# Siting and Maintenance of Weather Stations

## Introduction

A growing number of equipment manufacturers are providing weather stations (Figure 1) and computer software that help the groundskeeper with irrigation management decisions. The level of sophistication of this equipment varies, but all systems use the weather station to estimate a parameter known as evapotranspiration (ET). ET is the scientific term for the more common terms water use or consumptive use. Effective utilization of ET information in irrigation management can assist in efforts to manage limited and / or expensive water supplies more effectively, provided the stations are 1) sited and installed correctly, and 2) properly maintained. The purpose of this bulletin is to provide turf facilities information and guidance on siting and maintenance of automated weather stations.

## Weather Stations & ET

The critical first point to understand about weather stations is that they do not measure ET. True measurements of ET require sophisticated equipment and are difficult and time consuming to obtain. To get around the difficulties of actually measuring ET, scientists have developed weather-based models that estimate ET from a reference surface consisting of well-watered grass. This computed ET value is known as reference evapotranspiration and is abbreviated $ET_o$. Two related models — the Penman Equation and the Penman Monteith Equation — are among the most popular methods of estimating $ET_o$ because both models are based on sound scientific theory. The bulk of the weather stations sold to the turf industry generate $ET_o$ information using some form of the Penman or Penman-Monteith Equation.

The weather station provides the weather data necessary for computation of $ET_o$. The four weather variables used in this computation are: 1) solar radiation, 2) wind speed, 3) temperature, and 4) humidity. It is important for owners of weather stations to understand that ET estimates are only as good as the weather data used in the Penman computation. The old adage "garbage in equals garbage out" truly holds for the computation of $ET_o$. Poor quality weather data will produce erroneous ET values and make use of ET information very difficult.

*Figure 1. An automatic weather station commonly used to estimate turf ET.*

10/2001 AZ1260

Turf Irrigation Management Series: III

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ag.arizona.edu/pubs/water/az1260.pdf

There are two main causes of poor quality weather data: 1) improper siting of the weather station and 2) poor station maintenance. Both causes will be explored further in the paragraphs below.

## Siting Weather Stations

Proper siting is essential if the weather station is to provide the data necessary to estimate $ET_o$ in a consistent and reliable manner. One should always remember the weather variables used in the $ET_o$ computation when seeking a station site. Solar radiation, for example, is an extremely important variable in the Penman and Penman Monteith procedures. A weather station must therefore be placed in a location where no shading can occur. It is important to remember that shade patterns vary considerably with the season due to changes in earth-sun geometry. Thus, it is best to place the station well away from large obstacles if at all possible.

An open location is also necessary to measure wind speed. A station hidden from view behind an outbuilding or a solid wall will not accurately measure the wind speed over more open areas such as fairways or sports fields. As a general rule, weather stations should be isolated from large obstacles such as fences, trees or buildings by a distance equal to 7-10 times the height of the obstacle. Using this rule, one should place a station 70-100' away from a 10' high building to ensure proper wind flow at the site.

The final two parameters in the $ET_o$ computation — temperature and humidity — are greatly affected by the surface upwind of the weather station. Stations located over asphalt, gravel, or bare ground will produce higher temperatures, lower humidity, and higher $ET_o$ values than stations centrally located within large expanses of turfgrass. It is important to note that most Penman / Penman Monteith procedures were developed using weather data collected over a large expanse of well-watered vegetation. Failure to place the weather station over a similar surface will often result in overestimation of $ET_o$. Research conducted by the authors and others indicates that the surface characterisitics adjacent to a weather station can affect $ET_o$ values by as much as 20%.

The previous paragraphs clearly show that station siting is not to be taken lightly. The ideal situation would be to centrally locate the station in a large, well-watered turf area that is a considerable distance from objects that might disrupt wind flow or shade the station. The terrain surrounding the weather station should be relatively level if possible. If such a site is not available and a compromise site must be selected, we would recommend sites that 1) avoid shade and 2) have a limited number of large obstacles and some form of irrigated surface in the predominate upwind direction during the daylight hours.

## Weather Station Maintenance

A weather station, like any other piece of equipment, requires regular maintenance if it is to perform its assigned task correctly. Some of the more important maintenance chores can and should be performed by local grounds maintenance personnel since they have access to the station on a regular basis. Other maintenance work should be performed by a trained weather station technician. However, before describing the required maintenance chores and who should perform them, a brief physical description of the various weather station instruments is in order.

### Weather Station Sensors

Weather stations designed to provide turf ET information typically monitor five meteorological parameters — solar radiation, wind speed, temperature, humidity, and precipitation. The silicon cell pyranometer is commonly used to measure solar radiation (Figure 2). The sensor is a small (1" diameter) black cylinder that is situated on an adjustable base plate containing a bull's eye level. The actual sensing portion of this instrument is the small circular white "eye" that rests on top of the sensor. Some stations may employ a thermopile pyranometer to measure solar radiation. The sensing element of a thermopile pyranometer is typically located underneath a glass dome.

*Figure 2. Silicon cell pyranometer used to measure solar radiation on automated weather stations.*

Temperature and humidity are commonly measured with a combination sensor which is located in a naturally ventilated radiation shield that shades the sensor from direct sunlight. Various types of shields are used to protect the sensor, but the most common shields look like an upside-down stack of white plastic plates (Figure 3). Temperature is measured with thermistors or platinum resistance thermometers while humidity is measured with a resistance or capacitance chip.

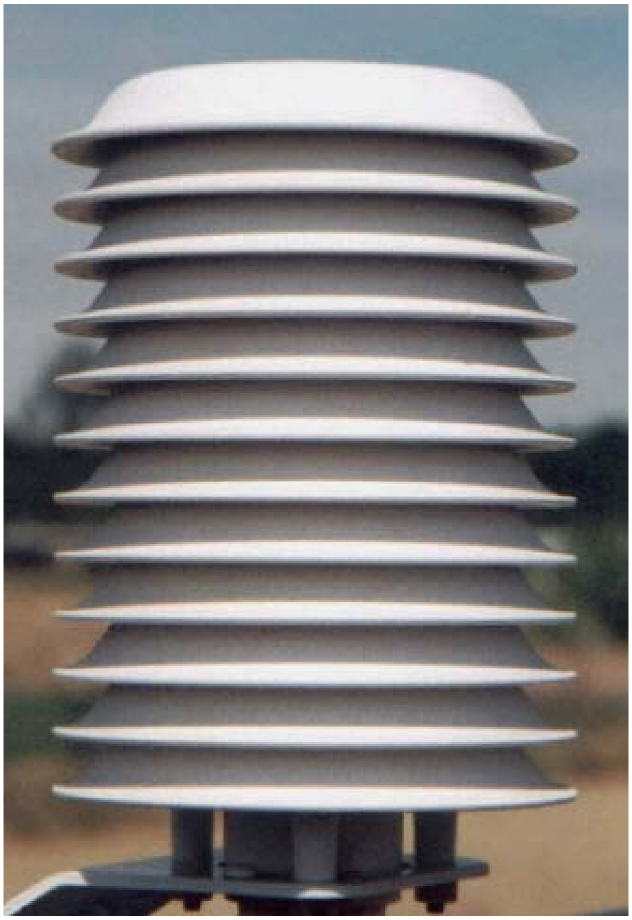

*Figure 3. A combination temperature and relative humidity sensor is housed within this radiation shield to protect the sensor from direct exposure to sunlight.*

*Figure 4. Anemometer (above) and wind vane (below) commonly used on automated weather stations.*

Wind speed and wind direction are measured with a cup anemometer and wind vane, respectively (Figure 4). The anemometer has three or four cups attached to spokes which in turn connect to a hub. The cup assembly connects to a sensing element that generates an electrical signal (e.g., switch closure or voltage) proportional to the rate of cup rotation. Cup rotation is in turn proportional to wind flow. The wind vane is designed rotate freely and point into the wind. A variable resistor (potentiometer) attached to the vane hub provides an electronic signal proportional to wind direction.

Precipitation is measured using a tipping bucket rain gauge which typically is a large (6-8" diameter) cylindrically shaped instrument (Figure 5). A funnel on the top of the gauge captures the precipitation and directs the water to a tipping bucket mechanism that rotates on a pivot each time a known quantity of water is collected (usually 0.01").

## Local Maintenance Chores

Local grounds maintenance personnel can help keep the weather station functioning by performing some simple routine maintenance chores. Perhaps the most important maintenance chore involves keeping the solar radiation sensor clean and level. Remember, solar radiation is a very important parameter in the $ET_o$ computation. The small white sensing surface or the glass dome (thermopile pyranometers) must be kept free of dirt, dust, debris (e.g., turf clippings), and bird droppings. A weekly examination / cleaning of the sensor should be adequate for most locations. Simply remove any debris from the top of the sensor and wipe off the white circle with a damp cloth. While cleaning the sensor, one can examine the bull's eye level on the

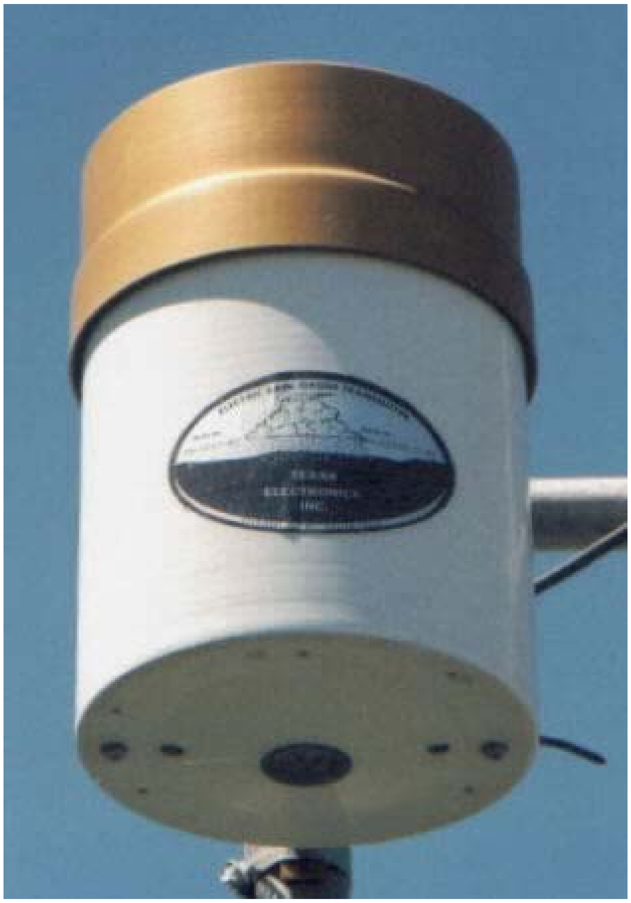

*Figure 5. A tipping bucket rain gauge used to measure precipitation.*

mounting plate to ensure the sensor is level. An off-level sensor can be brought into compliance by adjusting the leveling screws on the mounting plate. A screw driver or allen key wrench is required to adjust the level.

Actual maintenance of the temperature and humidity sensors should be left to skilled technicians. However, local personnel can extend the longevity of these sensors by regularly removing accumulated dirt and debris from the radiation shield and by adjusting sprinkler heads to minimize direct water contact with the shield and sensors. The radiation shield sheds rainwater reasonable well, but does not afford much protection against water arriving at an angle from ground level.

Observation is the main means of determining if the anemometer is operating correctly. The main problem causing poor anemometer performance is dirt in the sensor bearings. This problem is best observed when winds are light — usually early in the morning. An anemometer that emits a grinding sound, does not turn smooth at low wind speeds, or halts abruptly with a lull in the wind likely has bad bearings. Faulty bearings will generate erroneously low wind speeds and should be replaced as soon as possible. Bearing replacement is best performed by a trained technician.

Rain gauge maintenance involves keeping the gauge level and collection funnel clean. To check the gauge level, simply place a carpenters level across the opening of the collection funnel. If the gauge is not level, some adjustment may be necessary. Level adjustments can be made by local personnel, but it is best to have a trained technician do this since the gauge should be calibrated after leveling.

Turf clippings and dirt can occasionally plug the catchment funnel and prevent rainwater from reaching the recording bucket mechanism. Most gauges have a screen which prevents large pieces of debris such as leaves and twigs from plugging the funnel. However, turf clippings and / or dirt can easily move through the screen. A simple examination of the funnel during the weekly visit to examine the solar sensor can identify any possible problems with accumulation of debris. The funnel simply slides on the top of the cylindrical gauge base and can be removed if extensive cleaning is necessary. When replacing the funnel after cleaning, make sure it is level and seated against the base of the gauge.

The power supply of the weather station may also require some routine maintenance. Most stations operate off a 120 volt A.C. supply with a rechargeable battery serving as a backup when the power fails. Loss of data following a power failure is a good indicator of problems with the battery and / or charging circuit. Maintenance and repair of the power supply is best left to trained station technicians.

A solar panel may provide power to weather stations located away from a reliable source of A.C. power. The solar panel provides power to operate the station during the day and also charges a battery that supplies power for nighttime operation. Solar powered systems are quite reliable provided the panels are kept clean. Accumulated dust and bird droppings should be removed weekly to maintain proper power output from the panel. Output from solar panels is particularly vulnerable to isolated dark spots such as those created by bird droppings; thus, one should remove bird droppings as soon a possible to ensure optimal performance from the panel. Loss of data during the nighttime hours is a good indicator of a failed battery or a failed charging circuit. Again, repair of the charging circuit is best left to a trained technician.

Another important aspect of local maintenance is to compare the data collected by your weather station with data collected from another nearby weather station. A neighboring facility may have a station you can compare data with, or you may wish to access information from a public weather network such as the

Arizona Meteorological Network (AZMET). A regular weekly comparison of key meteorological variables such as solar radiation, wind speed, humidity, and temperature can help you identify when your weather station is not functioning correctly. The weather variables at another location will not be exactly the same, but solar radiation, humidity, and temperature should be very similar. Wind speed will vary somewhat between two locations, but the relationship (e.g., difference in average wind speed) between neighboring stations should be similar each week. Exceptions to this rule may develop for weather stations located in foothill or mountain locations where topography plays a major role in daily wind flow patterns.

Precipitation is the only variable that is difficult to check using neighboring stations. Rainfall in arid and semi-arid regions is particularly variable, as is rainfall generated by convective storms (thunderstorms). Rainfall totals can vary several fold over distances of just a few hundred yards; thus, site to site comparison is difficult.

Turf facilities throughout southern Arizona may find local AZMET weather stations useful when checking weather data collected at their facility. Weather data collected from 23 southern Arizona locations are updated daily and made available free of charge from the Internet at :

**http://ag.arizona.edu/azmet**

### Technical Maintenance

Technical maintenance should be performed anytime your routine maintenance reveals a problem. However, even if you do not identify problems with your routine local maintenance checks, we suggest having a technical representative check your system at least once every 12 months and preferably every six months. Our experience running 20+ weather stations in southern Arizona indicates that older resistance type humidity chips need replacement about every six months. Also, we have found that anemometer bearings need to be replaced at least every 18 months and preferably every 12 months to ensure proper measurement of wind speed. Our experience with the temperature sensors, pyranometers, and rain gauges commonly used on weather stations has been very positive, but these sensors should be examined by a trained technician regularly.

Technical maintenance is best performed by a trained representative of the company that supplied your weather station. Technical maintenance is an essential aspect of operating a weather station, and turf facilities should be wary of suppliers that do not provide both telephone and on-site technical assistance. If the supplier does not provide on-site technical service, they should be able to guide you to a qualified third party who can. Some companies provide a short training course so local facility personnel can perform most of the technical maintenance.

## Summary

The use of weather stations and ET represents a significant advance in the field of turfgrass irrigation management. However, to obtain the best and most reliable results from a weather station, the station must be first, properly sited, and second, properly maintained. Readers are encouraged to contact the authors at (520) 621-1319 or by e-mail at azmet@ag.arizona.edu if they have additional questions or would like assistance with accessing AZMET.

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