WaterSense® Notice of Intent (NOI) to Develop a Draft Specification for Soil Moisture-Based Control Technologies

I. Introduction

Residential outdoor water use in the United States accounts for nearly 9 billion gallons of water each day,[1] mainly for landscape irrigation. As much as half of this water is wasted due to evaporation, wind, or runoff, often caused by improper irrigation system design, installation, maintenance or scheduling. In addition to working with irrigation professionals to increase water efficiency outdoors, the U.S. Environmental Protection Agency's (EPA's) WaterSense program is addressing irrigation scheduling by labeling efficient irrigation system control technologies. EPA released the final *WaterSense Specification for Weather-Based Irrigation Controllers* in 2011. With the release of this NOI, EPA is indicating its intent to issue a draft specification for soil moisture-based control technologies.

By directly measuring the amount of moisture in the soil, soil moisture-based control technologies tailor irrigation schedules to meet landscape water needs based on seasonal patterns, as well as prevailing conditions in the landscape. Allowing soil moisture-based control technologies to earn the WaterSense label will help further transform the market from traditional clock timer-based irrigation control to control technologies that schedule irrigation based on landscape water needs.

II. Background

The most common technology used to schedule irrigation is a manually programmed clock timer that irrigates for a specified amount of time on a preset schedule programmed by the user (e.g., 20 minutes, three days per week). In these systems, the responsibility of changing the irrigation schedule to meet landscape water needs lies with the end user or a hired irrigation professional. Clock timer controllers can be a significant source of wasted water because irrigation schedules are often set to water at the height of the growing season, and the home or building owner may not adjust the schedule to reflect seasonal changes or changes in plant watering needs. For example, plant water requirements decrease in the fall, but many home or building owners neglect to reset their irrigation schedules to reflect this change (see Figure 1). Therefore, an irrigation system may be watering in January as if it were July.

[1] Kenney, Joan F., et al. "Estimated Use of Water in the United States in 2005." *U.S. Geological Survey Circular,* 1344. Department of the Interior. Table 6, page 20.

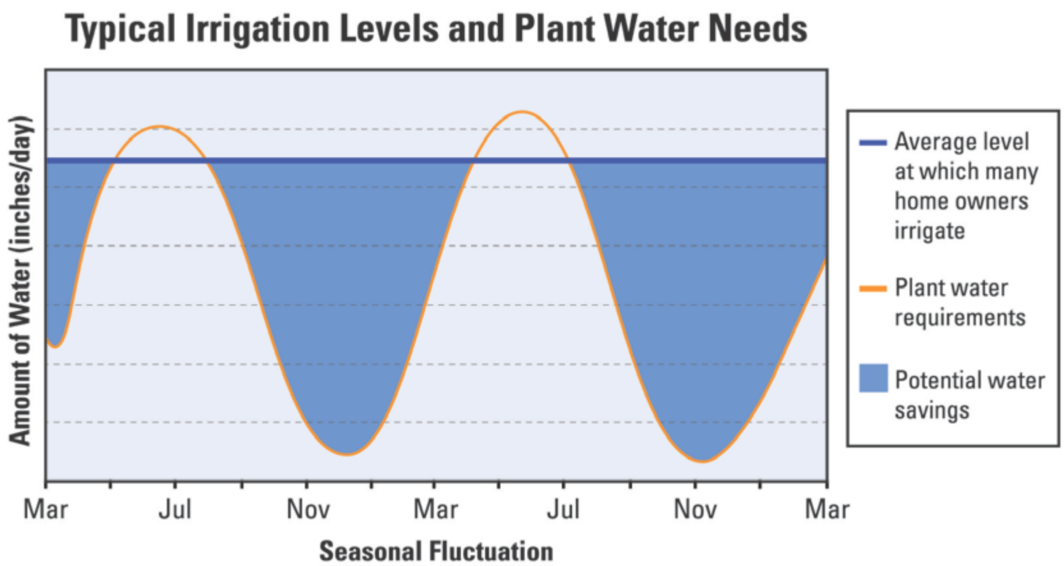

Figure 1. Potential Water Savings from Adjusting Irrigation Scheduling Based on Landscape Water Needs

As an alternative to clock timer controllers, soil moisture-based control technologies make irrigation schedule adjustments by automatically tailoring the amount and/or frequency and timing of irrigation events based on the moisture content of the soil in the landscape. There are currently two types of soil moisture-based control technologies: bypass (i.e., watering interruption) technologies and on-demand technologies.

- Bypass technologies include a soil moisture sensor that communicates with a device that is attached to a traditional clock timer controller with a pre-programmed watering schedule. The attached device will inhibit or suspend an irrigation event based on a reading from the soil moisture sensor, if the soil moisture meets a set moisture threshold. Otherwise, it will allow the irrigation event to occur. Bypass technologies are usually installed on residential and light commercial landscapes and are the most commonly used type of soil moisture-based control technology.

- On-demand technologies are stand-alone controllers that communicate with associated soil moisture sensors. These controllers automatically adjust irrigation schedules based on soil moisture levels. For example, in some technologies, a lower and upper soil moisture threshold is set in the controller. When the soil moisture sensor reads moisture content below the lower threshold, the controller will initiate irrigation until the upper threshold is reached. On-demand technologies are typically installed on larger commercial landscapes and are not as common as bypass technologies.

Research studies suggest that bypass technologies can achieve water savings of more than 20 percent over systems scheduled with clock timer controllers. Appendix A lists the water savings studies that WaterSense has identified to date. Note that the listed studies identified by WaterSense pertain to bypass technologies only. WaterSense has not identified any studies that examine water savings of on-demand technologies.

While there are currently no federal standards for soil moisture-based control technologies, the American Society of Agricultural and Biological Engineers (ASABE) is developing two standards for these products: S633, *Testing of Soil Moisture Sensors for Landscape Irrigation,* and S627, *Standardized Testing Protocol for Weather-based or Soil Moisture-based Landscape Irrigation Control Devices.* The ASABE S633 Committee is working to include in the standard a test protocol for bypass technologies that will determine the responsiveness of soil moisture sensors and their associated interrupt devices. ASABE S627 focuses on the test protocols for weather-based irrigation controllers and on-demand soil moisture-based technologies. The ASABE S627 Committee is basing its standard on the Smart Water Application Technologies (SWAT) *8th Testing Protocol for Climatologically Based Controllers* and the SWAT *Operational Test for Soil Moisture Sensor-Based Controllers*, Version 3.0.

WaterSense intends to ultimately develop specifications for both bypass and on-demand technologies. Separate specifications for these technologies are required because they function differently from one another and will need to be tested according to their function. WaterSense is focusing its initial specification development efforts on bypass technology because the fundamental aspects of the performance test protocol for that technology have been fully defined by the S633 Committee mentioned above. WaterSense plans to address on-demand technology at a later date. WaterSense intends to continue working with the ASABE S627 Committee and will have a clearer picture of the timeframe associated with the specification development process for on-demand technologies once the committee more fully defines the fundamental aspects of that test protocol. The remainder of this NOI focuses on EPA's plans for developing a draft WaterSense specification for bypass soil moisture-based control technologies.

III. Scope

WaterSense intends that the specification will apply to bypass soil moisture-based control technologies used in residential and commercial landscape applications. The product being tested and labeled will include the soil moisture sensor itself and the device that interrupts the signal from the controller to irrigate.

IV. Performance Measures

WaterSense intends to work through the ASABE S633 Committee to develop a performance test protocol and performance measures that assure the performance of bypass type soil moisture-based control technologies with respect to their intended purpose. The performance test protocol should test the ability of the product to sense soil moisture accurately and reliably bypass irrigation events at preset soil moisture values.

Once a performance test protocol is available, WaterSense will need to examine actual performance data resulting from the protocol on a range of products prior to developing a draft specification for this technology. This will require that a number of products available on the market undergo round robin testing with a number of independent laboratories to ensure that the performance test protocol is repeatable. The data generated from the round robin testing will be used to assess the range of performance that is achievable for the products on the market. These data will inform an appropriate threshold for product performance. The threshold will consider both the top echelon of products on the market and the minimum performance level that is necessary to ensure these products can accurately sense the moisture content of the soil and serve their intended function.

To aid in assuring the performance test protocol is repeatable and produces a body of data from round robin testing, WaterSense has developed a draft research proposal to seek support to accomplish the following objectives:

1. To evaluate and ensure that the performance test protocol for bypass type soil moisture-based technology included in ASABE S633, *Testing of Soil Moisture Sensors for Landscape Irrigation,* is repeatable among independent laboratories.
2. To provide performance data that could inform the establishment of performance level thresholds for bypass type soil moisture-based technologies.

Additional information on the research proposal is located in Appendix B.

V. Outstanding Questions and Issues

WaterSense welcomes feedback on all aspects of this NOI, but is seeking specific input on the following outstanding questions and issues:

1. Are the definitions of bypass and on-demand technologies clear and appropriate?

2. Regarding performance, WaterSense intends to test the accuracy of the soil moisture sensor in assessing the moisture content of soil and the device's ability to bypass an irrigation event based on preset soil moisture content.
    i. Are these appropriate performance attributes?
    ii. Are there additional performance attributes that WaterSense should consider in developing a draft specification for bypass soil moisture-based control technologies? Please provide associated test protocols, if applicable and available.

3. WaterSense has identified a number of studies that examine the water savings of soil moisture-based control technologies. Please submit any additional studies or data you would be willing to share on product performance and/or water use that are not included in Appendix A.

VI. Schedule and Next Steps

As mentioned above, WaterSense plans to work through the ASABE S633 Committee to develop a performance test protocol that is suitable for use in a WaterSense specification for bypass type soil moisture-based control technologies. The timeline for the development of a draft specification is largely dependent on the progress made by the ASABE S633 Committee and the resolution of the outstanding questions and issues described above.

All interested parties are encouraged to submit written information and comments regarding any of the concepts or issues presented in this NOI to EPA's contractor at watersense-products@erg.com. All feedback will be taken into consideration as WaterSense prepares to develop a draft specification for bypass soil moisture-based control technologies.

VII. References

Allen, Richard G. 1997. U.S. Bureau of Reclamation Provo Area Office. *Project Completion Report: Demonstration of Potential for Residential Water Savings Using a Soil Moisture Controlled Irrigation Monitor*.

Augustin, B.J. and G.H. Snyder. 1984. "Moisture Sensor-Controlled Irrigation for Maintaining Bermudagrass Turf." *Agronomy Journal*. Vol. 76. Pages 848-850.

Blonquist Jr., J.M., et al. April 4, 2006. "Precise irrigation scheduling for turfgrass using a subsurface electromagnetic soil moisture sensor." *Agricultural Water Management*.

Cardenas-Lailhacar, B., et al. 2008. "Sensor-Based Automation of Irrigation on Bermudagrass during Wet Weather Conditions." *Journal of Irrigation and Drainage Engineering.* Vol. 134(2). Pages 120-128.

Cardenas-Lailhacar, B., et al. 2010. "Sensor-Based Automation of Irrigation on Bermudagrass during Dry Weather Conditions." *Journal of Irrigation and Drainage Engineering*. Vol. 136(3). Pages 184-193.

Davis, Stacia L. and Michael D. Dukes. 2012. University of Florida Agricultural and Biological Engineering Department. *Implementation of Smart Controllers in Orange County, FL: Results from Year One*.

DeOreo, W.B. and P. Lander. 1994. *Automated Irrigation Scheduling Using Soil Moisture Sensors.* ASAE Paper No. 94-2119.

DeOreo, W.B. 1997. Evaluation of Reliability and Cost Effectiveness of Soil Moisture Sensors in Extended Field Use. City of Boulder, Office of Water Conservation. Boulder, Colorado.

Haley, Melissa B., and Michael D. Dukes. 2012. "Validation of Landscape Irrigation Reduction with Soil Moisture Sensor Irrigation Controllers." *Journal of Irrigation and Drainage Engineering*. Vol. 137(2). Pages 135-144.

Irrigation Association of Australia. Summer 2004. "Irrigation Technology - Urban: Soil Moisture Sensor Helps Save Water." *Irrigation Australia*. Vol. 19(4). Pages 13-15.

McCready, M.S., et al. 2009. "Water conservation potential of smart irrigation controllers on St. Augustine grass." *Agriculture Water Management*. Vol. 96(11). Pages 1623-1632.

Pathan, S., et al. 2003. "Soil Moisture Sensor Controlled Irrigation for Maintaining Turf." *Irrigation Australia*. Vol. 18(4). Pages 7-11.

Quanrud, David and Glenn France. 2007. Arizona Department of Water Resources. *"Smart" Irrigation Controller Study in Tucson, Arizona*.

Shedd, Mary, et al. May 2007. University of Florida Agricultural and Biological Engineering Department. *Evaluation of Evapotranspiration and Soil Moisture-based Irrigation Control on Turfgrass.*

APPENDIX A: Soil Moisture Sensor Water Savings Studies

Study Reference	Study Location and/or Sponsor	Product(s) Tested	Objective(s) of Study	Study Findings(s) Relevant to Soil Moisture Sensors
Residential Field Studies				
DeOreo, 1997	City of Boulder, Office of Water Conservation (Boulder, Colorado)	Watermark (Irrometer Company Inc.)	(1) To understand the time and expense required to maintain the soil moisture sensor irrigation systems. (2) To understand how systems performed in the field after several years. (3) To understand how well irrigation applications matched theoretical ET requirements.	▪ Irrigation occurred at 76 percent of the theoretical evapotranspiration (ET) value. ▪ Systems were reliable following 3-5 years in the field. ▪ Maintenance requirements were ~6-7min/week/unit ▪ Some fine tuning was required. ▪ Irrigation scheduling tables were developed to monitor performance.
Allen, 1997	U.S. Bureau of Reclamation Utah Office and Utah State University (Salt Lake City and Providence, Utah)	Water Watcher System (Turf Tech, Inc.)[a]	To demonstrate soil water control technology for conserving irrigation water use by residential users.	▪ On average, the 27 participants demonstrated 10 percent reduction in water use compared to 39 control households.
Irrigation of Australia, 2004	Defence Housing Authority and Water Corporation (Perth, Australia)	Watermatic soil moisture sensor (Watermatic Irrigation Company)[a]	To evaluate potential water savings using different types of irrigation control devices.	▪ Total water savings of 41 percent were demonstrated in households using soil moisture sensor controlled irrigation systems compared to households using standard irrigation systems.
Quanrud and France, 2007	Office of Arid Lands Studies at University of Arizona & Arizona Department of Water Resources (Tucson, AZ)	WeatherTRAK ET Controller (Hydropoint)[b], WeatherMiser temperature/humidity sensor (Weathermiser)[b], and RainBird® MS-100 (RainBird)[a]	To evaluate the efficiency of several types of smart irrigation devices for residential use.	▪ Results have shown that compared to the previous two years, there were 4.3 percent water savings using soil moisture sensors, 3.2 percent using humidity sensors, and 25 percent using ET controllers.

Study Reference	Study Location and/or Sponsor	Product(s) Tested	Objective(s) of Study	Study Findings(s) Relevant to Soil Moisture Sensors
Haley and Dukes, 2012	University of Florida (Gainesville, Florida)	Acclima Digital TDT RS-500 (Acclima Inc.)	To determine if documented irrigation reductions found for soil moisture sensor under research conditions could be validated in actual landscapes.	▪ Reduced irrigation applications by 65 percent relative to homes running on a timer-based system. ▪ Bypassed at least 62 percent of scheduled irrigation events that were determined unnecessary through soil moisture readings.
Davis and Dukes, 2012	University of Florida (Orange County, Florida)	Baseline Watertec S100 (Baseline Inc.) RainBird ESP-SMT (RainBird)[b]	(1) To evaluate types of smart controllers to determine whether they can reduce irrigation applications. (2) To determine the impact of user training of the smart technologies.	▪ Irrigation applications with a soil moisture sensor were reduced 23 percent; when a soil moisture sensor was combined with user education, savings increased to 45 percent. ▪ ET controllers reduced irrigation applications 16 percent without user education and 38 percent with user education.
Turf Plot Field Studies				
Augustin and Snyder, 1984	Tennessee Valley Authority and International Minerals Corporation (Florida)	Irrometer TGA Tensiometers (Irrometer)	(1) To investigate basing irrigation on soil moisture versus clock scheduling during periods of high and low rainfall. (2) To assess the influence of irrigation practices on nitrogen fertilization.	▪ Irrigation occurred 42 percent to 95 percent less often in plots using soil moisture sensor controlled irrigation compared to plots using standard clock driven irrigation. ▪ Plots with sensors received 26 percent less water than the control plots. ▪ Better turf appearance was noted in plots using sensors.
Pathan et al., 2003	University of Western Australia (Perth, Australia)	Water Smart[TM] soil moisture sensor (Rainbird)[a]	(1) To evaluate water used and turf quality of plots irrigated using a control system linked to a soil moisture sensor compared to current best practices recommended by Water Corporation in Western Australia.	▪ Turf plot irrigation using the sensor resulted in water savings of 25 percent compared to those using the best practice methods. ▪ No reduction in turfgrass quality was observed.

Study Reference	Study Location and/or Sponsor	Product(s) Tested	Objective(s) of Study	Study Findings(s) Relevant to Soil Moisture Sensors
Blonquist et al., 2006	Utah State University (Logan, Utah)	Acclima Digital TDT (Acclima Inc.)	(1) To compare irrigation scheduling in turfgrass based on weather station ET estimates with those from a time domain transmissometry (TDT) soil moisture sensor. (2) To apply a computer-based numerical model to simulate volumetric soil water content dynamics at the burial depth of the sensor and any drainage occurring below the turgrass root depth.	▪ Relative to ET-based recommendations, the system that included the soil moisture sensor applied approximately 16 percent less water. ▪ Relative to a fixed irrigation schedule, the soil moisture sensor system applied approximately 53 percent less water.
Shedd et al., 2007	University of Florida, Plant Science Research and Education Unit (Citra, Florida)	Acclima Digital TDT RS-500 (Acclima Inc.) LawnLogic (LawnLogic)	(1) To evaluate the differences in irrigation water application and the resulting quality of St. Augustine turfgrass. (2) To test two types of soil moisture sensor-based controllers set at three different moisture content thresholds. (3) To test a time-based scheduling system with and without a rain sensor. (4) To test two types of evapotranspiration-based irrigation controllers.	▪ The medium threshold settings for both soil moisture sensors resulted in 11 percent to 28 percent water savings, without any significant difference in the turfgrass quality. ▪ The low threshold settings for both soil moisture sensors resulted in a 40 percent to 63 percent water savings, but did not maintain acceptable turf quality. ▪ The high threshold settings for both soil moisture sensor treatments showed no reduction in water applications.

Study Reference	Study Location and/or Sponsor	Product(s) Tested	Objective(s) of Study	Study Findings(s) Relevant to Soil Moisture Sensors
Cardenas-Laihacar et al., 2008	University of Florida (Gainesville, Florida)	Acclima Digital TDT (Acclima Inc.) Watermark 200SS-5 (Irrometer Company Inc.) Rain Bird MS-100 (Rain Bird International Inc.)[a] Water Watcher DPS-100 (Water Watcher Inc.)[a]	(1) To quantify the differences in irrigation water use and turf quality between soil moisture sensor-based irrigation systems versus time-based systems during wet weather conditions. (2) To test the different commercially available soil moisture sensors. (3) To test a time-based scheduling system with and without a rain sensor.	▪ Water savings ranged from 27 percent to 92 percent for the four sensors studied compared to the control, with an average savings of 72 percent. ▪ Water savings were dependent on the frequency of scheduled irrigation and the choice of technology. ▪ No differences in turfgrass quality were visible.
McCready et al., 2009	University of Florida (Gainesville, Florida)	Acclima Digital TDT RS-500 (Acclima Inc.) LawnLogic LL1004 (LawnLogic)	To evaluate the effectiveness of soil moisture sensors, ET controllers, and rain sensors at controlling irrigation and providing adequate turf quality.	▪ Reductions in irrigation applied were as follows: 7 to 30 percent for rain sensors, 0 to 74 percent for soil moisture sensors, and 25 to 62 percent for ET controllers. ▪ The soil moisture sensor treatments at low threshold setting resulted in high water savings but unacceptable turfgrass quality. ▪ The soil moisture sensor treatments at the medium threshold produced good turfgrass quality and reduced irrigation water use by 11to 53 percent. ▪ The soil moisture sensor treatments at the high threshold reduced water use by 0 to 14 percent.

Study Reference	Study Location and/or Sponsor	Product(s) Tested	Objective(s) of Study	Study Findings(s) Relevant to Soil Moisture Sensors
Cardenas-Laihacar et al., 2010	University of Florida (Gainesville, Florida)	Acclima Digital TDT (Acclima Inc.) Watermark 200SS-5 (Irrometer Company Inc.) Rain Bird MS-100 (Rain Bird International Inc.)[a] Water Watcher DPS-100 (Water Watcher Inc.)[a]	(1) To quantify the differences in irrigation water use and turf quality between soil moisture sensor-based irrigation systems versus time-based systems during dry weather conditions. (2) To test the different commercially available soil moisture sensors. (3) To test a time-based scheduling system with and without a rain sensor.	▪ Water savings ranged from 9 to 83 percent for the three sensors studied compared to the control, with an average savings of 54 percent. ▪ Water savings were dependent on the frequency of scheduled irrigation and the choice of technology. ▪ No differences in turfgrass quality were visible.
Commercial Field Studies				
DeOreo and Lander, 1994	(Boulder, Colorado)	Watermark Soil Moisture Sensor (Irrometer Company, Inc.)	To determine how efficiently soil moisture sensors perform in the field.	▪ Water applications were similar to the theoretical applications. ▪ Water cost savings were demonstrated in the amounts between $1,000 and $3,000.

Notes:

a. Product is no longer available. The manufacturer has either gone out of business or the type of soil moisture sensor is no longer made.

b. Product is a weather-based controller.

APPENDIX B: Research Proposal for Soil Moisture-Based Control Technologies

I. Background

To address irrigation scheduling inefficiencies and water waste, the U.S. Environmental Protection Agency's (EPA's) WaterSense program is interested in labeling efficient irrigation system control technologies. In 2011, EPA released the *WaterSense Specification for Weather-Based Irrigation Controllers.* EPA issued a Notice of Intent (NOI) on May 16, 2013 announcing its intent to add soil moisture-based control technologies to its suite of WaterSense labeled products.

Soil moisture-based control technologies make irrigation schedule adjustments by automatically tailoring the amount and/or frequency and timing of irrigation events based on the moisture content of the soil in the landscape. There are currently two types of soil moisture-based control technologies: bypass (i.e., watering interruption) technologies and on-demand technologies.

- Bypass technologies include a soil moisture sensor that communicates with a device that is attached to a traditional clock timer controller with a pre-programmed watering schedule. The attached device will inhibit or suspend an irrigation event based on a reading from the soil moisture sensor, if the soil moisture meets a set moisture threshold. Otherwise, it will allow the irrigation event to occur. Bypass technologies are usually installed on residential and light commercial landscapes and are the most commonly used type of soil moisture-based control technology.

- On-demand technologies are stand-alone controllers that communicate with associated soil moisture sensors. These controllers automatically adjust irrigation schedules based on soil moisture levels. For example, in some technologies, a lower and upper soil moisture threshold is set in the controller. When the soil moisture sensor reads moisture content below the lower threshold, the controller will initiate irrigation until the upper threshold is reached. On-demand technologies are typically installed on larger commercial landscapes and are not as common as bypass technologies.

The American Society of Agricultural and Biological Engineers (ASABE) is developing two standards for these products: S633, *Testing of Soil Moisture Sensors for Landscape Irrigation,* and S627, *Standardized Testing Protocol for Weather-based or Soil Moisture-based Landscape Irrigation Control Devices.* The ASABE S633 Committee is working to include in the standard a test protocol for bypass technologies that will determine the responsiveness of soil moisture sensors and their associated interrupt devices. ASABE S627 focuses on the test protocols for weather-based irrigation controllers and on-demand soil moisture-based technologies.

WaterSense is focusing its initial specification development efforts on bypass technology because the fundamental aspects of the performance test protocol for that technology have been fully defined by the S633 Committee mentioned above. WaterSense plans to address on-demand technology at a later date.

II. Objective

The objectives of this research proposal are twofold:

1. To evaluate and ensure that the performance test protocol for bypass type soil moisture-based technology included in ASABE S633, *Testing of Soil Moisture Sensors for Landscape Irrigation,* is repeatable among independent laboratories.
2. To provide performance data that could inform the establishment of performance level thresholds for bypass type soil moisture-based technologies.

The research approach outlined below provides a mechanism to generate vital data that will allow WaterSense to move forward with its specification development efforts more quickly and with the necessary assurance to provide for and maintain the integrity of the WaterSense label.

III. Approach

Assessing Test Protocol Repeatability

To assess the performance test protocol repeatability, three independent laboratories will conduct round robin testing of a representative set of bypass type soil moisture-based control technologies on the market using the performance test protocol under development by the ASABE S633 Committee. Other laboratories and manufacturers participating in the S633 Committee will also be encouraged to voluntarily participate in the round robin testing to augment the data set. All round robin testing data generated will be aggregated, masked, analyzed, and reported back to the committee for consideration. The committee will then use the data to make adjustments to the test protocol as necessary to ensure that independent laboratories can achieve similar results. It should be noted that in order for this research to proceed, the committee will need to be at a point where the protocol is ready for round robin testing.

Establishing Performance Thresholds

The data generated from the round robin testing will also be used to assess the range of performance that is achievable for the products on the market. These data will inform an appropriate threshold for product performance. The threshold will consider both the top echelon of products on the market and the minimum performance level that is necessary to ensure the products can accurately sense the moisture content of the soil and serve their intended function.

For more information on this research proposal please send an e-mail to: watersense-products@erg.com