Recommendations for Installing Soil Moisture Sensors in Rock Wool

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June 24, 2021

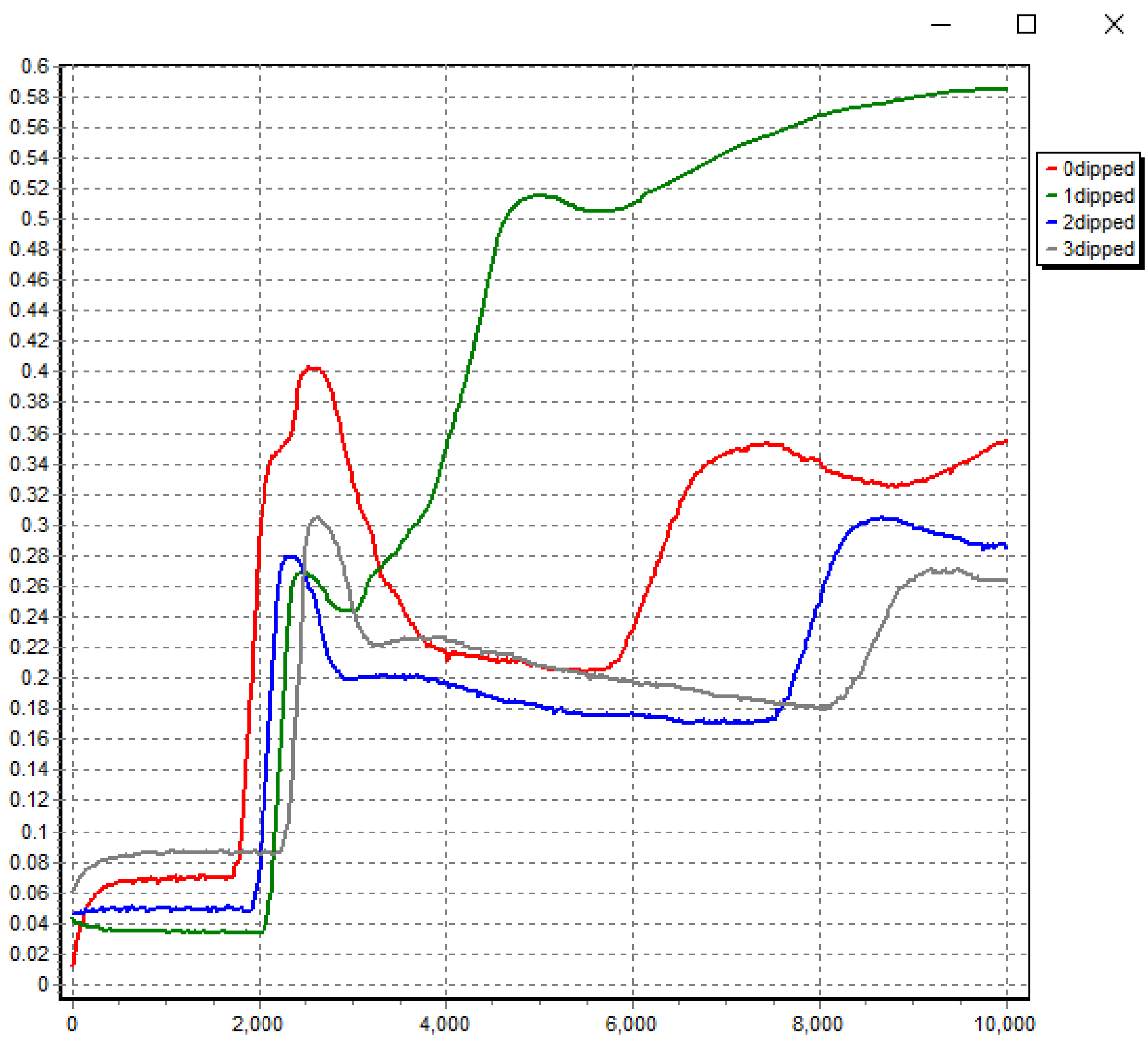

Acclima
Soil Smart Series
TDR-310W
Sensor
PARGRO
QUICK DRAIN

Setup for Gathering VWC Data from Rock Wool:
The data in this report was gathered from 4 sensors mounted in one common Rock Wool block. The picture above shows how the sensors were installed in the block. The chosen orientation for the sensors was arrived at through previous experience with Rock Wool and was deliberately arranged to show the differences in VWC readings vs sensor position and orientation in the Rock Wool block.

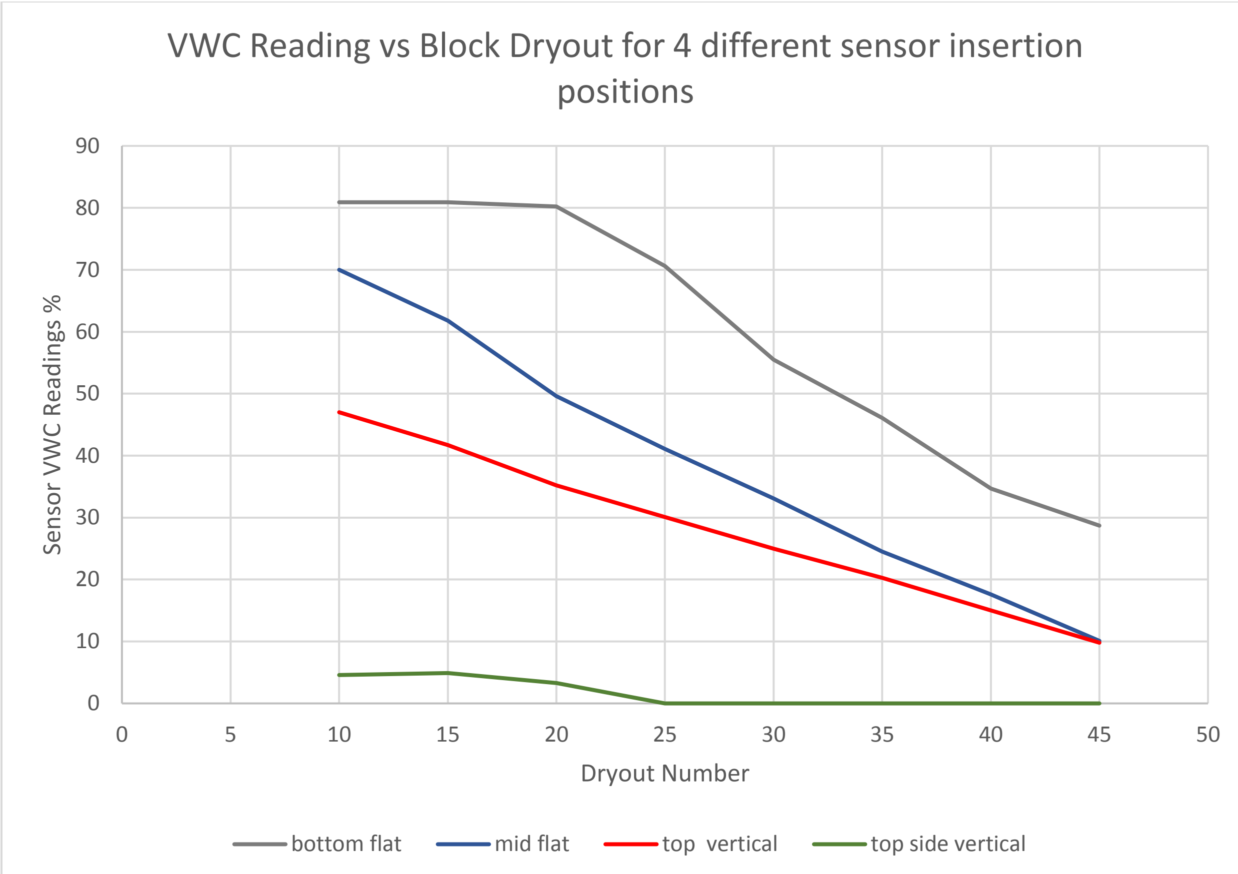
Test Sensor Installation:
The sensor at the top was installed vertically in the top of the block. Its address was set to '0' and its waveforms and readings are displayed in red. The next sensor down the block was installed in the side of the block with the plane of the waveguide in a vertical orientation. Its address is '1' and its waveforms and readings are displayed in green. The next sensor down has address '2' and it is installed horizontally in the side of the block near the vertical mid-point. Its waveforms and readings are displayed in blue. The bottom sensor uses address '3' and it is installed horizontally near the bottom of the block. Its waveforms and readings are displayed in gray.

Preparation:
The entire block with its 4 installed sensors was immersed in salt water at about 1100 uS/cm salinity. It remained immersed until all the entrapped air had bubbled out of the block. The block had been previously used in testing using water at 6000 uS/cm and contained dried salt crystals. Hence the salinity of the wetted block was likely in the 1500 - 2000 uS/cm range when withdrawn from the wetting solution.

Initial Observations:
After draining the block for about one minute, initial readings were taken from each sensor. It was noted from these readings that there was a severe gradient in water content from the top of the block to the bottom. In this initial saturated condition the bottom sensor (addr 3) reported 80.9% VWC. The next up sensor (addr 2) reported 70%. The top sensor (addr 1) reported 4.6%, and the vertical sensor installed in the top surface (addr 0) reported 47%. Most of the water in the block was suspended in the lower half of the block. The upper inch of the block contained less than 5% of the total water. Hence the top-inserted vertical sensor was exposed to rock wool at the top containing less than 5% water and to rock wool at its lower rod tips of 70%+ water content. The average was 47%. This severe vertical gradient causes some appreciable challenges in choosing the proper area in the block to measure water content. The plant growing in the block does not have a uniform exposure to water throughout its root. This testing yielded some recommendable installation orientations and positions where a 'reasonable average' water content for the root can be measured.
The gradient also causes the TDR waveforms to be distorted for the two vertical sensors (red and green). It was discovered a few days before this test that a sensor installed from the top surface into a water gradient would occasionally report zero water content. The cause of this failure was determined through an inspection of failed waveforms and was corrected in FW. The tests reported in this document were conducted using the modified firmware. The dropped readings are cured.



In the graphs above the red sensor had reported an occasional zero for VWC in earlier testing in its vertical position. After a minor correction in the FW the zero-reporting was fixed. The red waveform shows an initial dry area at the beginning of the waveguide with increasing water content further down the waveguide. The original FW was not designed to handle this gradient and occasionally returned a zero for VWC. The green sensor waveform also shows distortion, but it always returned good readings. The green waveform is distorted due to a lateral water gradient across the waveguide. This gradient causes an underestimation of VWC. Although it is not a serious underestimation, it is recommend that the sensor not be used in that orientation.



Dry-out Testing:
After the initial saturation of the cube a dry-out test was performed. The method for drying out the rock wool block was to place a few sheets of paper towel under the block and allow the water to be drawn out by capillary force. The top-installed vertical sensor (red) was used as a monitor for measuring the progress of the drainage. Readings from all sensors were taken in 5% increments as reported by this red sensor. Three rolls of paper towels were required to dry the rock wool at that sensor from 47% to 10% water content. The responses of the other 3 sensors were taken at each step also. The graph above shows the responses of the sensors. Comments regarding each sensor orientation and position follow:

Sensor 0 (red) installed vertically from top surface:
Although this sensor orientation caused drop-outs prior to the FW upgrade, it shows good representation of the overall block average water content. Hence this is a recommended sensor installation method provided that the PWEC errors caused by the gradient are addressed. The tips of the waveguide do not reach to the very wet regions at the bottom of the block and so the average VWC reading is lower than the average VWC for the whole block. Due to the gradient the reported PWEC is about 60% high and must be corrected if this method is to be used.

Sensor 1 (green) installed in the side wall of the block near the top with a vertical waveguide plane:
Sensors should not be installed near the top of the block in a horizontal orientation. The water content there is not representative of the average content throughout the block. The sensor waveguide in a

horizontal insertion must be flat. Do not install with a vertical waveguide plane. The vertical plane installation has a water gradient laterally across the waveguide that causes a large error in PWEC.

Sensor 2 (blue) installed in the side wall of the block near the vertical mid-point of the block:
This is a good position and orientation for the sensor. It provides sensitive detection of water content across the full range of block water content and is reasonably close to the block average water content. It detects the stress region for water content much better than more deeply installed sensors.

Sensor 3 (gray) installed in the side wall of the block near the bottom of the block:
Do not install sensors near the bottom of the block. This location is always much wetter than the upper regions of the block. Sensors installed here cannot see the stress levels experienced by the plant roots in the upper regions of the block.

Summary:
One of two orientations is recommended for sensor installation.

The preferred is a horizontal installation into the sidewall of the rock wool block with the waveguide in a flat orientation and the insertion point between the 1/3 and 2/3 point up the sidewall. Note that with a horizontal installation into the sidewall that the reported water content will depend heavily upon the vertical position in the sidewall where the sensor is installed. If installing into the sidewall be sure to always use a consistent elevation on the sidewall for the sensor insertion. Otherwise the shift in the data will result in confused control of irrigation.

The second is a vertical installation from the top of the block with the waveguide fully inserted into the block. This method does not provide accurate PWEC readings because of the gradient along the waveguide. If it is to be used a special PWEC modification will need to be done in the FW.

Where drip emitters are used for irrigation there may be wet spots under the drippers that percolate water directly to the bottom of the block without much lateral diffusion, resulting in non-homogenous wetting across the block. This could be improved by placing several folded paper towels or a sponge on top of the block to diffuse the water laterally before it enters the block.