HydroServices
A DIVISION OF AQUALINC

Wireless Soil Moisture Monitoring — Making Good Use of Soil Moisture Sensors

Measurement and monitoring of soil moisture is becoming the norm and in some regions a regulatory requirement for irrigation management – to demonstrate timely management, to demonstrate efficiency and to quantify drainage.

Not all sensors are the same, so **how do you** choose and get the best from sensors?

There are many companies making soil moisture sensors to measure volumetric water content (V%). Almost all measure the soil's dielectric constant with capacitance or frequency domain technology. All of the sensors are sensitive to soil temperature and salinity (conductivity). The best filter and/or correct the signal to minimise the effect of salinity, temperature and texture on the measurement of V%. Temperature and conductivity are simple to measure (easier than soil moisture), but the relationship with V% is complex.

What sensor is best?

Before buying any sensor or array of sensors consider:

1. **What are you growing** – pasture or crops or trees/vines and how deep are the roots?
   - Pasture has a shallow root depth and is a "permanent" crop
   - Crops will have shallow, deeper and deep root depth and are temporary mostly annual
   - Trees and vines have deep and very deep root depth and are permanent

2. **How deep is your soil** (A and B horizons) and do you have stony soils?
   Sensors need to measure in discrete horizons — both the A and B horizons.

   The A-horizon (the dark topsoil) contains most of the roots, nearly all of the available nutrients and often a high proportion of the available moisture. This is the key zone to measure soil moisture.

   The B-horizon (mostly yellow brown silt or silty clay or silty/sandy gravels) are relatively unweathered and contain little in the way of nutrients for plant growth. A B-horizon that does not consist of a high proportion of stones will have water available for plant growth.

   The depth to gravel sub-soil (common on the alluvial flood plains of Canterbury, Hawkes Bay, Wairarapa and other areas of NZ) is an important characteristic to measure. The depth of soil above the gravel is where most of the roots will be found, will supply all of the nutrients and contain about 80% of the available water for plant growth.

3. **What do you need the sensor to measure?**
   MOST OF ALL the sensor needs to measure or output volumetric content (% or mm). Note V% is simply mm/100mm of soil depth. It is important to have measurements in V% or mm (or converted to mm depending on the depth sampled by the sensor) to compare and understand evapo-transpiration (mm abstracted by the plant from the soil), rainfall (measured in mm) and irrigation (measured in mm).

Considering the points above, dielectric type sensors are most suited for:

- Soil moisture measurement for pasture irrigation management;
- Soil moisture measurement in shallow rooted semi-permanent crop irrigation management; and
- Soil moisture measurement for waste water and effluent irrigation management;

Most dielectric type sensors also measure temperature and conductivity. Soil temperature is an especially valuable measure in the A-horizon – the 10cm depth soil temperature at 9am is a key parameter driving crop production modelling and nutrient availability. For example:

- If soil temperature is below 10°C, there is little value to be gained from irrigation; and
- Nitrification ceases below 4.5°C, the optimum is 15.5 - 38°C and is not limited above about 24°C.

Conductivity is of interest, especially if there is potential to concentrate salts in the topsoil; e.g. in central Otago.

How many sensors are needed and where?

Ideally measurement of soil moisture (no matter the sensor) should be:

- At more than one depth to ensure the root zone is measured and preferably (if not essentially) below the root zone. Below the root zone is important to quantify drainage to "ground-truth" the Overseer model.
- At more than one site or location to account for variations in soil type (not different soil types but minor variations), variability of crop growth and the variability of rainfall and/or irrigation.
- At sequential depths rather than discrete depths; that is 0-20cm, 20-30cm, 30-40cm etc. rather than 0-20cm and not at 0-20cm but not again till 50-60cm.
- Capable of recording the measurements

Which sensor is best?

There are many soil moisture sensors on the market. HydroServices has tested and had experience with many of them. HydroServices experience would recommend one of:

1. **Acclima**
    - Digital Time Domain Reflectometry
    - Reads volumetric water content
    - Reads soil temperature
    - Reads soil conductivity
    - Accurate in all soil conditions
    - 100 ml soil sample volume
    - No maintenance, simple installation
    - Sturdy construction
    - Moisture readings remain stable as soil salinity changes
    - Moisture readings remain stable as soil temperature changes

2. **Aquaflex**

- Digital similar to Time Domain Reflectometry
- Reads volumetric water content
- Reads soil temperature
- Reads soil conductivity
- Accurate in all soil conditions
- 6000 ml soil sample volume
- No maintenance, simple installation
- Sturdy construction
- Moisture readings remain stable as soil salinity changes

3. **Decagon Sensors**

- Analogue 10HS, digital 5TM & 5TE
- Read soil temperature (5TM & 5TE)
- Read soil conductivity (5TM & 5TE)
- Accurate in all soil conditions
- 30 ml soil sample volume (5TM & 5TE), 1000ml (10HS)
- No maintenance, simple installation
- Sturdy construction
- Moisture readings remain stable as soil salinity changes (5TM & 5TE)

The manufacturers state the sensors are be easy to install, robust, accurate in all soil conditions reading V% and require no maintenance. If high quality data is required, HydroServices experience is:

- Sensors are not easy to install and require very careful site selection and installation;
- Sensors are robust and there are very few failures (other than mechanical damage);
- Sensor sites require regular maintenance, especially in pasture that might become pugged or worn around the sensor location;
- Sensors do not read actual V%; i.e. the V% if a definitive gravimetric sample is taken to field compare or calibrate the sensor.

The key to high quality data is site selection, installation and field calibration.