How to Develop a Water Budget for Your Golf Course

A science-based approach for estimating landscape water requirements.

BY PATRICK J. GROSS AND CHRISTOPHER HARTWIGER

Can you answer three basic questions about water use at your golf facility?

- How much water does your golf facility need each year to keep the turf healthy?
- Does your golf facility use water efficiently?
- Can you prove it?

If you are unable to answer any of these questions, a water budget is just what you need.

Whether the issue is water use or finances, managers have long known that efficiently managing resources requires measuring the use and consumption of those resources. Once consumption is measured, objective decisions can be made to influence behavior and outcomes. These same principles can be applied to developing a water budget for a golf facility. The water budget establishes a benchmark for golf course water requirements that can be compared to actual water use, ultimately confirming if water is being used efficiently or if changes in management strategy are needed. This article will introduce the concept of a water budget, define the terms that make up a water budget, and provide the reader with step-by-step instructions to create a water budget using the USGA Water Budget Calculator Tool.

THE WATER BUDGET FORMULA

The formula used by many water agencies to calculate a water budget is:

Estimated Water Use =
$[(ET_o \times K_c) - R_e] \times LA \times 27{,}154$

To understand this formula and how it works, let's begin by quickly reviewing the basic information needed to complete the formula.

How much water does your golf course need? Creating a water budget will help answer this question.

Creating a water budget is an important step toward making sure that every drop of irrigation water counts.

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Golf courses in drought-prone areas have been developing and fine tuning their water budgets, but they are a valuable tool for courses in any location.

LA = landscape area and managed turf areas measured in acres

ET_o = reference evapotranspiration

R_e = effective rainfall

K_c = crop coefficient for the type of grass being managed

27,154 = conversion factor to change from inches of applied water to gallons

DEFINING THE TERMS

(LA) Landscape and turf area measurement: To create an accurate water budget, it is essential to have a precise measurement of all turfgrass and landscape areas that are being irrigated. There are a variety of resources available for gathering this information, including contract services, auto-CAD maps of the golf course from previous projects, or satellite photos of the golf course from Google Earth™ that can be measured using various online tools (Measure Plus™, Draft Logic, ACME Planimeter, etc.). Buildings, parking lots, and water features should be subtracted from the property's total acreage to present a fair and accurate assessment of the irrigated acreage.

(ET_o) Reference evapotranspiration: Reference evapotranspiration (ET_o) is a historical measurement of how much water evaporates from the soil combined with the amount of water that is used by an actively growing reference crop for a particular climate and location. For turf and landscapes, the reference crop typically is clipped, cool-season turf that is not limited by soil water content (Green, 2005). Over the years, a variety of tools have been used to determine ET_o, including atmometers that measure the amount of water lost from an open pan and weighing lysimiters — i.e., buckets containing soil and turfgrass that are irrigated and weighed daily to determine the amount of water lost (Leinauer and Green, 2011). Today, ET_o typically is calculated using information from a nearby weather station. For the purpose of developing a water budget, it is best to use an average monthly ET_o that represents data over a 30-year period to help balance out the variability of weather patterns from year to year. In general, the most reliable sources of ET_o information are state weather station networks. Some golf courses also have on-site weather stations that record daily ET calculations. On-site weather stations are excellent sources of ET_o information if the data are accurate and can be accessed and averaged over multiple years. Another source for ET_o data is the Rain Master website, which allows users to search for ET_o data by zip code.

(R_e) Effective rainfall: Over the course of a given year, rain events will offset the need to irrigate. This is accounted for in the water budget formula by subtracting average monthly rainfall amounts from average monthly evapotranspiration. Average monthly rainfall data, ideally from a 30-year period, can be obtained from state weather station networks, on-site

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weather stations, and Internet sites like U.S. Climate Data. It is important to note that not all the precipitation that falls to the ground is available for plant use because a portion of rainfall is lost to runoff. To account for this fact, the water budget formula only considers 50 percent of precipitation as effective rainfall.

(K_c) Crop coefficients: Recognizing that different types of plants use different amounts of water, an ET adjustment factor — i.e., a crop coefficient (K_c) — is included in the water budget calculation. The K_c is expressed as a percentage of the ET_o value reported by the weather station. Extensive research has been done on turfgrass water requirements in different climatic regions using a variety of methodologies. These studies have demonstrated that K_c values can range from 0.7 to 1.3 for creeping bentgrass in Nebraska, while values range from 0.4 to 0.8 for bermudagrass in Arizona (Leinauer, Green 2011). K_c values also vary depending on the time of the year. What is clear from these studies is that cool-season grasses have a higher water-use rate than warm-season grasses. For simplicity, water budget formulas for many states and government agencies use seasonal average crop coefficients of 0.7 — i.e., 70 percent ET_o — for warm-season grasses like bermudagrass, zoysiagrass, and seashore paspalum, and a coefficient of 0.8 — i.e., 80 percent ET_o — for cool-season grasses like creeping bentgrass, perennial ryegrass, Kentucky bluegrass, and *Poa annua*.

CREATING AND USING A WATER BUDGET

The first step toward calculating a water budget for your course is collecting some basic information:

- The total irrigated acreage of the property
- Reference evapotranspiration
- Average annual rainfall
- The type of turf being irrigated

Once all the information is collected, enter the data into the USGA Water Budget Calculator Tool for each month and the water budget will be automatically calculated for your golf course.

The completed water budget is a tool that can help a water-management program in many ways:

- The water budget estimates the amount of water needed to irrigate the golf course each month, assuming historically average temperature and rainfall patterns occur.
- The water budget establishes a benchmark for comparing estimated water use with actual water use.
- The water budget creates a means to evaluate the effectiveness of any water conservation measures implemented during the year.
- As monthly water-use data are tracked, managers can get an indication of irrigation system efficiency and the accuracy of programming decisions.
- The water budget document can be shared with regulators, water district personnel, golf course officials, and any other entity that requires documentation on water use.

It is important to note that some government agencies and state regulators use different water budget calculations and different crop coefficient (K_c) values. Golf facilities should use the water budget formula and K_c values established by their local government agency.

A water budget does not take into account irrigation system efficiency or distribution patterns. It always is a good idea to touch up areas with hand watering as needed.

Improving water management by creating an accurate water budget can have secondary benefits, like reducing the cost of energy used to pump the water.

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Not all rainfall is available for plant use because some runs off before soaking into the soil. Water budgets account for this fact by adjusting rainfall totals to determine a variable called effective rainfall.

Data from weather stations can provide historical and current data regarding the amount of moisture lost through evaporation and plant transpiration. This variable is called evapotranspiration.

STAYING ON BUDGET

As actual water-use data are entered and compared to the estimated water budget each month, a clearer picture will develop regarding water-management practices. Some golf courses may find that meeting their water budget is relatively easy, while others may be over budget every month. If a course consistently needs to use more water than the budgeted amount, there may be site-specific issues like compacted fairways, water quality issues, poor distribution uniformity, undetected leaks, or other irrigation problems that need to be addressed. As these problems are identified and fixed, actual water use should correspond more closely with the water budget.

It is important to remember that the water budget formula outlined in this article does not account for the efficiency and distribution uniformity of the irrigation system. Newer irrigation systems that are well designed and properly maintained should operate closer to the water budget than older, broken-down systems with poor distribution uniformity. This fact alone could provide the necessary justification for upgrading the irrigation system.

Also, it is important to point out that the water budget is an estimate of how much irrigation is needed for an average year. In reality, there can be wide fluctuations in rainfall and temperatures that will create disparities between the water budget and actual water use. If a year is abnormally hot or dry, more water from the irrigation system will be needed. If the year is cold or wet, less irrigation will be needed. Sometimes, all the rainfall during an entire month occurs over a short period of time and the remainder of the month is dry. In this situation, the course will still need to use more irrigation water than normal, even though there has been average rainfall. Finally, the water budget is not a document to be put on a shelf and forgotten; it must be actively managed by recording data on actual water use and effective rainfall. It should also be used regularly to make management decisions based on the data being gathered.

There are good reasons to create a water budget, no matter where your

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The first step in calculating a water budget is determining the total irrigated area.

course is located and regardless of your current water situation. First, a water budget enhances decision making by using science- and research-based information to make sound water management decisions. Improved decision-making will, in turn, have a positive impact on turf health and playing conditions. Second, golf courses are conspicuous water users that need to practice and demonstrate good stewardship of a precious natural resource. Third, there is a good chance that someday a government agency will have a say in how much water your golf course is allowed to use. Having a science-based water budget helps a facility prepare for dealing with regulators.

CONCLUSION

Water budgets are an important tool for both management and communication. Developing a water budget estimates how much water a golf facility needs for an average year and sets a benchmark for comparing actual water use with historical water use. Water budgets take into account the size of the property, historical climate data, effective rainfall, and plant factors. This helps managers make informed decisions about their current water use and the effectiveness of programs designed to improve water use. The water-budget approach as outlined in this article is also recognized by the EPA and other state and federal agencies as a science-based approach for estimating landscape water requirements. Therefore, water budgeting is incorporated into laws and regulations in many parts of the country, especially during times of drought. Ultimately, the process of developing and managing a water budget helps answer the questions of how much water a golf course needs to stay in operation, whether the course is an efficient user of water, and, most important, provides the means to prove it.

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PATRICK J. GROSS *is director of the USGA Green Section West Region.* CHRISTOPHER HARTWIGER *is director of the USGA Green Section Course Consulting Service.*

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