Paul J. Roche, CID
Matthew Mikucki

Proper irrigation system management can result in an efficiency of 80 percent or higher, and calculating your "water window efficiency" will help you hone in on what improvements you can make to reach that target. **Photo courtesy of Paul J. Roche**

(irrigation)

Window of opportunity

Improving your "water window efficiency" can pay dividends in terms of both the conditions on your course and your facility's bottom line.

The WWE is a simple calculation that assesses how effective the irrigation system is at applying water in the least amount of time.

Achieving maximum efficiency is the goal of any golf course irrigation system manager. When high efficiencies are reached, savings follow that can positively impact operational expenses — something golf course superintendents are always looking to do. A new and increasingly popular way to measure the irrigation efficiency of an irrigation event (complete irrigation cycle) is by determining the "water window efficiency," or WWE. The WWE is a simple calculation that assesses how effective the irrigation system is at applying water in the least amount of time. Some of the benefits of managing — and possibly improving — WWE are:

- Maximizing the efficiency of the pump station
- Shortening the irrigation event, which allows for scheduling flexibility
- Helping to eliminate pumps from cycling throughout the irrigation event

In the same way a car uses less fuel per mile traveled on the highway than it does during start-and-stop city driving, reducing pump cycling will lower the electrical costs associated with the higher electrical current required to start idle pumps. Through reduced cycling, a more efficient system decreases unnecessary wear on the pumps, motors and other mechanical components, and helps manage hydraulic surges that can occur when pumps turn on and off.

Calculating WWE

The information needed to determine WWE is available on most central control software programs and can be easily gathered. Look at the Projected Flow View, Dry Run or Flow Graph on your central control software to find the following details:

- Total flow (gallons) for the irrigation event
- Total time for the irrigation event (when the event started and when it ended)
- Operational capacity of the pump station, or the maximum flow limit that's programmed into the central software

Armed with this information, you can quickly compute the WWE in two easy steps. First, calculate the shortest possible operating time (Equation 1), aka the shortest possible time that the irrigation event would take if the irrigation system were operating at its full programmed flow.

Equation 1

$$\textbf{Shortest possible operating time (expressed in minutes)} = \frac{\text{Total flow for the irrigation event (total gallons)}}{\text{Operational capacity of the pump station (gallons per minute)}}$$

Then, calculate the WWE (Equation 2), which will be the hydraulic efficiency percentage for an irrigation event. In general, a WWE is considered very good if it's 85 percent or higher. A WWE below 80 percent indicates that improvements can be made to increase it.

Equation 2

$$\textbf{Water window efficiency (expressed as \%)} = \frac{\text{Shortest possible operating time (from Equation 1, in minutes)}}{\text{Actual irrigation operating time (in minutes)}}$$

Figure 1

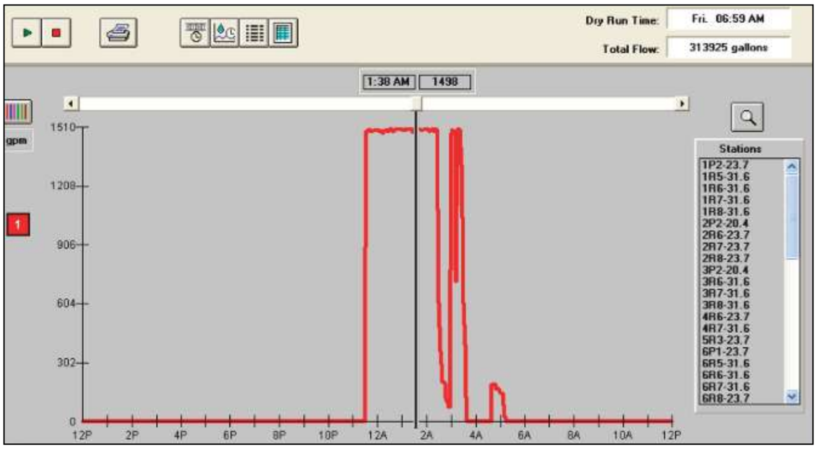


Figure 2

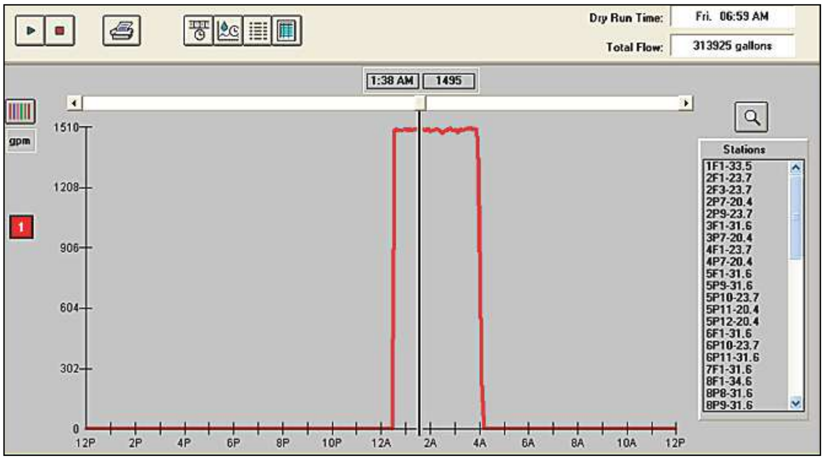


Figure 1 (above) illustrates a system dry run with excessive pump cycling. With some management of the program start times, the same amount of water was programmed more efficiently, as shown in Figure 2. In this instance, pump cycling was reduced while shortening the water window.

Case in point

At Prestwick Country Club in Myrtle Beach, S.C., GCSAA Class A superintendent Paul Kaufman watches his water window efficiency closely. Kaufman uses the features on his central control system to complete a "projected flow" (Figure 3, Page 76) before each irrigation event, which shows him the expected flow of the irrigation system before the scheduled irrigation event, and gives him the opportunity to make any tweaks needed to adjust the sequencing of his programs before he irrigates the golf course.

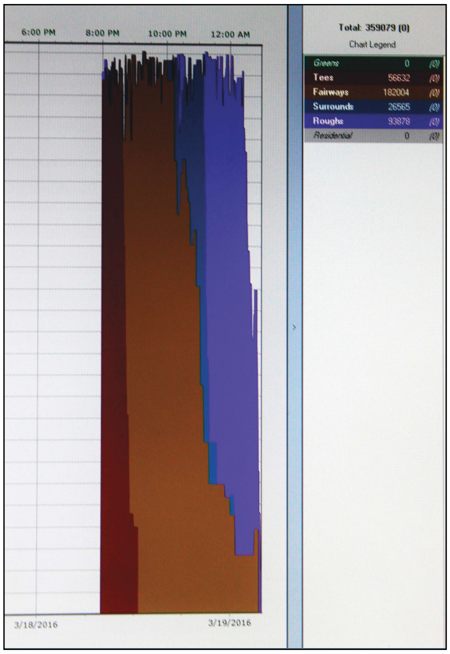
This pre-check enables the 20-year GCSAA member to irrigate at high operational efficiency. The system is set up to run at 1,400 gallons per minute (gpm), and an early irrigation event gives Kaufman time to allow for percolation across the golf course, and to schedule other irrigation events if needed before play begins.

The WWE at Prestwick can be quickly calculated using the information from the central control software and the formulas presented earlier. First, Kaufman determines that 359,079 total gallons were pumped, so at 1,400 gpm, that equates to the shortest possible operating time of 256.5 minutes. Kaufman then takes that figure and divides it by actual irrigation run time, which was 300 minutes, to arrive at a WWE of 86 percent.

Sequencing pumps

The best possible WWE would, of course, be 100 percent, with the pump station turning on and operating at peak flow through the entire irrigation event before it shuts down after completing all programs and stations that were assigned to operate. That, however, isn't practical, as several factors can affect WWE.

Figure 3



An irrigation system should be programmed to slowly but deliberately "ramp up" to the set flow. This would include several minutes during which each pump is slowly brought up to full capacity before the next pump is brought on and repeats that process. Ramping up flow demand reduces the possibility of water hammer and pipe network stress. This process continues for main pumps that are required to meet the operational capacity of the pump station, so the more pumps you have, the longer this ramp-up period will take.

A ramp-up sequence of a typical variable-frequency drive (VFD) pump station delivering 1,500 gpm is shown in the chart on Page 77. In this case, the station is configured with a 5-hp pressure maintenance pump and two 75-hp motors, each delivering 750 gpm, with a total flow of 1,500 gpm. The irrigation control system is programmed so that 50 percent of the flow from Pump 1 is brought on line first, then increased to 80 percent of flow before additional pumps are brought on line. Following this sequence allows the system to slowly and methodically reach full flow.

Large pumps are not intended to be constantly starting and stopping. The horsepower of the motor and the speed at which the pump and motor are rated to rotate (revolutions per minute, or rpm) will dictate the allowable motor starts and stops per hour. An interval of rest time between motor starts is recommended to let the motor cool. Smaller motors are able to handle more starts per hour than larger motors of 50 horsepower and higher.

For example, a 75-hp pump has a maximum of two to five starts recommended per hour, depending on whether the motors are 1,800- or 3,600-rpm motors (1,800-rpm motors can handle more starts per hour than 3,600-rpm motors). These motors should have a 90- to 180-second rest period between starts, with 3,600-rpm motors requiring the longer rest periods. Smaller motors, such as pressure maintenance pumps, will have more allowable starts and shorter rest periods.

Contact your authorized pump station service provider, irrigation designer or irrigation consultant to help you establish the proper number of ramp-up sequences based on your irrigation system and pump station.

Built-in buffers

Operating a pump station at its full rated capacity is usually not possible. A number of things can influence this, including pump age

Sequencing pumps

Pumps: Maximum flow	Sequence 1	Sequence 2	Sequence 3	Sequence 4	Sequence 5
	(gallons per minute)				
Pressure maintenance pump					
Pump 1 (750 gpm)	375	600	750	750	750
Pump 2 (750 gpm)			375	600	750
	(minutes)				
Settle time	1-2	1-2	1-2	1-2	1-2
Total flow (gpm)	**375**	**600**	**1,125**	**1,350**	**1,500**

and wear, inaccuracies in the flow management database in the central computer (inaccurate nozzle/pressure data), slow-operating valves, and the general variability encountered in managing 20 miles or more of pipeline and 1,400 or more sprinklers routed across 120 to 150 acres of land.

Adding a buffer — a percentage below the full flow rating of the pump station — can help prevent the pump station from experiencing a low-pressure shutdown (a safety measure that turns off the pump station if it cannot maintain pressure). As a practical approach to regulating flow, this buffer is typically set at about 10 percent below total flow capacity for newer pump stations and irrigation systems, and slightly higher for older pump stations that have lost some efficiency or do not have an accurate flow management database.

Calculating your water window efficiency to identify improvements you can make to the operation of your irrigation system is a best practice for those in the golf course management profession, and you can easily determine WWE with just a few pieces of information from your central computer. Although 100 percent efficiency isn't attainable, as there are some inherent inefficiencies with any irrigation system, proper management practices can result in efficiencies of 80 percent and higher.

Paul J. Roche, CID, and Matthew Mikucki are golf course irrigation consultants with Golf Water LLC.