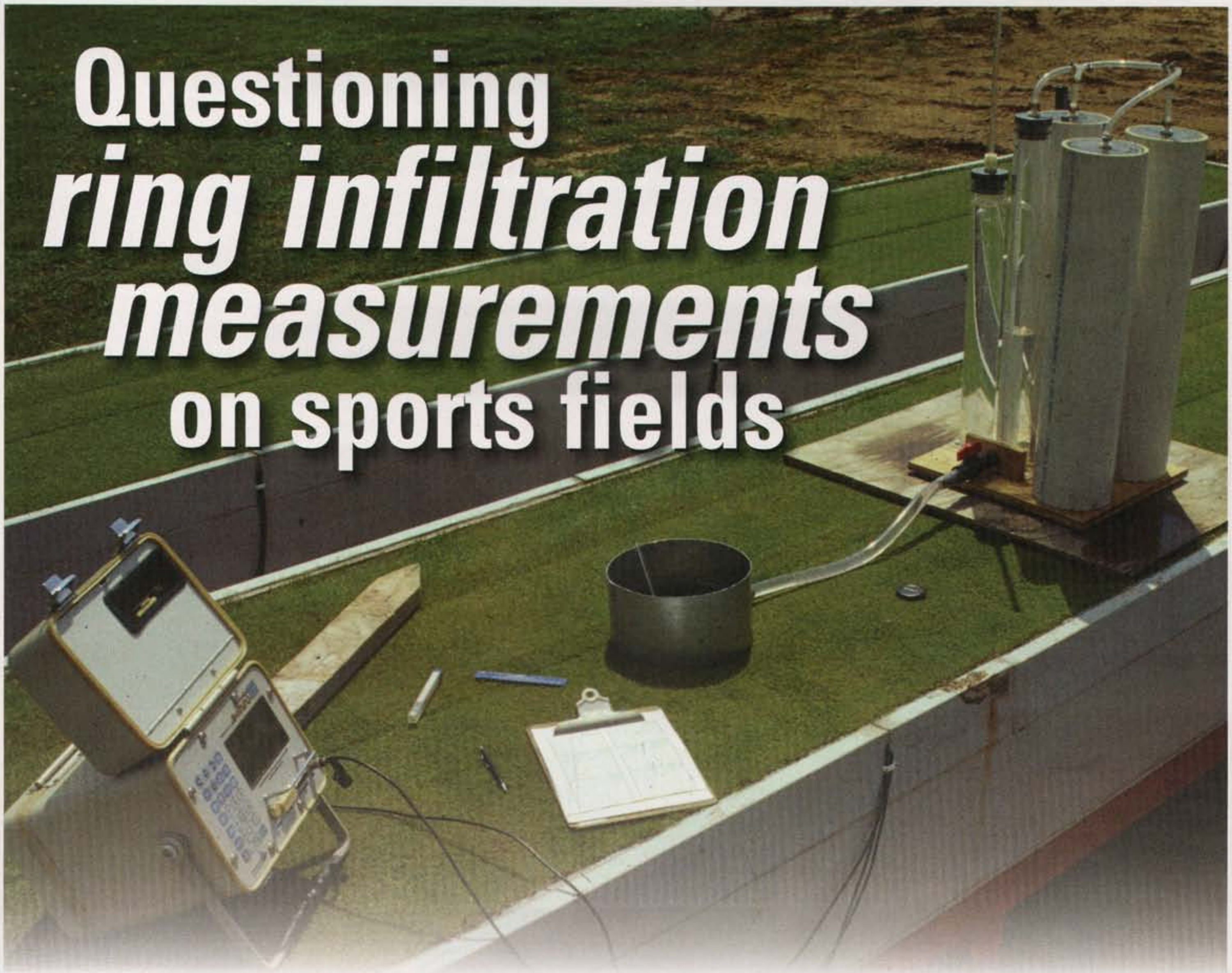

Questioning ring infiltration measurements on sports fields

By Dr. Ed McCoy

In a previous article (Prettyman & McCoy, 2003) we observed a small but significant effect on our double ring infiltration measurements of profile layering 12-inches below the surface. This got me thinking about the possible effect on ring infiltration measurements of shallower layering that may occur in some layered athletic field soils and push-up greens.

Double ring infiltration measurements have long been used in research, and more recently by athletic field managers, to determine the permeability of soils and whether water flow limitations exist. It is a relatively simple measurement and does not require sophisticated equipment, but as is generally true with simple soil physics measurements, its validity rests on satisfying certain assumptions.

The measurement is essentially conducted like this: Concentric 6-inch and 12-inch diameter rings are insert about 1-inch into the soil surface and both are provided water sufficient to maintain a shallow ponding within each ring. Following a period of equilibration that can range from 15 minutes to 8 hours, the volume rate of water entering the soil from the inner ring is measured, and knowing the surface contact area of the inner ring, the infiltration rate is determined. Similar ponding of water in the outer ring is required only to satisfy a basic assumption of the measurement, that the path of water flow within the soil below the inner ring is uniformly vertical.

To explore this issue further, I spent a weekend constructing and running a simulation model of soil water flow associated with a double ring

Top layer† Ks (cm h-1)	Bottom layer† Ks (cm h-1) 20	4	2	0.4	0.2	0.04
20	27	14	11	7	6.5	6
4		4.3	4	2.3	1.8	1.5
2			2.2	1.6	1.3	1.0
0.4				0.43	0.4	0.3
0.2					0.2	0.2
0.04						0.04

† The top layer was 4-inches thick and the bottom layer was 20-inches thick.

Table 1

infiltration measurement. The simulation model I used has widely been proven as a valid tool to investigate water flow and the simulation approach allowed me to investigate a wide range of soil layering situations.

The essential results of this study are listed in Table 1 where observed infiltration rates are given for a range of soil layering situations. Reading across, the results show that whereas the infiltration rates decline, they do not show nearly the reduction as the corresponding bottom layer permeability; when in fact it is this lower layer permeability that should control the double ring infiltration process. Consider for example, the scenario with a top layer permeability of 20 cm h-1 and the bottom layer permeability of 0.2 cm h-1. In this case, the infiltration rate should be comparable to the most flow limiting layer and have a value near 0.2 cm h-1. Yet the observed infiltration rate of 6.5 cm h-1 was over 32 times greater.

Table 1. Infiltration rates (cm h-1) from the inner ring of an infiltrometer as a function of soil layer permeability (Ks). The top layer and bottom layer Ks values correspond to those expected of a sandy root zone, a sandy loam soil, a silt loam soil, a clay loam soil, and a silty clay loam soil; respectively. Values are only given for the situation where a coarser textured soil overlays the same or a finer textured soil, and values on the diagonal are for the same soil within both layers.

The top layer was 4-inches thick and the bottom layer was 20-inches thick.

Also notice that the deviation between the observed and the expected infiltration rates increase as the contrast between the individual layers increases. Yet even when the permeability difference between the layers is as little as 5-fold, the observed infiltration rate is four times greater than expected.

The explanation for inaccuracy of double ring infiltration measurements in layered soils comes from examining the water flow paths within the soil beneath the infiltrometer rings (Figure 1). Because of the proximity of the flow limiting lower layer to the ground surface, the flow paths within the soil below the inner ring are not vertical but curve laterally. This violates a basic assumption of the measurement; and the measured infiltration rate from this scenario would more reflect the resistance to radial outward flow within the top layer than the permeability of the bottom layer.

Figure 1. The paths of water flow as a function of radial distance from the center of a double ring infiltrometer and depth in the soil. The region

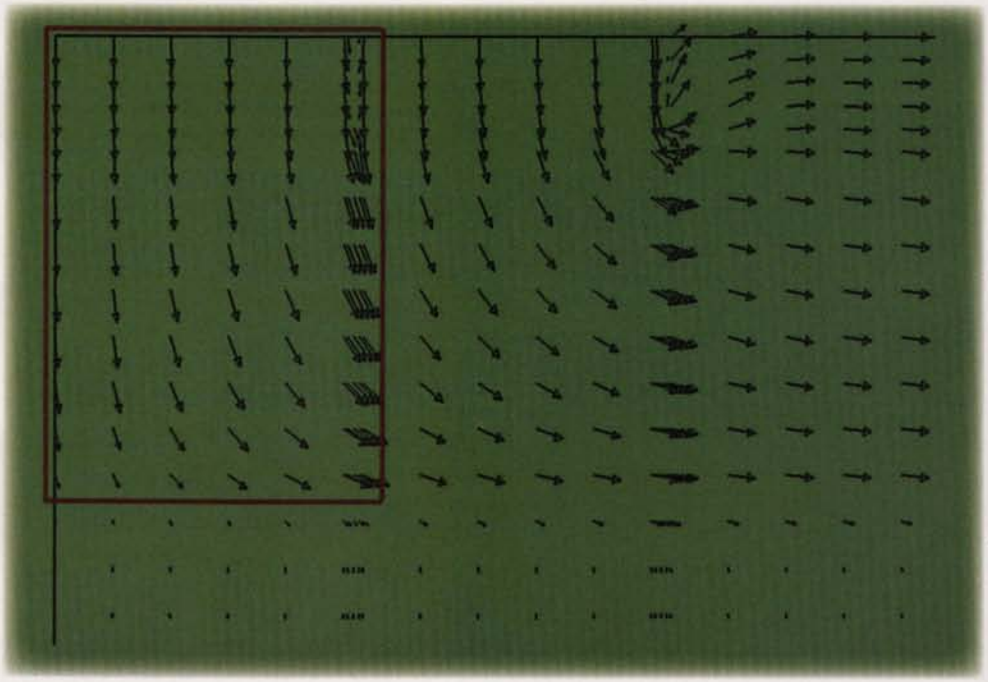

Figure 1

The measurement validity is questionable when the layer interface is near to the ground surface.

outlined in red is the soil of the top layer within the radius of the inner ring. The scenario of this view is a sandy root zone top layer with permeability of 20 cm h-1 and a clay loam bottom layer with permeability of 0.2 cm h-1. Also, this view corresponds to 2 hours following the start of the measurement when infiltration rates were acceptably close to equilibrium.

Thus, one has to question the validity of double ring infiltration measurements in layered soils, and particularly so when the layer interface is near to the ground surface.

The double ring infiltration technique is an example of an unconfined measurement because flow paths within the soil are not limited to any particular direction. Confined measurements methods are those that restrict the flow paths to a specific (usually vertical) direction.

I also conducted a separate, layered soil simulation where flow was confined to only occur vertically, and infiltration rates were, as expected, comparable to the permeability of the bottom and most limiting layer. An example of a confined measurement approach is that commonly used when working with a testing lab. In this case, an undisturbed core confined within the sampling tube is taken from the green or athletic field and sent to the lab for measurement. The results from the confined infiltration rate measurement in the lab are a valid representation of the soil permeability regardless of any soil layering.

This analysis demonstrates that in addition to being a poor method to measure the permeability of layered soils, it is also a poor method to assess the influence of spaced-apart drainage elements placed in greens or athletic fields having shallow soil layering. ■

Reference:

Prettyman, G.W. and E.L. McCoy. 2003. Profile layering, root zone permeability and slope affect on soil water content during putting green drainage. Crop Sci. 43:985-994.

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John Mascaro's Photo Quiz

Can you identify this sports turf problem?

Problem:
Torn up grass on baseball infield

Turfgrass Area:
FirstEnergy Stadium

Location: Reading, PA

Grass Variety: Kentucky Bluegrass

Answer to John Mascaro's Photo Quiz on page 45

John Mascaro is President of Turf-Tec International