Public Comments: Soil Moisture Sensor-Based Controllers Phase 2, 4th Draft Testing Protocol

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11-12-2008

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Comments:
1. The introduction is superfluous, the document should be strictly procedural, not a commentary on soil moisture science.

2. I support the testing protocol.

3.Our "off the shelf" units will not interface with a black box designed to interpret data from a virtual landscape environment; Our units are designed to work in a real world environment. We will build the box but it's certainly not "off the shelf".

12-1-2008

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Comments:
Responses to Phase 2 Draft 4 Protocol.

Significant philosophical additions have appeared in this draft that shed a different interpretive light on the technical intent of the protocol. Over the past 3 drafts the general trend of the protocol evolution has been in the direction of 'irrelevance', arising out of a willingness to accommodate the instabilities of all sensor technologies. Throughout this process I have supported much of this 'watering-down' in order that the protocol development can be completed. But with some of the new statements in draft 4, these accommodations have reached the point of 'legitimizing' the historical problems associated with soil moisture sensors. If implemented with the current tolerances of poor system performance, the result will be dissatisfaction by the users and an increased mistrust of sensor-based irrigation control.

The historical problems of soil moisture sensors and associated controllers can be characterized in one word - 'instability'. The concept of stability is vital to SMS-based control. It implies consistent interpretation of root zone moisture with changing conditions of soil EC, temperature and time. The root zone control range (between Field Capacity and Management Allowable Depletion) is only a few percentage points wide for coarser soils. Systems that drift by several percentage points due to changing EC, temperature or time cannot avoid wasting water or stressing grass. Manual re-calibration is not an option, since the need for calibration only shows up too late - in the water bill or in dead grass. Furthermore, most users are not inclined to make periodic adjustments to equipment that purports to be automatic.

The original Phase 1 testing was developed precisely for the purpose of measuring sensor stability. The various dry-out tests made at differing temperatures and salinity conditions were designed to expose instabilities that would lead to poor system performance. The rationale behind these tests arose from years of experience with 'snake-oil' sensors that proponents have attempted to use for irrigation control for the past 50 years without success. The failures of these past attempts at SMS-based irrigation are primarily rooted in 'instability'. All references to stability have been eliminated from the test protocol over that past several revisions. The role of the IA protocol should be to protect the market from the disasters of the past 50 years rather than to legitimize them.

Here are the objections to the draft 4 text:

Page iii - 2nd paragraph - footnote 1

"The protocol recognizes that the root zone environment can change dramatically as for example, water tables drop and irrigation water becomes more saline. With the current state of the art, soil sensors are not automatically compensated for this root zone environment change. In this case a periodic manual change in the threshold settings is anticipated."

The whole point of the phase 1 protocol was to characterize the sensor stability such that sensors that react severely to EC changes are not classified as being effective for closed-loop irrigation. EC changes are not only brought on by water table drop but also by temperature change,

fertilization, compaction, evaporation and other complex events. The proposed manual intervention will be very frequent, ineffective and ultimately rejected - as it has been historically.

Page iv - last Paragraph

This whole paragraph seems to be a generalized judgment of soil moisture sensing technology and is generally in disagreement with current best practices and data gathered from tens of thousands of installations. I would recommend deleting the whole paragraph.

Page 2 - paragraph 2:

"The operational concepts also assume that the threshold adjustments can be made manually in response to seasonal changes in on-site conditions."

This is an invitation to use manual intervention to compensate for poor system performance. Allowing such systems to enter the market through rebates supported by IA endorsement will result in tax money being used to subsidize purported automatic, water-conserving systems that are neither automatic nor inherently water-conserving.

12-9-2008

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Comments:
this would be an exceptional breakthrough in the irrigation industry, this will ensure the so much needed food security.

1-9-2009

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Comments:
Regarding sentence 2 in section 5.3, should the term "soil moisture sensor manufacturer" actually read "soil moisture sensor based controller manufacturer"?

any manual adjustments. Allowing manual adjustments does not test the ability of the sensor to operate properly but tests the ability of the operator to program the controller properly.

- Paragraph 4
  - Previously the electronic link is referenced as the "data conversion device". Be consistent within the protocol.
- 5.2 Sampling
  - How does the testing agency randomly purchase a controller? Why does the protocol not allow the manufacturer to provide the controllers to the testing agency that are production? This appears to be allowed by the second paragraph but it is not clear. Should be worded as a part of the same paragraph.
  - How many sensors will be used in the test?
    - 1 sensor per controller or 1 sensor per zone
    - This will affect the outcome of the test.
- 5.3 Test for Adequacy.
  - Paragraph 1
    - The first sentence is not a complete sentence. We are not sure what it says.
    - It is confusing as to which table is going to be used; Table 1-A or Table 1-B and/or who makes the decision.
    - The consumer is not going to know the water conductivity and therefore that should not be an option for programming. A well designed sensor will operate properly regardless of the conductivity. Allowing water conductivity to be set in the controller does not test the ability of the sensor to operate properly but tests the ability of the operator to program the controller properly.
  - Paragraph 2
    - Why the minute by minute or daily options? Who makes the choice?
  - Table 1-A and Table 1-B
    - Why are there two tables? Which will be used?
    - The table for the footnotes of Table 1-B lists different soil textures than those in Table 1-B.
    - Is conductivity taken into account for calculating the available water and where wilt point is?
  - Page 9 - First full paragraph
    - Is water loss from runoff or deep percolation accounted for in the soil moisture calculations
- 5.5 Test Duration
  - It is just a virtual test so why do we not create some virtual weather. We could create a suite of virtual weather conditions that are defined in the protocol. Which one that is use for the test could be randomly selected so that the manufacturer would not be sure which one was used. This would eliminate the concern about weather stations, test duration, lack of rainfall, inadequate ET etc. It would not compromise the test because after all it is theoretical anyway.
- 7.0 Appendix:
  - Formulas
    - Shouldn't RN be calculated based upon quantity per hour; soil type; and slope?
- Phase 1 data should be included in the report so that sensor performance is understood across a variety of environmental conditions.

1-31-2009

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Comments:
There has been much communication regarding the phase 2 protocol that has not been recorded in this official public forum. In order that concerns that some of us have made might be brought to this official public site, I will summarize mine below:

The combination of the phase 1 and phase 2 protocols do not provide any data upon which a performance judgment of an SMS system can be made. The phase 1 protocol gathers sufficient sensor data that a very good judgment of sensor performance can be made - BUT THE RELEVANT DATA THAT IS SO PAINSTAKINGLY GATHERED IS NOT REPORTED. The merit of a sensor is associated with its repeatability under varying conditions of moisture, temperature, compaction and soil EC. These are characterized in the phase 1 testing but are not disclosed in the phase 1 reporting. Hence the public has no knowledge of the merit of a given sensor.

The phase 2 protocol does nothing to repair this reporting inadequacy. The phase 1 protocol derives response functions for the sensor under several static conditions of temperature, soil type and soil EC. These response functions correlate the weight-derived soil moisture content with the sensor reading for a given static temperature and static salt content over a range of volumetric water content. These individual static responses are then used in the phase 2 protocol to convert inputted VWC data from the test computer into sensor responses for the testing controller. Any monotonic response curve from any sensor technology will yield perfect adequacy and efficiency results for a reasonably designed controller, because the sensor response simulation from the interface device is precisely known for the static condition tested in phase 2. This is not really a system test but rather a controller algorithm test under highly static conditions. The overall system escapes meaningful
testing because the sensor response to varying conditions has not been considered. A SYSTEM DESIGNED AROUND A SENSOR THAT DRIFTS 100% WITH A 5 DEGREE TEMPERATURE SHIFT WOULD SHOW PERFECT RESULTS, YET SUCH A SYSTEM WOULD FAIL MISERABLY IN FIELD USE. THE SAME IS TRUE FOR CHANGING EC. By eliminating the rigorous reporting in phase 1 and using static testing in phase 2 the certification has been hijacked to provide all contenders with equal and perfect performance reports. The result will be disaster for the public, the purveyors, the IA and the SMS manufacturers.

There are two options to make the existing protocol work:

1. Report the full results from phase 1 sensor testing - especially the combined data from temperature and EC extremes. Report the r-squared values from these combinations of data.

2. Modify the phase 2 protocol to include multiple response curve use for temperature and EC. For the system to work properly in the field the response curves for two different temperatures must be closely aligned. By using temperature response curves from two extremes during the test and by not allowing readjustment of the system, the weaknesses of the sensor would be brought out in the adequacy and efficiency results. The same is true for EC response.

If the protocol is not strengthened to differentiate performance and weed out snake oil based on reasonable performance limits, then what is the purpose of the certification? I do not support the

argument of quickly passing a shoddy protocol in order to more quickly get into the rebate game - even if the ET protocol is also shoddy. We have an opportunity and an obligation to do it right.

2-2-2009

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Comments:
SWAT Soil Moisture Sensor Phase 2 Protocol Public Comments

February 2, 2009

From: Ad-hoc coalition of soil moisture sensor manufacturers

We appreciate the opportunity to offer comments to improve the testing protocol and look forward to the rapid advancement of the program so that testing of devices can begin.

Comments:

Sections of the protocol have been copied in this memo with ~~strikethrough~~ indicating existing text to be eliminated and *italics* indicating replacement text

Section: Introduction:
Editorial comments should be stricken from the text as indicated:

~~The protocol recognizes that the root zone environment can change dramatically as for example, water tables drop and irrigation water becomes more saline. With the current state of the art, soil moisture sensors are not automatically compensated for this root zone environmental change. In this case a periodic manual change in the threshold sensor settings is anticipated.~~

~~Soil moisture sensors, by their nature, operate in a responsive mode. The specifics of the mode are defined by the sensor laboratory results (Phase 1) and site considerations including soil classification, planting materials, and water quality. As a result then for a specific sensor, the operating mode can be different for different zones. In any case, the manufacturer must specify the mode(s) before the Phase 2 test evaluation can be conducted. Representative modes include the following:~~

~~a) when the soil moisture sensor reaches a lower threshold value then;~~

~~1) a fixed runtime application is made~~ ~~**or**~~

~~2) a variable runtime application is made with irrigation terminated when an upper threshold setting is reached.~~

~~b) Irrigations are scheduled on a time framed basis (e.g. daily) for a given runtime. If the soil moisture sensor shows readings above a wetter threshold value, the irrigation is aborted. If the soil moisture is below the threshold value, the irrigation proceeds for a runtime sufficient to reach at least the threshold value.~~

~~While not a part of this protocol, the dynamics of these control concepts need to be anticipated and dealt with. Specifically, the dynamics of the response time required for surface applied water (rainfall or irrigation) to be reflected in the sensor reading is not scientifically characterized. This~~

~~probably means, for example, that the soil moisture sensor will not function satisfactorily as an instantly responding rain switch. While an intuitive judgment characterizing their performance on coarse soils and shallow root zones is probably satisfactory, the same judgment on fine soils and deeper root zones would be misleading. This suggests that yesterday's moisture status readings that have reached at least near equilibrium conditions are a better basis for making today's irrigation decisions than to attempt a real time based program. Because of the fundamental dynamic of root zones, moisture gradients are always present. Perhaps the best temporal judgment is to read the sensor at the same time each day for purposes of scheduling the next day's irrigation events.~~

Section 2.0:

Substitute text as indicated:

~~The operational concepts also assume that threshold adjustments can be made manually in response to seasonal changes in on-site conditions. These changes could be represented for example by a change in the water quality as aquifers are over-pumped during drought conditions.~~

This paragraph is editorial and should be eliminated.

~~The protocol solicits, by zones (see Table 1-A), the mode of operation specified by the manufacturer. The data from Phase 1 allows the protocol to convert the sensor readings provided by the manufacturer to be converted into the equivalent root zone moisture. This value is used to then calculate the runtime. Runtime is calculated by the following formula:~~

$$R_T = \frac{60(MC_1 - MC_2)(RZWD), \text{minutes}}{PR_E}$$

~~Where: MC_1 = upper threshold moisture content as decimal equivalent~~

~~MC_2 = measured moisture content as decimal equivalent~~

~~RZWD = root zone working depth, in.~~

~~PR_E = effective precipitation rate [PR (App. Eff.)], in./h~~

~~This runtime is used to calculate the water applied today in response to the previous day's consumptive use. These runtime calculations will be administered by the manufacturer's controller.~~

The methodology described does not necessarily represent the way any or all manufacturers read their sensors and change run times and should either be stricken or completely re-written. Suggested wording:

For any sensor technology, there is a methodology of converting soil moisture into a characteristic that can be modeled in the "virtual environment" of the testing protocol. This characteristic is specific to the sensor/manufacturer. For instance, in the case of an electronic sensor the representative characteristic may be voltage. This principal was demonstrated in Phase 1 of the protocol, whereby a sensor response relationship was demonstrated. For the purposes of Phase 2, this sensor response is modeled by the "black box" provided by the manufacturer.

Section 5.1:

Substitute text as indicated:

Soil moisture-based system controllers from individual companies will be installed on-site at the testing agency complete with ~~required sensors and/or communication links.~~

This sentence erroneously states that the sensors would be physically attached to the controller, which is not the case with this "virtual" test. Recommended substitution wording as follows:

Soil moisture-based system controllers from individual companies will be installed on-site at the testing agency complete with *a "black box" that serves as an electronic link between the protocol's computer and the manufacturer's controller. The signal must be electronically readable by the manufacturer's controller as described in 1.0 Introduction.*

Section 5.2:
Substitute text as indicated:

~~The soil moisture sensors used in Phase 1 testing will be used in the Phase 2 test and will be connected/interfaced to the irrigation controller. The soil moisture sensor manufacturer will specify the make and model of irrigation controller to be used in the Phase 2 test. The testing agency will randomly purchase the irrigation controller from a retailer/distributor. The manufacturer will reimburse the testing agency for the cost of the controller. The unit selected will remain the property of the testing agency. At the manufacturer's option, he can provide a feature set that the controller must have to interrelate with his sensor. The performance summary will identify the controller actually used in the test. The manufacturer will have to make the "or equal" argument to the SWAT committee.~~
~~Alternatively, the testing laboratory will select the controller to be tested at random from a sample of at least 10 units supplied by the manufacturer. The testing agency will retain the controller.~~

This section erroneously states that the sensors from Phase 1 will be utilized in Phase 2, which is not the case for this virtual test. Associating a specific make/model of controller to the manufacturer's device, in the case of an "add-on" component is unrealistic and will serve to preclude the millions of existing controllers currently in use from being upgraded by the attachment of said Smart devices. Suggest replacing this entire section with the following:

The "black box" device, provided by the manufacturer, will be connected/interfaced to the irrigation controller.

Currently, two different versions of soil moisture sensor based irrigation controllers exist:

- *On the one hand, a single controller that incorporates the sensor(s) interpretation as well as the valve(s) operation in one enclosure and shall be referred to for purposes of this protocol as "stand-alone soil moisture based controllers." Such controllers schedule valve operation based on sensor inputs and/or time and sensor inputs.*

- *The other type combines a soil moisture interpretation device(s) coupled with a conventional time based irrigation controller, whereby the sensor device serves to over-ride and/or initiate the time based scheduling of the valves depending on sensor inputs. For purposes of this protocol, these devices shall be referred to as "add-on soil moisture based controllers."*

If the soil moisture sensor based controller being tested is a stand-alone soil moisture based controller, then the manufacturer shall supply 10 such complete units and the testing agency shall select one at random from the lot for testing.

If the soil moisture sensor based controller being tested is an add-on soil moisture based controller, then the manufacturer will specify a feature set that the time based irrigation controller, to be used in the Phase 2 test, must have to interrelate with his sensor device. The testing agency will use an existing compatible controller from their inventory or randomly purchase a compatible irrigation controller from a retailer/distributor. The manufacturer will reimburse the

testing agency for the cost of the controller, should it need to be purchased for the purpose of their test. The unit selected will remain the property of the testing agency.

The use of a "feature set" to define an acceptable controller to be used for testing add-on devices was unanimously agreed upon by the manufacturers that would yield uniform results no matter which brand or model of specific controller was used, so long as it comprised the elements of the feature set.

Section 5.3:

The group agreed, by majority vote, that the salinity and temperature parameters should remain as presented.

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2-2-2009

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Comments:
Section 5, Functional Tests:
These test are to be performed with a "data conversion device", however the definition of the device, the "black box", is missing. The need for these definitions was accepted in the Phase 2, 3rd draft protocol review, (Comment no 21), but were not yet implemented. The Phase 2 protocol is not complete until these points are contained in specific language:

1.) Testing agency communication:
a)hardware description,
b:)cables, signals, connectors,
c) communication data format to the Interface Device.
d) communication verification / handshaking

2.) Specify the Interface Device parameter / data format for:
a)Moisture
b)Temperature
c)Salinity
e)Soil Type
f)Variability in
cyclic test results.

3) The number of zones (6) requires up to six interface devices, thus each zone must have a hardware or firmware address definition for each of the parameters in (2.)