percent reallocation of reclaimed water to other areas of the property and a 50 percent time savings for the irrigation manager. Eventually, we plan to install the technology on the remaining five courses in the next 1-3 years which will require only the cost to integrate the software into the main platform. I also anticipate that the purchase and integration cost of the software will pay for itself in three years.

With today's continually rising costs, coupled with increased player expectation of the quality of course conditions and overall golf experience, it is important for superintendents to know the business of running their course on a daily basis and to recognize trends in order to maintain quality and to control costs. As innovative as the Desert Mountain Club is, we did not invent anything new to help us achieve these goals. We simply identified the issues and engaged our partners in helping us find the answers in an inexpensive way. And in the process, we'll become better stewards of the land and educators in protecting our natural resources. **GCI**

Shawn Emerson is director of agronomy at Desert Mountain Club.

Not too dry, not too wet

As we enter the dog days of summer, manage soil moisture to ensure cooler, healthier turf.

by Carmen Magro

Much of the industry faced a nearly non-existent winter with a quick, non-transitional period into warm summer-like weather far earlier than normal this year. While the weather variable alone will add to the complexity of seasonal challenges, one variable, soil moisture, will be a key indicator for many ailments or rewards you will encounter as the season progresses.

Some of you are witnessing the effects of poor and good soil moisture management from earlier this year. Those not able to dry out their turf early saw the development of early season disease pressures and slow uptake of nutrients in saturated conditions. On the other hand, those who had minimal soil moisture but started operations later due to calendar or labor restraints missed a golden opportunity to jump start the growing season and build early energy reserves in the turf, which will help in the summer months.

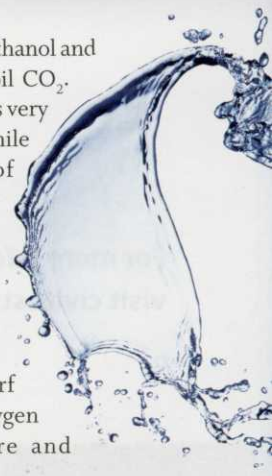
Temperature excluded, soil moisture is the single most important factor that affects the physiology of your turf and its growth habit as the season progresses. Ironically, moisture has a tremendous impact on temperature in the soil and the turf canopy.

WHY WE MONITOR. Early turf educational lectures taught us that a perfect soil is one where there is an optimal balance of soil moisture, air and gas that leads to strong turf growth. This is particularly true for growth under the typical stresses of golf course management. It is the reason why USGA specifications call for a high sand content mix to develop high quality putting greens, tees and other areas where compaction leads to loss of turf.

Even under packed conditions, these mixes maintain a quality level of soil moisture, air and gas. As a soil gets heavier...that is, less sand with a higher amount of smaller particles and therefore more compaction...we typically find less air and more water which leads to more compaction as we put traffic on these soils.

Those with "runway" type cart paths know exactly what I am talking about. The concentrated traffic of carts in these areas causes excessive compaction, especially under higher than optimal moisture conditions. This unfortunately was noticed much earlier this year due to the extended season with the early onset of traffic.

Soil moisture triggers many physiological responses in the turf plant. For one, turf cannot chew its food. It depends on dissolved nutrients in solution, including dissolved oxygen, to function properly. Even the fundamental process of respiration where the roots utilize soil oxygen is greatly affected when soil moisture levels are too high. The byproduct of respiring in low oxygen conditions is the production of ethanol and a buildup of soil CO_2. Ethanol alone is very toxic to turf while the buildup of soil CO_2, particularly when it cannot escape from the soil leads to exponential declines in turf activity as oxygen becomes more and more limiting.



As the ambient temperature rises and a condition of photorespiration kicks in – a process where oxygen replaces the desired carbon dioxide in photosynthesis – a much less efficient plant growth process produces a net loss of carbon and nitrogen with ammonia as the by-product of the latter. Both slow plant growth processes including those that we depend on to survive the stresses of play conditioning. While C4 or warm season grasses have a storage mechanism for basically storing CO_2 so that the plant can remain efficient even in hot temperatures, having excess moisture in the soil leads

Predictive solutions

Over the past decade, I have had the opportunity to monitor many variables in the soil and above ground through many regions around the world. As a result, I have written many predictive solutions and algorithms that draw on the changing variables affecting turf daily and throughout the season.

A key variable in these predictive models is soil moisture. For instance, too much moisture leads to moisture stress. Too high of a temperature leads to temperature stress. The combined effects of temperature and moisture, however, are much more important to the turf manager. Throw in salts and the needs and limitations of the turf with regard to water change dramatically. The key is knowing how much impact any one variable has on the target we are after. These targets include stress, disease likelihood, recuperative capacity, playability and performance, aesthetic quality and a whole slew of other things. Moisture has a significant weighted impact compared to many other variables. Also, when we consider that the finest turfgrass performance comes when the grass is almost on the brink of dying, any slight change in management that affects moisture in either direction will have an impact on whether our players are happy or not with the performance on the golf course on any given day.

to similar declines in growth no matter what type of grass you are growing.

With regard to the uptake of those dissolved nutrients, this process is impacted by the plant's fundamental growth patterns. If it is not photosynthesizing or respiring efficiently, it simply is not taking up nutrients well or at all. However, positioning key nutritional elements through foliar feeding is proving to have a positive impact on jump starting certain plant growth processes even under stress (another topic for another article). Finally, in soil where moisture is kept higher than optimal, we often see black layer form.

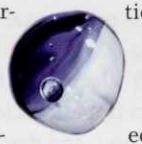
Many think black layer forms from using too much sulfur based fertilizers. The truth is that only under anaerobic conditions can black layer form. The microbes that cause black layer function in anaerobic or low oxygen soils where they attack and feed on sulfur based compounds and leave behind a fine black oxide particle that bonds with soil particles and clogs soil pores. This problem gets worse and worse until oxygen is introduced in which case the anaerobic-loving microbes cannot function any longer.

In every case above, monitoring soil moisture on a regular basis will have a positive impact and allow for the best chances of integrating a pest, stress and conditioning management program that is sure to keep golf course superintendents, members and players happy... something that is not easily achieved on a regular basis.

MONITORING METHODS. Many superintendents have found a way to use their thumbs, a knife, a coring tool or some way of monitoring the moisture on a routine consistent basis.

Today, there are options that have taken soil monitoring to a level of precision we only dreamed about a decade ago. I am amazed at how far technology has come in such a short time. In my early work for UgMo, where I served as chief agronomist, I coordinated how to utilize the information that sensors give us, I was able to put well-defined models to use in real time. One example was the ability to predict seedhead emergence by narrowing the window of this physiological effect to less than 48 hours compared to the 7- to 10-day window previously achieved with above ground only growing degree day models. Of course, any predictive model depends on the proper quantity and location of sensors to make sense. For those of you waiting for the technology to become affordable, your time is fast approaching so keep your eyes open for updates coming your way very soon.

But short of investing in the new technology to help you with soil monitoring, use your head at the very least. Know what your limitations are with your irrigation and make the necessary adjustments to insure the compromises you make to insure adequate coverage are the right ones that aren't going to hinder turf by putting too much water into the soil.



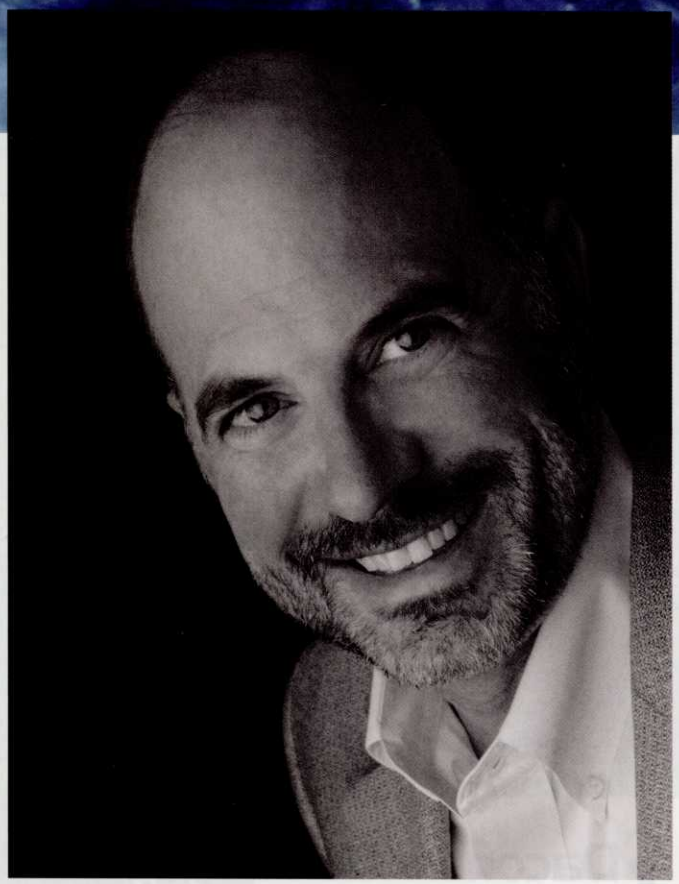
Remember that any length of time where the soil moisture level is too high is too much time...even if it is only for a day or night. On the flip side, too little water can initiate a dormancy mechanism that leads to less resiliency at the surface...a condition having a tremendous impact on ball roll and traffic stress resistance.

The best in the business know that achieving that optimal soil condition comes from being on top of that condition day in and day out. Employ whatever practice you can to take control of your soil moisture whether it is hand applications of water when called for or cultural practices designed to help dry out the soil after a rain event. One day of poor moisture conditions will have a negative impact that can last days, weeks or months depending on what the other surrounding conditions are. But at the very least, don't read into this like fine print.

Moisture management is part of an overall holistic approach to turf management. If you monitor it consistently, your entire program will be impacted by the decisions you make based on that monitoring. **GCI**

Carmen Magro, CGCS MBA, is chief agronomist/owner of Agronomy Management Solutions and a frequent GCI contributor.

Thirst Quencher



"The Big Thirst" author Charles Fishman shares solutions for water shortages and how you may be using water in the next few years.

By Mike Zawacki

We're in the middle of a water crisis. Actually, the golf industry is in the middle of a thousand water crises from coast to coast – and that's the good news, explains Charles Fishman, the author of "The Big Thirst," which takes an engaging look at the challenges of smart water management today and into the future.

"Whether its drought, bad water management or shifting water availability, many places in the country are having water problems that they're not accustomed to having… If you run a golf course in Orlando, or Atlanta, or in Dallas, all of those places have serious water problems, but those are local water problems," Fishman says. "That's a good thing because local problems can be solved at the local level."

And the good news, he adds, is that solutions exits – both from inside and outside the golf industry.

"There are some important things to keep in mind. One, there is a dawning era of water scarcity," he says. "People who depend on water for their businesses are going to have to going to have to change how they think about water every day. There's lots of transferable knowledge because lots of water problems have been solved by someone. But it's important to understand the community where your facility exists and what's available and possible in your community."

As you worked on your book, what struck you as the most common misconception people have about water? The thing most people need to get comfortable with is that water can be reused. The easiest water we have and the most inexpensive water we have is the water that's already been used once. There's nothing wrong with cleaning that water and then using it to water an athletic field or golf course. All the water on earth is the same water. There's no mechanism creating new water.

There is a hesitation to accept systems that clean and reuse water… and I believe that's a mistake.

Another misconception is the idea that water should be so cheap

that it's essentially free. I don't believe anyone in the world should be denied a ration of water because they can't afford it. However, most big companies that use large quantities of water have a problem putting conservation efforts in place because water is so cheap. No one wants to spend $10 million to save $100,000 worth of water. A commodity that's too cheap ends up not being used for the right purpose, wasted and misallocated. So cheap water ends up being a corrosive problem because no one ever thinks about it.

A third misconception relates to the fact that there is no global water crisis. Water problems are local and most water problems are solvable. Yes, the drought across Texas and in East Africa can't be fixed by waving a magic wand. But that's not what most water problems look like. Most water problems are the result of poor water management and poor planning, and that's what makes them solvable. And often there's enough water and enough money to solve them, there's just not good engagement of the problem and clear-headed thinking.

If you can figure out a way to educate people that it's OK to reuse water, then it could help you solve a lot of problems.

Fewer and fewer courses are drawing their water directly from potable sources. Instead, they've been depending on their own sources – retention ponds, gray water sources, secondary-use. Could these sources ever be at risk? Although it's inconvenient, I believe golf courses should be standing up and saying "No, we will not be using potable water sources to water turf because it doesn't make sense." By the same token, I'm not singling out golf courses. Any community that can figure out how to do it, should have a reuse system for office parks, athletic fields, campus… Think about it, we flush our toilets with drinking water. That's just absurd.

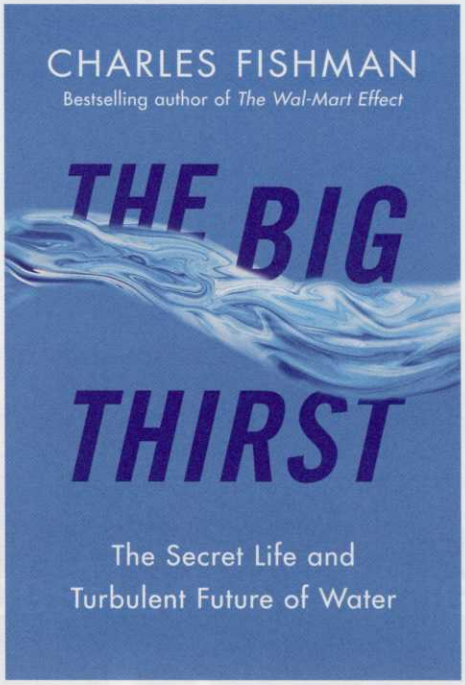
So are those grey water sources going to come under pressure? Yes, they will come under pressure because as people discover the use for lower-grades of water – say a steel factory or a mass-transit car-wash barn – those sources will come more in demand. Once people discover the value of non-potable sources there will be competition for those sources, which will put pressure on golf courses to compete for them. Unfortunately, a golf course has a difficult time making the argument – compared to a steel mill or other business entity – that they're equally important enough to use those resources. People will say, we'll you're just a golf course.

So what is a good, solid, sustainable source of water for a golf course? You don't want to have to rely on a single source for your water. However, you may be a course that doesn't have the financial means to have multiple sources for water. So you need to ask some basic questions. Where do we get our water? Where do the people who supply our water get their water? What's the dependability of that source and what happens if they see their supply drop by 20 percent?

And this goes for those living in what would be considered water-rich areas, what would you do if you found your water resources cut 20 percent? What would that look like? I don't know many golf course superintendents are ready to answer that question.

But that's the world we live in. Even the best water managers should be asking themselves, how do we increase our efficiency by 5 percent next year?

Those peoples who don't think they have to worry about this scenario should begin worry right now. And just assume you never have a water problem. If you could run your course on 5 percent less water, wouldn't you like to save in those related costs?



Charles Fishman's "The Big Thirst," takes an engaging look at the challenges of smart water management today and into the future.

So what needs to change? The most important thing is to look ahead and imagine how you would operate under scarcity. Most people think this means "How do I get through?" That's the attitude that has to change.

Scarcity may not be a temporary thing. Instead, it may become the new normal. You used to get X-amount of water. Now X minus 20 percent isn't temporary… it's reality.

That's the world golf course superintendents need to imagine.

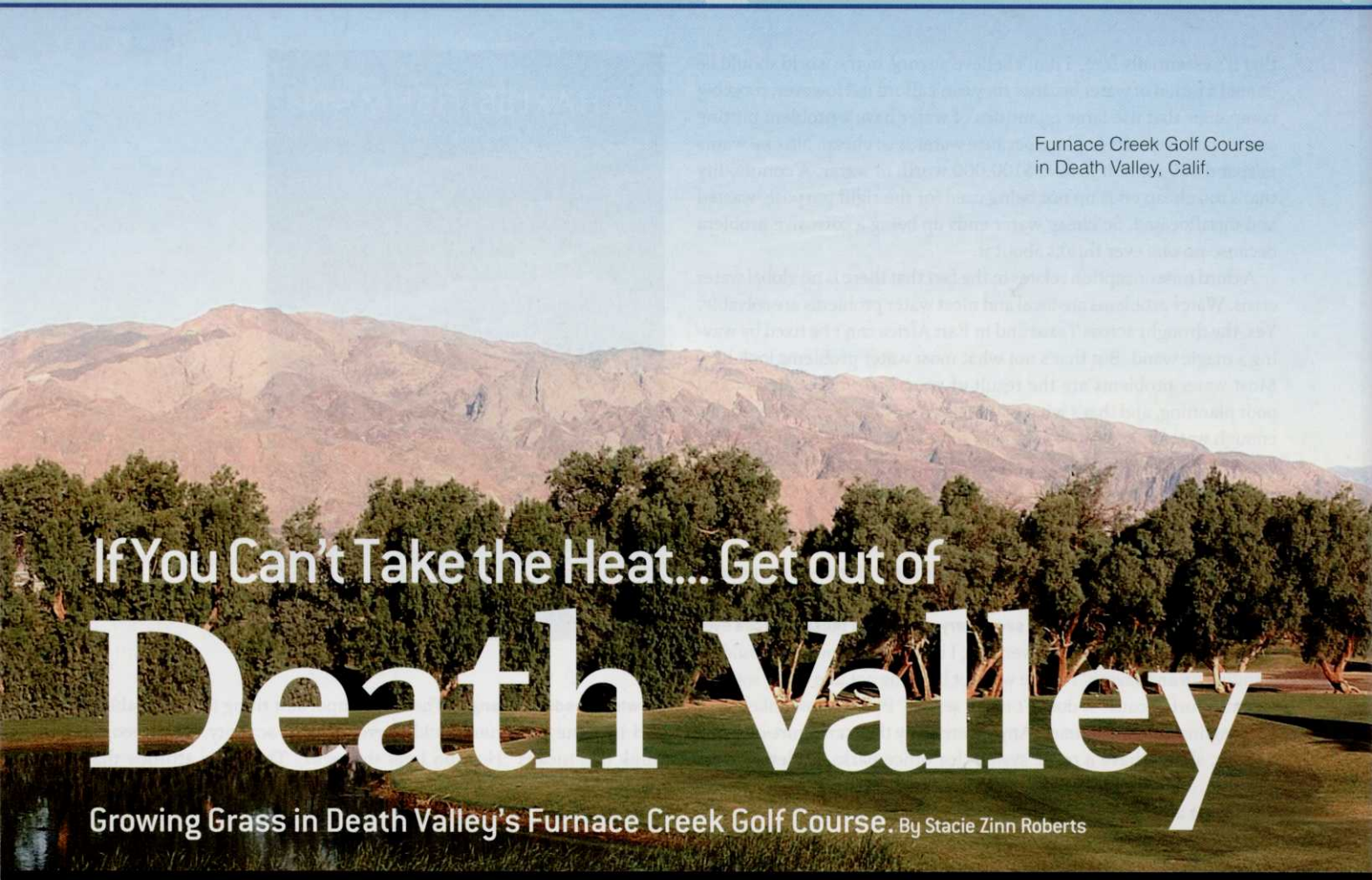
What do you envision is the state of water in 25 years? 50 years? You want to know about the state of water in 25 years? How about 10 years or 5 years?

Competition for water is going to happen, and a lot of superintendents live in that reality now. In the next 10 years many more golf courses will see water as the issue they need to address. You may see courses given a budget of how much water they can use. Then competition for water from other industries will increase. Finally, the people who golf will need to ask if their course is becoming smart with water management in the midst of scarcity. This could possibly corrode people's attitudes toward golf.

My suggestion is that anyone managing a golf course should be as far out in front of water as you can be. Go to your water supplier and ask what you can do better to use less water. Ask the question, do we need to be using this water (on certain areas of the course)? Is our technology efficient?

You're going to come under pressure for how you're using water. Getting out in front of it is smart strategically. Reaching out to the community and understand how other users are achieving efficiency and smart water management. Build the connections that will allow you to manage water smartly and give you insight into the politics of water in your community so that when scarcity comes you're in a better position to handle it. **GCI**

Mike Zawacki is GCI's editor.



Furnace Creek Golf Course in Death Valley, Calif.

If You Can't Take the Heat... Get out of

Death Valley

Growing Grass in Death Valley's Furnace Creek Golf Course. By Stacie Zinn Roberts

It's noon on a Thursday at the end of May and it's already 117-degrees. But that's nothing. In just a few months, overnight temps will hover around 100-degrees. The scorching days could push past the 130-mark. Now imagine growing grass under these conditions. Such is the life of Chris Bessette, golf course superintendent at Furnace Creek Golf Course in Death Valley, Calif., one of the hottest, driest places on earth.

Furnace Creek is literally an oasis in the desert. The closest town, Pahrump, Nevada, is a good hour drive by car. Between here and there, the open expanse of barren desert wasteland stretches out over dry creek beds, dusty ravines, rock-strewn plateaus and towering mountains.

Still, people from all over the world come to Furnace Creek Inn & Ranch Resort. The stay at the hotel, swim in the pool and play golf. The 18-hole course supports about 10,000 rounds of golf per year at the resort, located on the only privately owned land within Death Valley National Park. Visitors come to experience for themselves how hot is hot. Bessette says busloads of European and Asian tourists are a common sight in the summer. They take pictures in front of the thermometer to show off to friends back home.

> "It varies a lot and the problem is, it's always the opposite that I need. In the wintertime, when I don't need very much water, then I'm flooded. I have too much."
>
> —*Chris Bessette, Furnace Creek Golf Course*

What does 131-degrees, the hottest Bessette has experienced in Death Valley, feel like? "It's so hot that people would not believe it. Picture your head in front of the oven door. You move your head but there's nowhere to go," Bessette says.

The heat is a real issue when scheduling maintenance projects on the course. In the summer, work begins at 5:00 a.m. and ends at 1:30 p.m., unless it gets too hot. "Above 123-degrees, I send them home. We haven't lost anybody yet," Bessette says with a chuckle.

Maintaining a full crew, though, is a challenge. Bessette says he's supposed to have an eight-person crew, including himself. Right now, he's running the course with the help of five staffers. Since there's no town nearby to draw employees from, he advertises widely on the internet, in magazines and in newspapers. "People generally look at it and say, 'You want me to move where? Temps will be what? For how much money? You've got to be kidding,' " he says.

But Bessette says there are some real benefits of working in such isolation. All of the staff lives on property. He describes it as "like a small town." Bessette and his wife Henny, who also works at the resort, live in a house rent-free. They don't pay for electric or satellite t.v., and can eat for free in the employee dining hall. At 61-years old, Bessette says the arrangement "was a big part of what attracted us

FURNACE CREEK GOLF COURSE

"It's so hot that people would not believe it. Picture your head in front of the oven door. You move your head but there's nowhere to go."

— Chris Bessette, Furnace Creek Golf Course

here. Instead of putting money into a mortgage or rent, I might be able to retire someday."

His staff lives "in a dorm situation and pays some rent, maybe $30 a pay day, but they still get free breakfast and lunch, and dinner is $3."

Furnance Creek is owned by Xanterra Parks & Resorts. The company operates resorts and lodging facilities in various State and National Parks including Yellowstone, Mount Rushmore and the Grand Canyon. One of the appeals of working for a company like Xanterra, Bessette says, is that staffers can apply to transfer between facilities, having the ability to live in some of the most unique places in the country.

"When I looked at it, I went 'Wow, there's no houses around it. That means there's no men's club, no women's club, no senior club, no board of directors. There's nobody to complain that your water's getting in my yard, your tree branch is hanging over the fence, the grass in somebody else's section of the golf course looks better than mine.' You don't have any of that. And so I went, 'Wow, that would be interesting, wouldn't it?" Bessette says.

He was also attracted by the stark beauty of the place.

"On one side of us we have a mountain range that's 8,000-feet-high, and on the other side of us, it's 12,000-feet-high. So every place you look, it's just really nice scenery. It's very quiet and peaceful out here. We have more wildlife than anybody would guess. We have a population of coyotes that live here and they're very comfortable with people as we are with them. We have roadrunners, rabbits, we have ponds, of course, on the golf course so we're a natural bird sanctuary," Bessette says.

The first three holes at Furnace Creek Golf Course were built in 1927, giving it the distinction of being the first grass golf course in the California desert region. It was expanded to a full nine in 1931. The second nine was added in 1968. Perry Dye redesigned the course in 1997, and installed an irrigation system and sulfur burner to lower the pH from about 8.3 down to a grass-friendly 6.5. The course is grassed with common Bermudagrass except for the greens which are 328-Tifgreen Bermudagrass.

Furnace Creek is also the world's lowest golf course, sitting at 214-feet below sea level. While the lack of elevation poses no maintenance issues, it does wreak havoc on ball roll.

To describe the affect, Bessette used the analogy of how kickers in football love to play at Mile High Stadium in Denver because the altitude makes the ball fly farther. "We have the opposite effect. The ball won't go as far as you're used to. You'll need one extra club than you're used to. If it's cold, maybe two clubs," Bessette says.

The deviation was enough to prompt Golf Digest magazine to name Furnace Creek to the March 2007 list of America's 50 Toughest Courses, saying that along with the challenges of playing in extreme heat, "the barometric pressure makes the ball go even shorter and more crooked than usual."

Water management is a big part of Bessette's job at Furnace Creek. The golf course and resort are made possible by the existence of three springs in the mountains beyond the property. The water that comes bubbling up out of the ground is stored in a large holding tank and then funneled down to the two swimming pools on the property.

"We label the pools as spring-fed and that means we can't put chemicals in the water. We have to circulate the water according to how many people use the pool, on average. The circulated water from the pools is what comes to me in underground pipes and goes into my irrigation pond. That is the amount of water I get to use. It varies a lot and the problem is, it's always the opposite that I need. In the wintertime, when I don't need very much water, then I'm flooded. I have too much," Bessette says. To store the excess water in the winter, he moves the water through a series of holding ponds on the property.

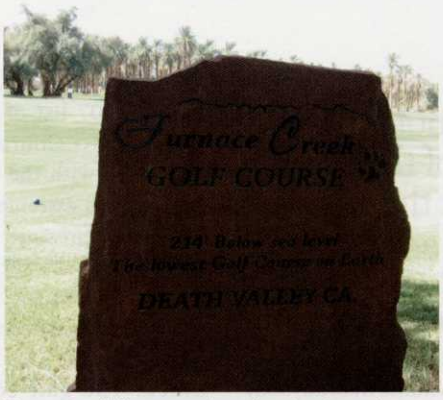
"In the summertime, we have to put out enough water but the pools don't keep up with the amount that we need. So, they have to bump up the amount of water that circulates through the pools in order to give me enough to keep the golf course irrigated," he says.

Furnace Creek is a Certified Audubon Cooperative Sanctuary, through the Audubon International environmental program. Bessette felt the most obvious way to start in the certification process, which was achieved about four years ago, was with water conservation.

"We started cutting back and going off of our ET figures instead of just throwing out water everywhere. Then we looked at ways where we could cut back during the summer months when we have almost no play. It's usually just employees and we keep the golf course open. But we turn the water off on our driving range and we save a significant amount of water there. We turn our rough down to 70 percent of ET. It gets a little dry, a little bit yellowed, but like I say, there's almost no outside

Three springs in the mountains beyond the property feed water to the course.

FURNACE CREEK GOLF COURSE



Bessette: "We started cutting back and going off of our ET figures instead of just throwing out water everywhere."

play, it's almost all employees so we all know that and we all put up with it," Bessette says.

His methodology for maintaining the golf course seems to be one of working smarter, and not being afraid to try something new.

The weather station at Furnace Creek is tied by computer into the irrigation system. "At night I set it so that my computer goes off of the weather station. So if I have 2.7 ET, that's what the computer will put out, that amount of water to make up for what was lost yesterday. We try to run it at 90 – 95 percent of ET and that gives us a little leeway so that in the middle of the day we can send some people out to hand water dry spots," he says.

Up until about 5 years ago, the dormant Bermudgrass was overseeded in the winter. But that proved to be a challenge in trying to time the Bermudagrass coming out of dormancy with the ability of the ryegrass and *Poa trivialis* filling in. The greens were slow. Now, Bessette says, he simply paints greens, tees and fairways. He says, "It's worked out better than anyone could have imagined." The greens play faster. The only real difference, he says, is that divots don't fill in so there are more divots on the course in winter.

Bessette also uses some good common sense to work with weeds on the golf course.

"Cattails have been a problem here forever. They had cattails that were 8 feet tall and they'd go out and spray gallons and gallons of Roundup on them. So what I decided to do was, cut them down first. Then when they start to grow and they're only 6 inches tall, then we spray the Roundup on it. So we're only spraying about a tenth of what we did in the past. We found other ways where we could mechanically removed weeds instead of spraying chemicals on them," Bessette says.

Bessette began his career as a member of the maintenance crew at Pebble Beach and he's spent his career maintaining golf courses in California. "One thing that's strange – this is my sixth golf course. Before I was here, I never had an interview with anybody. Since I've been here I've been on TV four times, and had three or four different magazine articles," he says, laughing. "You gotta go to the middle of nowhere to get recognized." **GCI**

The heat is a real issue when scheduling maintenance projects. Above 123 degrees and Bessette sends everyone home.

FURNACE CREEK GOLF COURSE

SWAP MEET

Superintendents explain their irrigation nozzle choices to achieve distribution uniformity for flawless fairways and gorgeous greens.

by Helen M. Stone

Bill Swancutt

ILLAHE HILLS COUNTRY CLUB, SALEM, ORE. A golf course is much like a symphony. Each instrument needs to be in tune and harmonize, otherwise there are discordant notes that can spoil the experience for listeners.

Likewise, soggy areas and brown spots can spoil a golfer's experience on even the most beautiful of courses. Now at Illahe Hills country club in Salem, Ore., everything is tuned up and harmonious, offering the finest play possible for its members.

Bill Swancutt has been conducting maintenance on the 50-year-old course for the past 31 years and has faced his share of trials. The heavy clay soil makes irrigation a challenge, even if it's necessary only four months a year.

"We put in a whole brand new system in 2000 – new mainlines, laterals, heads and controllers. But we noticed distribution uniformity problems almost from the get-go," Swancutt says.

"If you had sandy soils and good drainage, it probably wouldn't have mattered that the nozzles delivered about 20 percent more water near the heads," he explains. "Since we only start irrigating around June, it took about a month before it really became a problem."

About 10 years ago, while at a GCSAA conference he discussed the problem with his local USGA turf advisor. New metal retrofit nozzles were now available and on display at the trade show. Swancutt visited the booth after a bit more research, decided to give them a try.

Installation was a bit of a headache, so he decided to pass. He tried various other nozzles from the manufacturer. "But the different

Illahe Hills Country Club's heavy clay soil makes irrigation a challenge, even if it's necessary only four months a year.


Illahe Hills CC

nozzles would just move the wet spot in the profile," he notes wryly.

The next step was plugging the short-distance nozzle, which dried out the wet spots. "But then the turf would burn out around the head and we would have to unplug the nozzles or hand water," he says.

By now, Profile nozzles had been improved and renamed and Swancutt decided to try again on a fairway. "Installation only took a few minutes per head, and I started noticing results in a couple weeks," he says.

Fall rains came and irrigation was a non-issue, but the next summer, Swancutt changed over 150 more nozzles, then 150 the next year. "They are more expensive than plastic nozzles, but we can budget for them. And they save labor; no more hand watering. We use our labor other ways to make the course play better.

"Knowing what I know now, if I could have had the irrigation heads bid without nozzles, I would have done it. I'm planning on replacing all the nozzles anyway," he says.

"It's all about uniformity," Swancutt concludes. "Bottom line is that these nozzles give you better results for the golfers, and that's what it's all about."

Now, that's harmony.

Joel Kachmarek

TACOMA COUNTRY AND GOLF CLUB, LAKEWOOD, WASH. When the sun shines in the soggy Pacific Northwest, everyone smiles. The precious clear days of summer are a signal to get out and enjoy the magnificent surroundings.

The Tacoma Country and Golf Club in Lakewood, Wash., has been putting a smile on golfers' faces since 1894. As the oldest private country club west of the Mississippi, the majestic mature trees, immaculate fairways and greens and almost faultless playing conditions reflect the attention to detail and passion for perfection golf course superintendent Joel Kachmarek pours into his work each day. Kachmarek recently completed a bunker re-design by the late golf course architect and his friend John Harbottle III, which is the jewel in the course's crown.

So although irrigation is only necessary from about June to September, distribution uniformity is critical to flawless fairways and gorgeous greens. However, with the last upgrade in the late 1980s, the 70-foot head spacing made it virtually impossible for the manufacturers' nozzles to deliver water evenly.

"Even when I started as an assistant in 1993, we had donuts around the sprinkler heads," says Kachmarek. He worked as an assistant until

1997, took a promotion at another course for two years, then returned as superintendent in 1999.

"I immediately started changing the sprinkler heads, but we were still having distribution issues," he recalls. "We played around with plugging nozzles to keep the turf from getting too wet near the sprinkler. But then we had to hand water to avoid brownouts."

Kachmarek almost resigned himself to the hand watering regimen. "After all, our irrigation season is only around 90 days," he says. But coupled with the poor uniformity, nozzles would clog on their own as the vintage 1953 mainlines sent rusty metal flakes through the system. "You could drive around in the morning and see where the nozzles were plugged by rust."

Voicing his frustration to his Underhill representative resulted in a dozen Profile nozzles provided as a sample. "I threw them out there and saw results right away," says Kachmarek. He immediately ordered 50 nozzles. Installation was easy; less than five minutes a head.

"The difference was night and day," he adds. "Night and day." He switched out 200 heads that year, 500 in 2012, and plans on completing the entire course with 500 next year.

"It'll probably run about $12,000 by the time we're done, but when you compare that to a $2-million system overhaul, it's worth it," Kachmarek says. "If you had to irrigate all year, it would pay for itself in water and electricity savings in a few years. And from an environmental aspect, it's cool to save water; it's cool to save electricity on pumping." **GCI**

Helen Stone is a West Coast-based freelance write and frequent GCI contributor.



Distribution uniformity is critical to flawless fairways and gorgeous greens at Tacoma Country and Golf Club, Lakewood, Wash.

NO SHORTCUTS

An irrigation audit reveals which areas of your course are covered... and which aren't. by Mike Vogt

THINKSTOCK

There remains no simple way or shortcut to arrive at a method to manage irrigation water, especially given the inherent inefficiencies of a water application with a circular pattern with designed overlaps along with single-head coverage.

However, the increase use of handheld moisture meters and in-ground moisture sensors have brought about many changes in water management and hand-water applications particularly on greens surfaces. The superintendent must quantify the use of the current irrigation system by adjustments individual heads on a constant basis, which remains our best practice today. Without the baseline numbers from an audit, it remains a guessing game on what areas of the course are receiving quality coverage. Out of all information attained from irrigation audits, the most important number to attain remains Distribution Uniformity (DU); that percentage is the broad report card of the irrigation systems ability to apply water evenly over a given area.

When a superintendent designs a schedule for water distribution, that schedule must be modified to accommodate changes in weather or evapotranspiration (ET) which can change the turfs need for water. An audit provides the tools necessary to meet these requirements.

Our modern irrigation systems become less efficient with time and even the most advanced systems were never designed or intended to be a "set-it-and-forget-it" water distribution tool. The recommended schedule resulting from an audit is based on the field results; inspections, distribution uniformity, precipitation rate, soil intake amounts, turf water use, root zone depth and soil water holding capacity. Further adjustments to scheduling must be made to accommodate the limits of the control system used to operate the system.

An added benefit to an irrigation audit, or multiple audits, is to identify trends in irrigation system maintenance or other system needs. Typical irrigation maintenance activities that may be identified by an audit include:

- Adjusting and leveling sprinkler heads
- Adjusting arcs for proper pattern coverage
- Ensuring there is nozzle and sprinkler uniformity
- Clearing clogged nozzles;
- Replacing drive mechanisms or irregular rotating heads.

Also, an audit may alert superintendents to more significant problems, such as:

- Moving heads to more appropriate spacing
- Adjusting pressures at pumping source
- Adding pressure regulating devises
- Component upgrades – sprinklers, valves, pressure regulating valves, screens, filters).

Audit Worksheets

These worksheets use data accumulated from a proper and complete Irrigation Audit to quantify cost savings and operational efficiencies. *Editor's Note: These worksheets are based on information from Irrigation Association, Certified Golf Irrigation Auditor Manual, July, 2004.*

Power Savings Worksheet

	Data Required	Value	Unit	Source
#	**Part 1: Calculate Irrigation Requirements**			
1	Total Irrigated Area	110	Acres	Site Maps
2	Yearly Plant Water Requirements	32.20	Inches Per Year	ET0 3 Avg. K_c 3 Avg. K_{mc}
3	Yearly Irrigation Requirements	19.20	Inches per Year	#2 2 Effective Rain
4	Adjusted Yearly Irrigation Requirement (gross)	23.42	Inches per Year	#3 3 Run Time Multiplier
5	Total Gallons Recommended per Year	69,954,135	Gallons per Year	#4 3 27,154 3 Acreage
	Part 2: Calculate Power Cost			
6	Historic Yearly Power Cost	$8,379	$	Power Bills
7	Historic Gallons Pumped	76,973,885	Gallon per Year	Pump Station / Records
8	Historic Average Power Cost per Gallon	$.000109	$ per Gallon	#6 4#7
	Part 3: Estimate Power Savings			
9	Cost of Recommended Gallons	$7,625	$	#5 3 #8
10	Potential Yearly Power Savings	$754	$	#6 2 #9
11	Reduced Pump Maintenance Costs	$1,000	$	Estimate Impact of #5 on Frequency of Maintenance
12	Cost of Audit and/or Equipment Upgrades	$7,000	$	Calculate
13	Estimated Life of Pump Remaining	9	Years	Calculate
14	Return on Investment	$2.26	Ratio	#13 3 (#10 + #11) / #12

MONEY SAVINGS. A properly maintained and scheduled system will save money. An irrigation audit provides superintendents with the correct data to calculate accurate savings.

Once field data is gathered an illustration of saving can become clear and a return on investment can be communicated to club or course leaders.

WATER SAVINGS. Water will always have a cost, whether its cost is just pumping or you must actually purchase water. In the example above Distribution Uniformity (DQLQ) was collected for a golf course on the East Coast that purchased water by the unit (1,000 gallons) which costs $1.40. Simple math tells us that saving 10 percent in DQLQ will yield a savings of 4,236,024 gallons per year. The equation would look work out to be 4,236,024 divided by 1,000 to equal 4,236. Then multiply 4,236 by $1.40 to get a savings of $5,930.40.

POWER SAVINGS. Pump station pumps 1,000 gallons per minute, we save 4,236,024 gallons per year or 4,236 minutes of pumping time or 70.6 hours. If your course irrigation power bill was $21,000 per year based on 55,910,086 gallons at 60 percent DULQ that number would be 0.000376 (55,910,086 / $21,000 = 0.000376) per gallon in electricity or electricity savings of $1,592.00. In addition, saving 70.6 hours over the life of the pump system, that would equate to at least one free year added to the life of the pump station. Combined savings of $5,930.40 water plus $1,592.00 electricity would equal a total yearly savings of $7,522.40. **GCI**

Mike Vogt, CGCS, CGIA, leads McMahon Group's Golf Division and is a frequent GCI contributor.

Sample Audit

Plant Water Requirements	Uniformity DU_{LQ}	Irrigation Water Requirement	Gallons per Acre Inch	Irrigated Acres	Total Gallons per Year
15.6 Inches per Year	60%	20.59 Inches per Year	27,154	100 Acres	55,910,086
15.6 Inches per Year	70%	19.03 Inches per Year	27,154	100 Acres	51,674,062
				Difference	4,236,024

Pump Operation Savings Worksheet

	Data Required	Value	Unit	Source
#	**Part 1: Calculate Irrigation Requirements**			
1	Total Irrigated Area	110	Acres	Site Maps
2	Yearly Plant Water Requirements	32.20	Inches Per Year	ET_0 3 Avg. K_c 3 Avg. K_{mc}
3	Yearly Irrigation Requirements	19.20	Inches per Year	#2 2 Effective Rain
4	Adjusted Yearly Irrigation Requirement (gross)	23.42	Inches per Year	#3 3 Run Time Multiplier
5	Total Gallons Recommended per Year	69,954,135	Gallons per Year	#4 3 27,154 3 Acreage
	Part 2: Calculate Pump Operation Hours			
6	Recommended Hours of Pump Station Operation	1214	Hours Per Year	#5 4Avg. Pump GPM 60 Minutes
7	Historic Hours of Pump Operation	1,336	Hours Per Year	Yearly Gallons Used4Avg. Pump GPM 60 Minutes
8	Potential Operational Reduction	122	Hours Per Year	#7 2#6
	Part 3: Estimate Pump Operational Savings			
9	Potential Operational Savings	$765	$ per Year	#8 3 (Yearly Power Cost 4#7)
10	Potential Yearly Power Savings	$754	$	#6 2 #9
11	Reduced Pump Maintenance Costs	$1,000	$ per Year	Estimate Impact of #8 on Frequency of Maintenance
12	Cost of Audit and/or Equipment Upgrades	$7,000	$	Calculate
13	Estimated Life of Pump Remaining	9	Years	Calculate
14	Return on Investment	$2.27	Ratio	#12 3 (#9 + #10) #11

Water Cost Savings Worksheet

	Data Required	Value	Unit	Source
#	**Part 1: Calculate Irrigation Requirements**			
1	Total Irrigated Area	110	Acres	Site Maps
2	Yearly Plant Water Requirements	32.20	Inches Per Year	ET_0 3 Avg. K_c 3 Avg. K_{mc} [1]
3	Yearly Irrigation Requirements	19.20	Inches per Year	#2 2 Effective Rain
4	Adjusted Yearly Irrigation Requirement (gross)	23.42	Inches per Year	#3 3 Run Time Multiplier
5	Total Gallons Recommended per Year	69,954,135	Gallons per Year	#4 3 27,154 3 Acreage
	Part 2: Calculate Water Cost			
6	Cost per Billing Unit	$1.40	$ per Unit	Water Bills
7	Convert Recommended gallons to Billing Units	93,522 ccf[2]	Units per Year	$5 4748 (for ccf units) -OR- #5 41,000 (for 1,000 gallon units)
	Part 3: Estimate Water Savings			
8	Historic Yearly Water Cost	$135,485	$ per Year	Water Bills
9	Cost of Recommended Gallons	$130,931	$ per Year	#6 3#7
10	Potential Yearly Water Cost Savings	$4,554	$ per Year	#8 2 #9
11	Cost of Audit and/or Equipment Upgrades	$7,000	$	Calculate
12	Estimated Life of Pump Remaining	9	Years	Calculate
13	Return on Investment	$5.86	Ratio	(#103#13)4#12

(Footnotes) 1. ETO refers to Evapotranspiration, specifically in turf; Kc refers to Crop Coefficient - type of turf and height of cut. Kmc refers to Microclimate factor for different exposures, such as south facing slopes, shade, high wind areas. 2. ccf refers to 100 cubic feet