Readily Available Water and Neutron Probe Deficit

The explanation of the difference in readily available soil water (RAW) as determined in a laboratory and the deficit (Full - Refill Points) as indicated by the neutron probe in the field is commonly asked by farmers working closely with scientists. In essence it is a question of a field versus laboratory determination of available soil moisture. In other words what is actually happening in the field versus what is predicted from laboratory based experiments. The important outcome of this situation should be that the farmer uses the product he is selling ie the apple, grape etc as the ultimate criteria for irrigation decision making. The soil moisture measurement simply has to be repeatable in order to be able to project forward an irrigation date and amount that will produce a desirable plant response in market terms.

Calculation of The Deficit from Neutron Probe Readings.

The depth graph in Figure 1. demonstrates the calculation of Full Point (FP) and Refill Point (RP). These example values of FP (0-70cm) 227mm and RP (0-70cm) 205mm are simply integrations of the area under the curves from the measured VSW% to Zero VSW% for each depth. This is set out in greater detail in ICT Application Note 314. From the example shown in Figure 1. the deficit is the difference between FP and RP, in this instance is 22mm for Farm 4 (corresponding to Table 1).

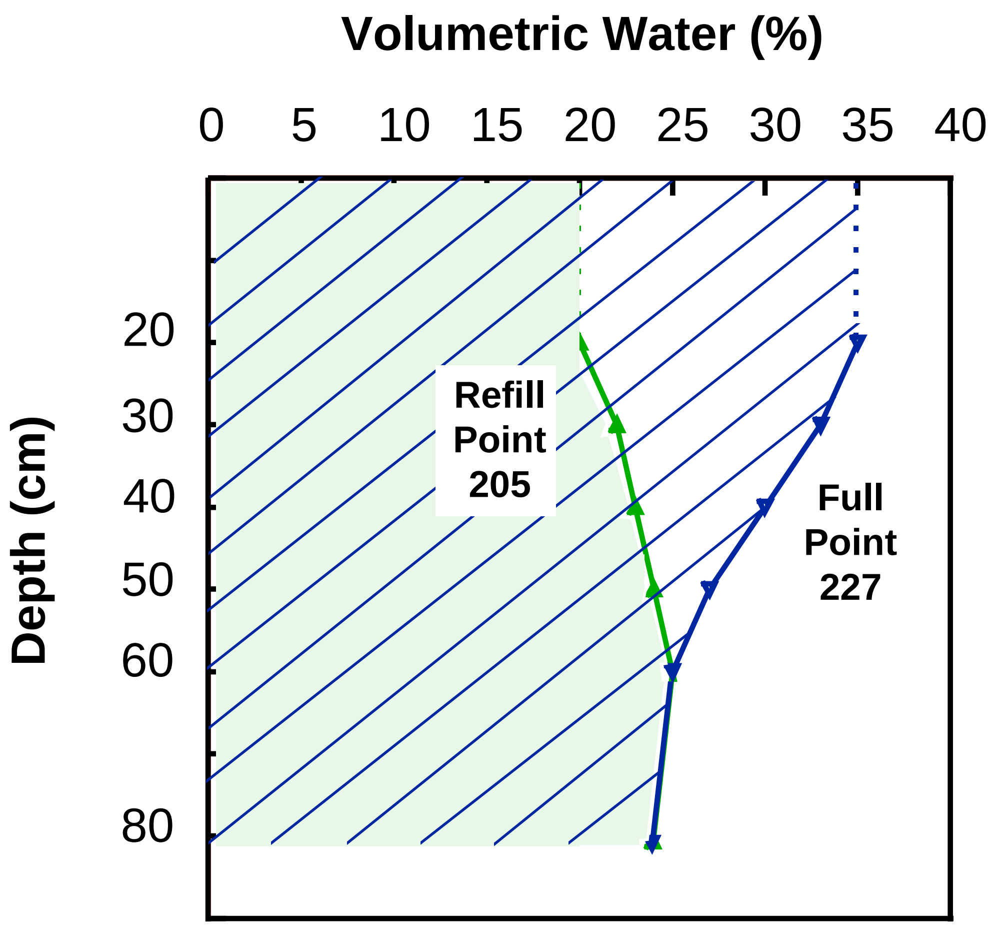

Figure 1. Full and Refill point determined by Neutron Probe Measurement.

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Calculation of The Deficit from Neutron Probe Readings

- the Effect of Calibration Slope.

The calibration converting neutron counts to VSW% is linear and the slope of this calibration is independent of soil type as shown in Figure 2. In other words for a given change in recorded counts there is a given change in VSW% irrespective of the soil type being measured or the soil moisture content at the time of measurement.

ICT has found consistent agreement around the world, independent soil type, relating accurately recorded irrigation and rainfall amounts to changes in the deficit from neutron probe readings taken before and after irrigation and rainfall events.

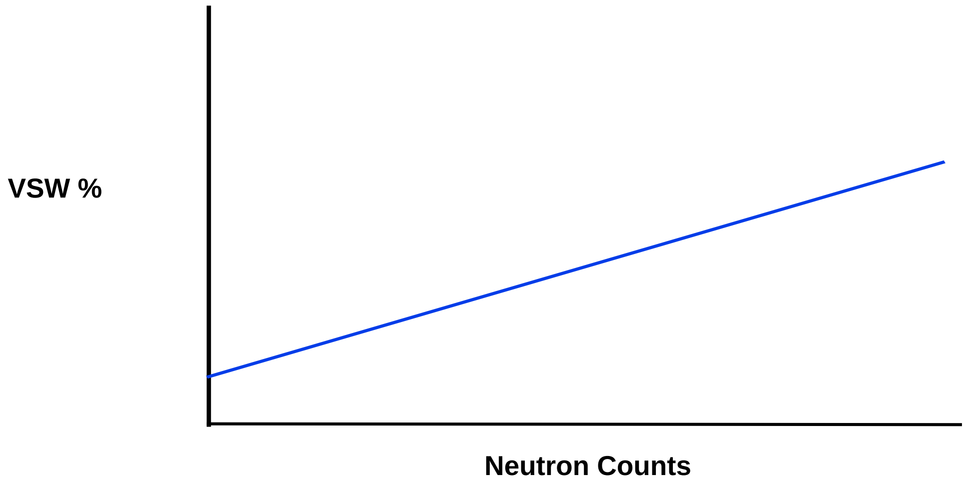

Figure 2. Calibration of neutron counts versus VSW%.

Calculation of Full Point and Refill Point from Neutron Probe Readings
- the Effect of Calibration Intercept.

ICT provides a single intercept for all neutron probe calibrations, thus enabling direct comparison of varying soil texture using the neutron probe. Figure 3. illustrates moisture content measured in a clay soil with a sand lens (at 50cm depth) versus a uniform loam soil profile. When neutron probe readings were taken both soils were at FP. The textures can be determined because a single calibration (slope and intercept) is used in both instances. The clay soil has a higher VSW% as determined by the neutron probe because of a relatively greater hydrogen content in the clay lattice than the loam soil. In practice in the field a clay soil will also have a higher VSW% when sampled gravimetrically than a loam soil at the same tension.

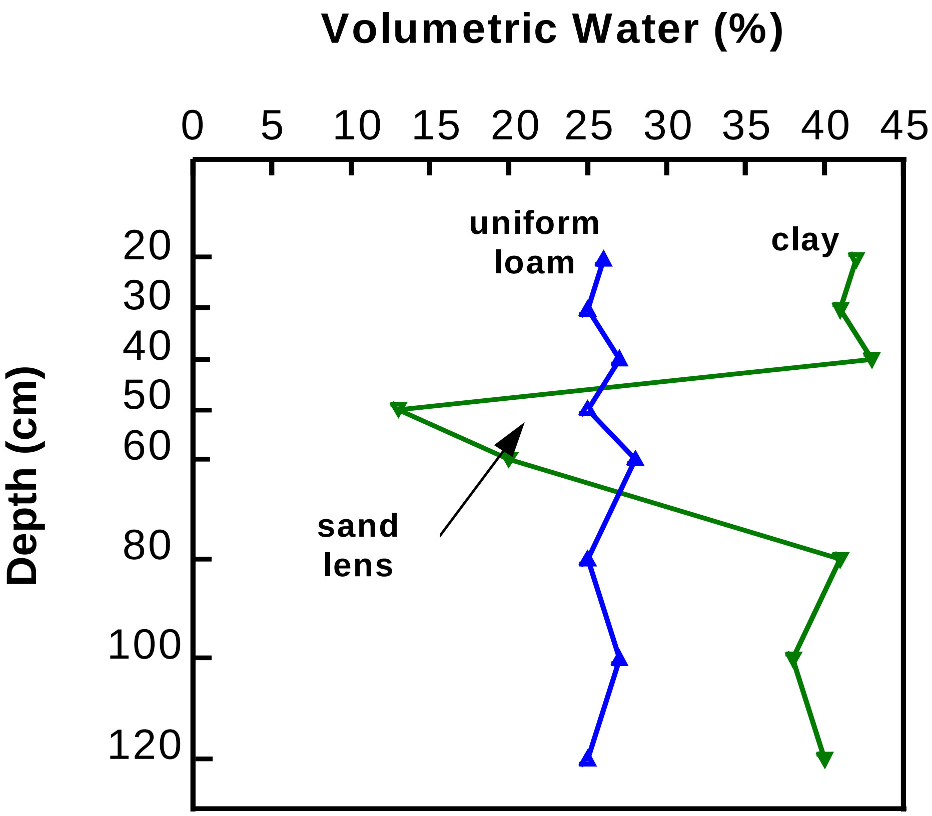

Figure 3. Soil texture as determined by the neutron probe.

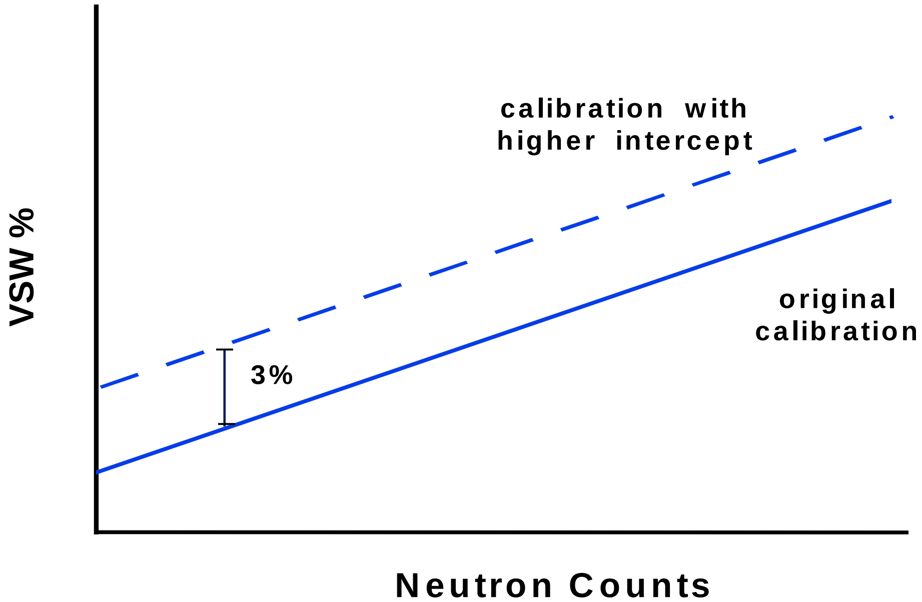

Figure 4. Effect of changing intercept for neutron probe calibration.

Figure (4) illustrates the linear calibration with a higher intercept than in Figure (2). Changing this intercept simply has the effect of changing the position of the FP and RP when plotted on a depth graph. The deficit however will remain constant as the slope of this linear calibration is independent of soil type. In this example increasing the intercept by a VSW% of 3% would add

21.0mm to the totals of 0-70cm (See ICT Application Note 307). From Table (1) Farm 4 the FP (0-70cm) of 227mm in field 2A would become 248mm and the RP (0-70cm) of 205mm would become 226mm. The deficit of 22mm remains constant, as shown in Figure 5. In conclusion changing the intercept will have no effect on the deficit, daily water use and the timing and amount of irrigation as determined from neutron probe measurements.

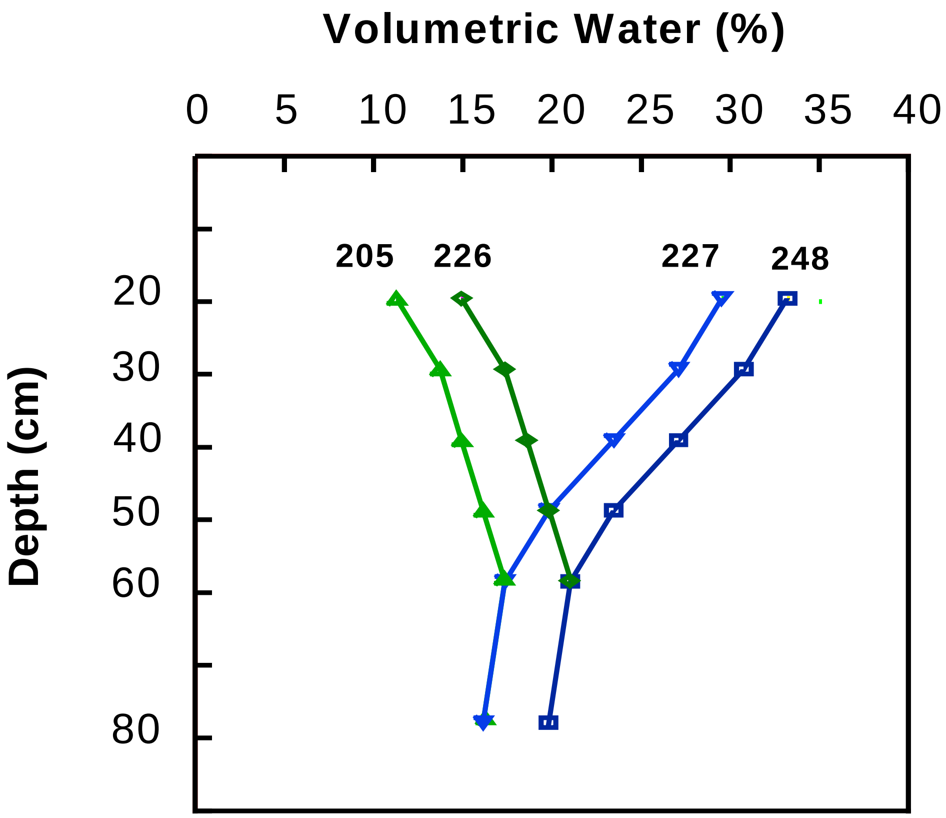

Figure 5. Shift in Full and Refill point due to increase in calibration intercept.

Calculation of RAW from Laboratory Determination

In determining RAW in a laboratory a soil moisture tension for FP and RP are allocated and measured. This is often 10 kPa and 100 kPa respectively. Soil samples are taken from the field and may either be "undisturbed" or dried and ground to yield a uniform sample. The VSW% at these soil moisture tensions are then determined using pressure plate apparatus for each major soil texture in the soil profile.

Observing Farm 4 a RAW of 69mm is calculated as the difference between the VSW% at 10 kPa and 100 kPa for 0-70cm root zone. To determine percentage extraction simply divide the determined RAW by the measured value of moisture content at 10 kPa.

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		Probe (0-70cm)				Laboratory (0-70cm)			
Farm	Field	Full point	Refill point	Deficit	% extraction	10 kPa	100 kPa	RAW	% extraction
4	2A	227	205	22	9.7	210	141	69	32.8
8	7	234	217	17	7.3	254	153	59	23.2
30	V2	201	173	28	13.9	186	146	40	21.5
	V11	250	220	36	14.4	203	145	58	28.6

Table 1. Data of FP and RP determined in the field by NP versus laboratory determined RAW.

Calculation of Deficit from Neutron Probe Readings in the Field versus RAW from Laboratory Determination.

There are several reasons explaining the variation between the % extraction determined in the field and % extraction measured in the laboratory:

(1) The NP measuring an *in situ* value will relate moisture conditions around the plant roots. Laboratory determined values by their very nature are affected by the change of some physical properties of the soil sample. For example, the soil sample may be conditioned such as crushing and mixing in order to obtain good contact with ceramic plates;

(2) In the field the NP accounts for changes in soil moisture extraction due to management practices such as soil compaction from trafficking. This change in moisture content (VSW%) at the same soil tension from season to season is dynamic in nature;

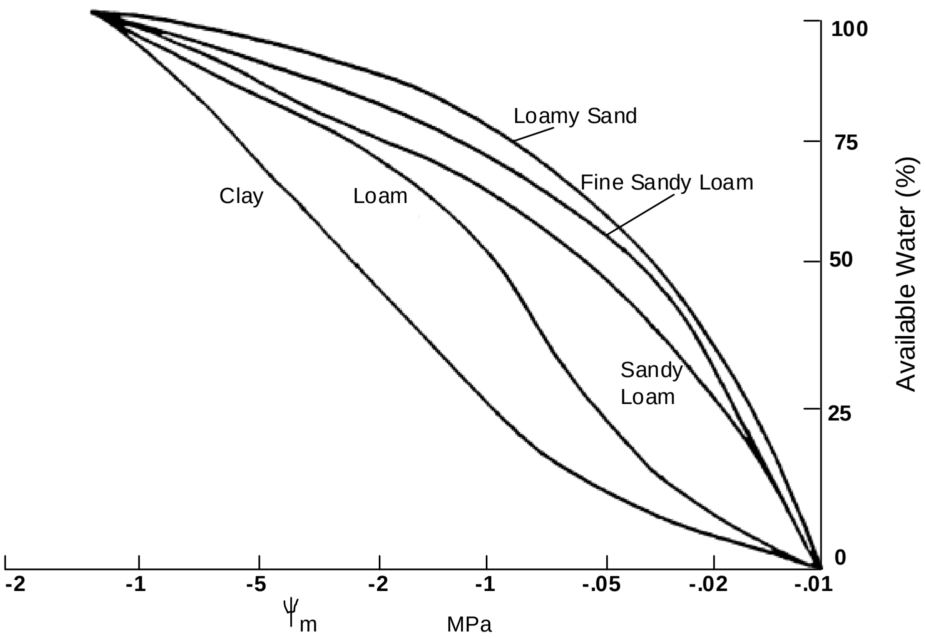

Figure 6. Soil water characteristic curves.

(3) Another consideration is the spatial variability of soil. To obtain one profile reading a sixteen second count at each depth by the NP over three aluminium tubes are read. To obtain similar results in the laboratory replication of samples at different depths is therefore required;

(4) Using the laboratory technique to measure the RAW is based on determing the energy moisture characteristic curve for a particular sample. This relationship is generally unique to a soil type and varies considerably from a clay soil to a sandy soil as shown in Figure 6. From this figure note that for a sandy loam soil a change from 3 kPa to 6 kPa will give a change in VSW of 33% to 14% respectively.

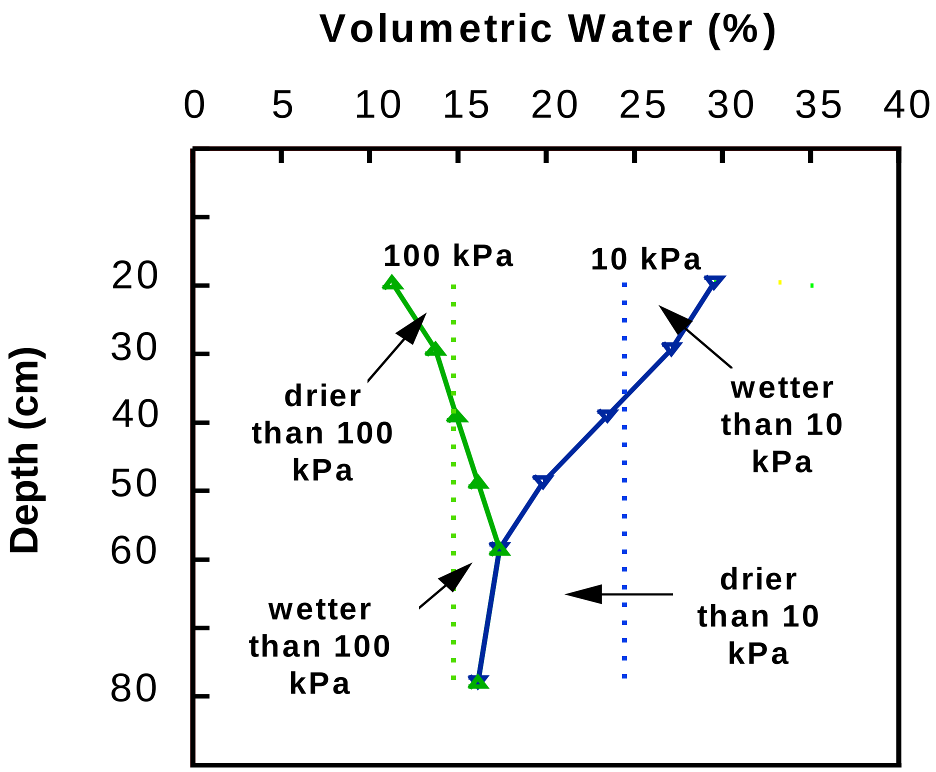

Figure 7. Determination of FP and RP with neutron probe compared to determination of RAW with laboratory derived moisture contents

The field determination of FP and RP is set with observation of the plants considered as shown in Figure 7. At FP the VSW% may not always be at a soil moisture tension of 10 kPa. Field capacity (ideally 10 kPa) is difficult to accurately determine in the field and is historically empirically defined at 12 to 48 hours after saturation depending on soil type. Using the NP a similar situation arises with the determination of RP. A standard approach to determine RP is to observe the daily water use of the plants. RP for a crop is determined from daily water use decline (accounting for atmospheric changes) as measured by the NP. The actual soil tension at corresponding depths may vary when this decline is observed. For example, the soil may be at a tension of 100 kPa near the soil surface (say 0 to 40cm) but may be at a lower tension (say 50 kPa) at a depth of 70cm. As root development is not uniform, though the water may be theoretically available, the RP may have been reached as roots cannot extract the water at depth.

Conclusion

It is far better to use the crop and product for sale ie apples as the integrated measurement of soil moisture tension for the whole soil profile. The neutron probe is simply recording the outcome of this.

The laboratory measurement of soil moisture tension is unnecessary to management. It is in fact impractical to do over a large number of monitoring sites which will be increasingly needed as management requires more site specific data in order to grow crops such as apples to an increasingly higher product specification.

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