INSTALLATION AND OPERATING INSTRUCTIONS

WATERMARK®

Soil Moisture Meter

Instant Readings with your Digital Meter

One Meter reads all Sensors

The soil acts as a reservoir to store water between irrigations, or rainfall events, so that it is available to the crop or plants as needed for healthy growth. The purpose of using sensors to measure soil water is to give you a better understanding of how fast water is being depleted in the different areas of your field, so you can better schedule your irrigations and correctly evaluate the effectiveness of any rainfall. By reading the sensors 2-3 times between irrigations, you will gain an accurate picture of this process over time, and develop an irrigation scheduling pattern that meets your crop's "need" for water. This eliminates the guesswork, can result in water savings, lower pumping costs and eliminate excess leaching of nitrogen due to over irrigation.

SENSOR SITE SELECTION — Often more than one sensor should be placed at a given location, at varying depths. For instance, one sensor in the upper portion of the plant's effective root zone and other sensors located deeper into the root zone profile. We refer to this as a "sensing station", and it can give a better representation of the plant's uptake of water.

PLACEMENT —

Furrow or Flood Irrigation – Locate sensing station about 2/3 the way down the run, just ahead of the tail or backup water. This is the area where water penetration is usually the poorest. With tree crops, locate sensors on the southwest side of the tree (in the Northern Hemisphere) as this side gets the hot afternoon sun.

Sprinkler Irrigation – Even though the distribution is typically more uniform with sprinkler irrigation, there can be great differences in penetration and holding capacity due to soil variations, interfaces and contour. These various sites make good locations for sensor stations. With tree crops, locate sensors at the drip line of the canopy being sure that they are not obstructed from the sprinkler's distribution. With row crops, locate sensors right in the plant row.

Center Pivot Irrigation – Place sensors at 4 - 5 locations down the length of the pivot (between towers) just ahead of the "start" point. Additional locations at "hot spots" (good or poor production areas of the field) can help give a better overall view of the field. Be sure to use enough "sensing stations"; every 10 - 15 acres is a good rule of thumb.

Drip or Micro Irrigation – Sensors must be located in the wetted area. With drip emitters, this

is usually 12"-18" (30-45-cm) from the emitter. With micro-sprinklers, usually 24"-36" (60-90-cm) is best. Monitor often enough to get a good overall picture of the field, or irrigation "block", and consider the soil variations which exist. Keep in mind that light soils dry very quickly and heavy soils more slowly.

DEPTH — This depends on the rooting depth of your crop, but can also be affected by soil depth and texture. With shallow rooted vegetable crops, one depth may be adequate (root system less than 12"[30 cm]). With deeper rooted row crops (small grains, vines and trees) you need to measure soil moisture in at least two depths. With deep well-drained soils, crops will generally root deeper – if moisture is available. With coarse, shallow or layered soils, root systems may be limited in depth. In general, sensors must be located in the effective root system of the crop. Guidelines on proper depths for specific crops and conditions can be obtained from IRROMETER as well as your local farm advisor.

Note — *Our recommendation for anyone using sensors for the first time is to use an adequate number of "stations" over a smaller area to begin with, to get an accurate picture. Then read them regularly over the season to learn the patterns which normally develop.*

SENSOR INSTALLATION — Soak the sensors overnight in irrigation water. **Always install a wet sensor.** If time permits, slowly wet the sensor by partlally submerging (no more than half way) for 30 minutes in the morning and let dry until evening, wet for 30 minutes, let dry overnight, wet again for 30 minutes the next morning and let dry until evening. Soak over the next night and install WET. This will improve the sensor response in the first few irrigations.

Make a sensor access hole to the desired depth with an IRROMETER installing tool or a 7/8" (22mm) O.D. rod. Fill the bottom of the hole with a thick slurry made of soil removed from the hole and water, then firmly push the sensor down into the mud in the bottom of the hole. This will "grout in" the sensor to ensure maximum surface contact between the sensor surface and the sorrounding soil. Alternately, the sensor can be firmly pushed to the bottom of the access hole as long as it is a tight enough fit to ensure adequate contact; a snug fit is absolutely necessary. A length of 1/2" Class 315 PVC or 3/4" CPVC pipe will fit snugly over the sensor's collar and can be used to push in the sensor. A good snug fit in the soil is important. This PVC can be solvent welded to the sensor collar with a PVC/ABS cement (IPS Weld-On #795 or equal).

If the PVC pipe is not left on the sensor, then backfill the hole so the sensor is buried (see Fig. 1). The sensor's wires can easily be staked up for easy access. If PVC is left on, then compact soil around the surface to seal off the hole (see Fig. 2). The PVC acts as a conduit for the sensor's wires. Be sure to cap off or tape the top of the pipe, so surface water will not infiltrate to the sensor and give a false reading. Drill a small hole at the bottom of the pipe to allow any trapped water to drain away. Label each pair of sensor wires to indicate the measurement depth.

For very coarse or gravelly soils, an oversized hole (1" – 1.25" [25 mm - 32 mm]) may be needed to prevent abrasion damage to the sensor membrane. In this case, auger a hole to the desired depth and make a thick slurry with the soil and some water, as described above. Fill the hole with this slurry and then install the sensor.

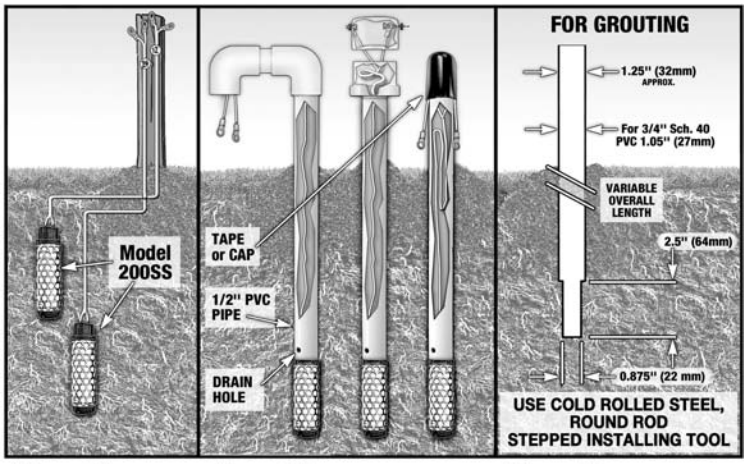


Figure 1 **Figure 2** **Figure 3**

Another method of installing sensors in difficult gravelly soils, or at deeper settings is to use a "stepped" installing tool (see Fig. 3). This makes an oversized hole for the upper portion and an exact size hole (sensor is 7/8" [22 mm] O.D.) for the lower portion where the sensor is located. The hole must be carefully backfilled and tamped down to prevent air pockets, which could allow water to channel down to the sensor.

If sensors are removed, clean and dry them. They can be stored indefinitely in a clean, dry location. Always soak before re-installation.

WIRING SENSORS — If additional wire length is needed, simply splice the additional wire to the sensors wire leads. This wire splice must be fully waterproof (3M Scotchpak, Duraseal heat shrink splice connector, or equal). This wire can be extended up to 1000' (305 m) with #18 gauge (.8 mm^2) UF wire. Avoid long wire runs near power cables. The transient currents can affect the small current used by the WATERMARK meter. This can be checked by reading the sensors at both ends of the wire run.

WATERMARK METER – 30 KTCD-NL *(Green Case)* **—**

Attach the meter's leads to the sensor's wires with the alligator clips, being sure the separate leads are not touching each other.

Press "READ" to wake up the meter, you will see "– –" in the display. The meter will stay awake for 5 seconds (to keep meter awake for 60 seconds, press "TEMP" before "– –" goes away).

Press "READ" again while "– –" is in the display. The soil moisture reading will immediately appear in the display and remain for 60 seconds while you record it. The meter will then turn itself off.

When taking readings, the soil temperature adjustment should be set for the actual soil temperature at the depth of sensor placement. A soil thermometer can be used to obtain this value. Soil temperature does not change drastically during the season, so usually a measurement at the beginning of the season is sufficient. If the temperature value is not changed, the trend of the readings will not be affected, only the absolute value will. Analysis of the trend is of primary importance to see how rapidly the soil is drying. This setting compensates for seasonal variations in soil temperature, which can go from the 60°F (16°C) range in the spring into the 80°F (27°C) range in the summer. This variation in soil temperature can affect the readings by 1% per degree Fahrenheit, so the temperature compensation greatly improves the accuracy of your readings.

To check the temperature settings, press "TEMP". The temperature setting and the scale (°F or °C) will alternate in the display.

To change the temperature scale, press and hold "READ", then alternately press "TEMP" until the desired scale (°F or °C) appears in the display and then release READ button.

To change the temperature setting, press and hold "TEMP" then press "READ" to change the setting. The temperature setting will begin to increase until the desired setting appears in the display. The full scale of temperature setting is 41°F (5°C) to 105°F (40°C). Once the temperature scrolls up to 105°F, it will go to 41°F and begin scrolling upwards again. You can reverse the direction of scrolling at any time by releasing the "READ" button and depressing it again (while continuing to hold "TEMP" down).

The temperature settings you programmed in will remain until you change them. The meter comes with a default setting of 75°F (24°C).

The meter has a built-in test function. To test the meter for accuracy, with the temperature setting at 75°F (24°C), press and hold "READ" and "TEST" simultaneously. A reading of between 95 and 105 should appear in the display. This reading indicates the meter is functioning properly. **During test, make sure cable leads are not touching or hooked to a sensor.**

This digital meter has a full range of 0 to 199 centibars built in.

The digital meter utilizes solid state electronics and is sensitive to extreme heat. Do not store the meter on the dashboard of your vehicle or any other very hot location. Replace battery with a good quality 9V alkaline battery at least once each year. The meter has a low battery indicator and the battery should be replaced whenever "LO" appears in the display.

DATA LOGGING DEVICES — If sensors are to be read by a data logging device, it must be compatible with WATERMARK soil moisture sensors. Please contact IRROMETER for compatibility information. Many data loggers are compatible with WATERMARK sensors and a current list can be obtained by calling **(951) 689-1701** or e-mailing **techsupport@IRROMETER.com**. If compatibility is not verified, inaccurate readings could be obtained and sensor longevity could be affected.

Modified WATERMARK sensors, with a linear voltage output, are available for use with data loggers that are not directly compatible. Always verify the reading by comparing to that obtained with the hand-held meter.

Note – *Our old style 30 KTCD meters, with the tan colored case, are still fully usable. They operate a bit differently than the newer 30 KTCD-NL, with the green case, but we will still offer repair and upgrade services for a number of years.*

TROUBLESHOOTING — Every now and then you may encounter a situation where the sensor doesn't seem to be working properly. Please follow the steps below to determine if the equipment is functioning correctly or to determine if the field condition needs modification.

1. First check the meter.

A. Is the battery O.K.? It should be replaced at least once a year, more often with frequent use. Check to be sure the battery contacts are clean and tight on the battery terminals.

B. Follow the test procedure on the meter.

C. If there has been some wire damage to the meter's leads, it could malfunction. To check this, clip the leads to each other and push the "READ" button. The number 0 should appear in the display. If it does, then the leads are O.K. Moving the wire leads while reading will help to show if there is an intermittent wire connection problem. Holding the "READ" button down will result in continuous reading, while you move the wires. Replacement cables are available as a spare part.

D. The LCD display on the meter has three digits. If you see only partial digits, the LCD may be suspect and should be returned for examination and/or repair.

2. Then check the sensor.

A. Partially submerge the sensor in water (no more than half way) for at least 30 minutes, your meter reading should be from 0 to 5. If the sensor passes this test, go on to step B.

B. Let the sensor air dry for 30 to 48 hours. Depending on ambient temperature, humidity and air movement, you should see the reading go right up from zero to 150 or higher – even off scale (LCD will read 199 when it reaches 199 cb or more)

C. Put the sensor back in water (partially submerged) with the meter leads attached. The reading should return to between zero and 5 within several minutes. If the sensor passes these tests, it is O.K.

3. Next check the field conditions.

A. The sensor does not have a snug fit in the soil. This usually happens when an oversized access hole has been used and the backfilling of the area is not complete. Re-install the sensor nearby, carefully backfilling the access hole.

B. Sensor is not in an active portion of the root system, or the irrigation is not reaching the sensor area. This may happen if the sensor is sitting on top of a rock, or below a hardpan, which may impede water movement. Re-installing the sensor should solve the problem.

C. If the soil dries out to the point where you are seeing readings higher than 80 centibars, the contact between the sensor and the soil can be lost. The soil starts to shrink away from the sensor. If the irrigation only partially re-wets the soil (soil suction above 40 centibars), it will not fully re-wet the sensor and may result in continued high readings. Fully rewetting the soil and sensor usually restores the contact. This is most often seen on heavier soils during peak crop water demand periods when irrigation may not be sufficient. Plotting your readings on a chart provides the best indication of this type of behavior.

MANAGEMENT — The key element in proper soil moisture measurement is the operator. Taking the time to properly read your sensors will give you a vivid picture of what is happening with the soil moisture down in the root system of your crop. Usually 2–3 readings between irrigations is sufficient. Plotting these readings onto a chart for each sensing station creates soil moisture curves, which show you exactly how quickly (or slowly) your soil moisture is being depleted.

Just as a thermostat in your home guides you in maintaining the desired temperature, the WATERMARK readings guide you in maintaining desired soil moisture content. And just as you need to know when and how much fuel is needed to keep a safe reserve on hand to meet varying climatic conditions, it is necessary to know when and how much to irrigate to maintain soil moisture content within the desired range. This requires planning irrigations in advance, based on seasonal use in the past.

The WATERMARK charts provide the simplest method of keeping records for this purpose. Special pocket size chart forms are included with each WATERMARK meter. Readings are plotted directly in the field. The resulting curves give a picture of the rapidly fluctuating soil moisture conditions throughout the root zone, in each section, that can be visualized in no other way. "Rate of

change" may be the best indicator of WHEN to irrigate. That is, if the reading increases 10-15 centibars (kPa) in just a few days, the soil is drying rapidly. Thus the charts provide a complete original record with an absolute minimum of clerical work. Projecting the seasonal curves for each section makes it easy for the grower, or executive in charge of larger operations, to plan irrigations in advance. Reference to past charts makes it possible to maintain the most desirable soil moisture content in each section year after year. The charts are a very important factor in WATERMARK irrigation control, and it is strongly recommended that they be kept up to date. The charts are also useful to keep rainfall information, fertilizer applications and unusual weather conditions posted with moisture readings for future reference.

Use the following readings as a general guideline:

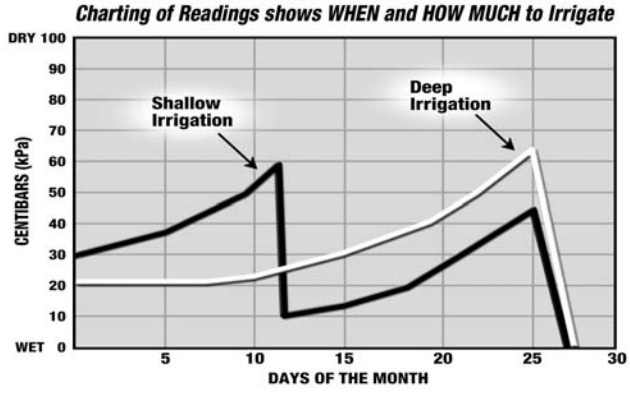
- 0 – 10 centibars = Saturated soil
- 10 – 30 centibars = Soil is adequately wet
  (except coarse sands, which are beginning to lose water)
- 30 – 60 centibars = Usual range for irrigation (most soils)
- 60 – 100 centibars = Usual range for irrigation in heavy clay soils
- 100 – 200 centibars = Soil is becoming dangerously dry for
  maximum production. Proceed with caution!

Your own situation may be unique because of differences in crop, soils and climate. Perhaps the most important soil moisture reading is the difference between today's reading and that of 3 – 5 days ago. That is to say, how quickly is the reading going up? A slow increase means the soil is drying out slowly. But a big jump means the soil is losing water very rapidly. This tells you **WHEN** to irrigate (see chart bel

By using sensors at two or more depths in the root system, you soon learn **HOW MUCH** water to apply. If the shallow sensor shows a rapidly increasing reading, but the deep sensor shows adequate moisture, you can run a short irrigation cycle as you only need to replenish the shallow root profile. If the deep sensor also shows a dry condition, then a longer irrigation cycle is needed to fully re-wet the entire root zone. The readings you take after an irrigation or rainfall event will show you exactly how effective that water application really was.

Your own experience and management will soon point you in the proper direction. You will be practicing "irrigation to need" with the expected positive results that come from any good management program.

INTERPRETATION — Wetting soil might be compared to wetting a sponge. The sponge will hold only so much water and will absorb that water in a few seconds. Holding it under the faucet for an hour will neither cause it to absorb more water nor hold that water longer. Various soils take longer to absorb



water but the same principle applies. Any excess water applied is wasted by deep percolation or run-off. By far the greatest waste is usually due to percolation because this loss is not visible.

Probably the greatest saving in water affected by WATERMARK control results from saving unnecessary and excessively heavy irrigations. Most growers find that they had previously been holding certain sections "under the faucet" far longer than necessary at times, while other sections may have been short of water. Correcting these conditions – using water where, when and in the amount needed – often results in surprisingly large net savings of water at the end of the year. However,

it is not unusual to find that more water is required, in some sections, during some periods.

In soils where there is a very slow rate of infiltration, seepage to the level of the "deep" sensor may take two or three days. The drop in readings will be delayed accordingly. Under these conditions, a substantial saving in water can be effected by applying half the water used previously and waiting to see whether this brings readings on the "deep" sensor down to field capacity, instead of continuing to irrigate right up to the time that penetration is registered. Experience over two or three irrigation cycles will indicate the minimum amount of water required to ensure penetration to the lower root zone. Also, there can be water savings if irrigations start while there is still considerable moisture in the soil. Water penetrates moist soil much more rapidly than dry soil, so less water is required to infiltrate to the lower root zone.

It is usually found that readings on the "shallow" sensor rise much faster than on the "deep" sensor, due to the higher plant use of water in the feeder root zone and to surface evaporation. If readings on the "deep" sensor indicate that there is adequate soil moisture at this level, water is saved by applying only enough water to bring down the readings on the "shallow" sensors. Under some conditions, water is saved by irrigating alternate furrows, during at least part of the irrigation season. In hillside plantings, sensors placed at upper and lower locations frequently indicate unsuspected run-off or subsoil drainage. Radical reduction or even discontinuance of irrigations in the lower sections during some periods often results in material saving in water and at the same time maintains better soil moisture content for crop growth.

In soils containing rock or gravel, frequent soil sampling is often either impractical or the cost is prohibitive, yet these are the soils where irrigation control is needed most. They dry out quickly in hot weather and to ensure adequate moisture, much water is often wasted to deep percolation by "guesswork" irrigation. Charting WATERMARK readings frequently – even daily – often results in material water savings and in better soil moisture conditions for plant growth.

In many cases, the value of WATERMARK control goes far beyond cash savings on the monthly water bill. It makes a limited supply of water go farther and thus saves the investment required for developing new sources of supply.

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Irrigation Association Bronze Member

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