Overview of Baseline's WeatherAccess™

History of Weather-based Watering

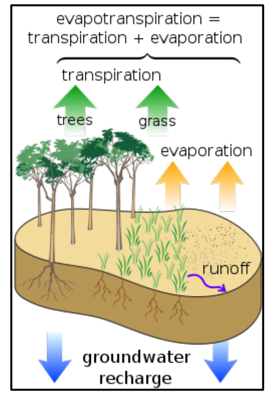

Figure 1: Surface Water Cycle, Wikimedia Commons

When early settlers started growing irrigated crops in the western US around 1850, over-irrigation was a common problem. In an effort to determine how much water plants need, scientists began studying the relationship between plants' use of water and various environmental and atmospheric factors. As a result of these studies, scientists determined that the loss of water through evaporation and transpiration from plants (known as evapotranspiration or ET) is a critical factor for crop cultivation. Studies also showed that ET varies greatly over time and by location. Factors such as air temperature, relative humidity, solar radiation, rainfall, and wind speed affect the rate at which ET occurs.

Throughout the first half of the 20th century, engineers, soil scientists, and agronomists worked on methods for estimating ET. These methods were based on monthly coefficients, but the results were highly variable. By the late 1950s, the Soil Conservation Service and the USDA Agricultural Research Service began standardizing the methods for calculating ET. These efforts defined weather data requirements and established equations that are used to calculate reference ET (ET_o).

Evapotranspiration-based Irrigation

Fast forward to the latter part of the 20th century… manufacturers of automated irrigation controllers began looking for ways to automate water conservation. By this time, the method of using reference ET to estimate irrigation needs had been widely used in agronomy for nearly a half century. Historical ET data was available and the reference ET equations could be programmed into the irrigation controller firmware. By the late 1990s, these controllers were starting to become available in the market.

ET-based irrigation controllers attempt to calculate the loss of moisture from the root zone and adjust the watering schedule to replace the lost moisture. The ET-based irrigation controllers that are available today use a variety of methods to gather data from weather sensors and perform the calculations necessary to adjust the watering schedules. The controller's ability to accurately adjust runtimes depends on the quality of the ET data and how many of the following site properties are considered along with the ET data:

- A specific plant type's water needs (known as the "crop coefficient")
- Root zone depth
- The plant's microclimate (ranging from full sun to total shade)
- The application rate of the irrigation method used (spray, rotor, drip, or bubbler)
- Type of soil at the site (such as clay, sand, or loam)
- Slope of landscape (ranging from slight to extreme)
- The latitude of the site

Water Efficiency and Water Conservation Programs

The growing problem of global water scarcity has prompted organizations and governmental agencies to promote water efficiency and conservation. Programs include testing, education, and incentives for consumers.

Irrigation Association's Smart Water Application Technologies (SWAT)

In 2002, the Irrigation Association partnered with water purveyors and irrigation industry representatives to develop testing and promote water efficiency. SWAT was developed in order to evaluate the water-efficient technologies, such as weather-based irrigation controllers that were becoming available on the market.

EPA's WaterSense® Program

In 2006, the US Environmental Protection Agency (EPA) launched the WaterSense program to encourage water efficiency. Through a collaborative process, the EPA develops specifications for water efficient products and establishes third-party testing to ensure that products meet the criteria. When a product passes the test, the manufacturer is allowed to put the WaterSense label on that product.

The WaterSense program bases their labeling criteria on SWAT's most current testing protocol, but the protocols are not identical and each organization administers their programs separately.

Water Districts' Rebate Programs

In response to drought and state and local ordinances on water usage, many water districts throughout the US have been offering incentives in the form of rebates on the purchase of WaterSense or SWAT-labeled irrigation controllers.

Baseline's Smart Watering Technologies

Baseline was founded on the premise that measuring the amount of moisture in the soil and replacing only the required amount is the smartest and most efficient way to irrigate.

Baseline's patented biSensors measure soil moisture levels where it matters, in the root zone of the plant. Combined with Baseline's patented fully bidirectional communication over two–wire, the biSensors create a "closed-loop" system that immediately reports the results of water application.

In contrast, weather-based ET systems rely on environmental factors and a complicated mathematical formula to estimate how much water the plants need. And after the water has been applied, ET systems don't measure the effectiveness of the decisions that were based on the complicated formula. By measuring instead of estimating, Baseline's biSensor automatically adapts to the effects of evapotranspiration in real-time.

In 2013, the EPA issued a Notice of Intent to develop a specification for soil moisture-based control technologies. This specification will enable soil moisture-based systems to earn the WaterSense label and qualify for similar product promotions as weather-based controllers.

Given our belief in the superiority of soil moisture sensor-based watering, Baseline focused on improving products and opted to wait to become a WaterSense partner under the soil moisture-based control technologies specification. However, due to the EPA's prolonged spec development process and the uncertain timeline for qualifying products under this spec, Baseline ultimately decided to develop weather-based watering for our irrigation controllers.

Released in the spring of 2016, WeatherAccess™ allows users of Baseline's BaseStation 1000™ and BaseStation 3200™ irrigation controllers with a BaseManager™ Plus subscription to program their controllers for weather-based watering. Now, Baseline customers have the ability to use our time-tested and proven soil moisture sensor technology alongside industry-accepted weather-based programming to achieve the best possible irrigation results. For sites where it's impractical to use biSensors, we recommend WeatherAccess as an alternate smart watering technology.

When operated in WeatherAccess mode with an active BaseManager Plus subscription, the BaseStation 1000 and BaseStation 3200 irrigation controllers meet the EPA WaterSense program's water-efficiency and performance criteria and have earned the WaterSense label.

Using WeatherAccess

All ET-based irrigation controllers need a source of weather data in order to perform the calculations necessary to adjust the watering schedules. The accuracy of the calculations depends on the timeliness and validity of the data transferred from the weather station. While the ideal setup is an onsite, scientific-grade weather station connected directly to your irrigation controller, a complete precision weather station can be quite costly.

Baseline's WeatherAccess uses real-time weather data from a weather station in your area. Our BaseManager central control platform connects to Weather Underground's weather station network, which enables you to select weather stations close to your irrigation controller locations.

Weather Underground's weather station network includes thousands of personal weather stations as well as National Weather Service and public stations.

The weather station sends the following data points required for ET calculations to BaseManager:

- Temperature
- Atmospheric pressure
- Dew point
- Precipitation
- Wind speed
- Solar radiation (If the weather station does not provide this value, Baseline's system will estimate it.)

Configuring the Zone Properties

In order to supply the additional data points for the standardized evapotranspiration (ET) equation, you need to configure the properties for each of your zones in BaseManager. In the Additional Zone Properties section of the Zone Properties page in BaseManager, you can accept the defaults for the fields, or you can make selections from values in the drop-down lists. You can also choose Custom in some fields which enables you to adjust the values in those fields to reflect the conditions at your site.

Note: Having a good working knowledge of horticulture, water management, and an understanding of the science behind weather-based watering will help you be successful with WeatherAccess.

The zone properties and their values are based on the requirements found in SWAT's testing protocol. Continue reading for a description of each zone property and the accepted values.

Zone Properties

Sprinkler Type: This field assigns the type of device used in this zone for distributing water under pressure. Each device in the drop-down list has a default application rate and default distribution uniformity. If you choose Custom, you can adjust the values in the fields.

Sprinkler Type	Precipitation Rate in./hr	Distribution Uniformity %
Pop-up Spray	1.60	60
Pop-up Rotor	.50	70
Bubbler	2.50	80
Surface Drip	.20	80
Impact	.45	60
Rotor	.35	65

Application Rate: The Application Rate is the rate at which water is applied to an area within the landscape by an irrigation system. If you increase the value in the Application Rate field, the irrigation runtime decreases.

Distribution Uniformity: Distribution Uniformity (DU) is a measure of how evenly water is being applied by an irrigation system. The EPA refers to DU as "application efficiency." Entering a lower DU results in an increased runtime.

Use Basic Plant Information: If you select this option in the Zone Properties, you can use the root depth, crop coefficient, and sun exposure for your zone runtime calculations.

Use Detailed Plant Information: If you select this option in the Zone Properties, you can include the species factor, root depth, density factor, and micro climate factor in your zone runtime calculations. To get the best results from these settings, we suggest that you have a working knowledge of weather-based watering science.

Use Monthly Values: If you select this option in the Zone Properties, you can enter values for each month in specific fields based on your selection of Basic or Detailed Plant Information.

Species Factor: The Species Factor (K_s) is a value used to adjust reference evapotranspiration to reflect a specific plant species. The Species Factor is a component of the Landscape Coefficient (K_L).

Enter a high value in the Species Factor field for plant material that needs a lot of water and a low value for plant material that is drought tolerant.

Root Depth: Root Depth refers to the length of the section of a plant's dense roots, which draw most of its water and nutrients. Increasing the root depth increases the amount of water that can be applied during one watering event.

Density Factor: The Density Factor (K_d) refers to the amount of leaf area in the planting in this irrigation zone. More leaf area typically means greater water loss for the planting. This factor changes as the landscape matures. The Density Factor is a component of the Landscape Coefficient (K_L).

Micro Climate Factor: The Micro Climate Factor (K_{mc}) is a value used to adjust reference evapotranspiration to reflect the specific climate of an area. Use this factor to indicate whether the area is cool, shady, and protected or hot, sunny and windy or an average area that is somewhere in between. The Micro Climate Factor is a component of the Landscape Coefficient (K_L).

Enter a high value in the Micro Climate Factor field for areas that are exposed to direct sun (or reflective heat) and high winds. Enter a low value for areas in shade and/or areas that are protected from the wind.

Crop Coefficient: The Crop Coefficient is a value used to modify reference evapotranspiration (ET_o) to reflect the water use of a particular plant or group of plants. If you increase the Crop Coefficient value, the irrigation system will water longer.

Sun Exposure: This field describes the amount of sun this zone receives during the day.

Soil Type: This field describes the soil type in this zone. The soil type you choose directly affects cycle time. Each soil type in the drop-down list has a default intake rate.

Soil Textural Class	**Basic Soil Intake Rate in./hr**
Clay	0.1
Silty Clay	0.15
Clay Loam	0.2
Loam	0.35
Sandy Loam	0.4
Loamy Sand	0.5
Sand	0.6

Taken from: **8th Draft Testing Protocol Rev. 3 – September 2008 © 2008 Irrigation Association**

Allowable Depletion: When the soil moisture content reaches the Allowable Depletion level, irrigation needs to start. In most cases, the maximum allowable depletion level is just before the plants begin to show visible signs of stress.

Slope: This field represents the angle of the slope in this zone.

Enabling the Controller for WeatherAccess

In the BaseStation 1000, you enable WeatherAccess in BaseManager at the program level. In the BaseStation 3200, you enable WeatherAccess in BaseManager at the zone level.

Calculate the Runtime

After you have assigned the weather station and configured the zone properties, BaseManager will provide the following data to each controller daily:

- ETo (inches of water)
- Rainfall (inches of water)

BaseManager will also provide the following programming settings for each zone that will use weather to calculate runtimes:

- The Root Zone Working Water Storage, which indicates how much water in inches can be held in the plant's root zone
- Kc-l – either the crop coefficient or the landscape coefficient (which includes shade index)
- PR – precipitation rate (inches per hour)
- E – irrigation system efficiency percentage (distribution uniformity)

The controllers calculate the following data points that will be used to determine zone runtimes:

- Moisture balance
- Effective water put down yesterday
- 80% of any rainfall that occurred
- The ETc deficit for the day
- Inches of water required to balance the moisture deficit

This calculation estimates the loss of moisture from the root zone, and then the irrigation controller uses the calculated value to adjust the runtime in order to apply just enough water to replace that lost moisture.

Further Information

Find instructions for setting up WeatherAccess in the WeatherAccess User Manual on the Baseline website:

https://www.baselinesystems.com/mediafiles/pdf/WeatherAccess_Manual.pdf

You can also find online help within BaseManager by clicking on the **Help** option in the main BaseManager menu, and then scrolling to the **Working with Weather-based Watering** section in the Table of Contents.

References

Jensen, Marvin, E. Historical Evolution of ET Estimating Methods, A Century of Progress. 2010. https://coagmet.colostate.edu/ET_Workshop/ET_Jensen/ET_history.pdf

Wikipedia. Evapotranspiration. https://en.wikipedia.org/wiki/Evapotranspiration