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Hydrology and Hydrogeology Condition of a Small Catchment of Glacial Till, Soil Content Using a Neutron Probe

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ABSTRACT: To measure the soil water content in sand and clay areas of glacial till, to determine differences in hydrological and hydrogeological behaviour between these areas. Soil water content may through light on patterns of recharge and discharge of water and so provide corroborative evidence for interpretations reached based on analysis of these measurements.

The hydrographs of soil water content for the sand and clay areas shown similarities in behaviour and shown significant difference between variations of soil water status between sand and clay areas.

The similarities, is that soil water content declines at all the sites through the summer period in response to the changing balance of rainfall and evaporation, decline markedly with depth below the surface in both sandy and clay areas. The most significant difference perhaps is the much smaller overall decline of water content through the summer at the sand site.

KEY WORDS: Hydrology, Hydrogeology, Soil, Glacial Till,Neutron Probe

I. INTRODUCTION

Access tubes installed in the instrument transects and sub-catchments facilitated neutron probe (Fig. 1) measurement of soil water content in the sand and clay areas during the summer. In this work measurements of sub-surface storage changes in both saturated and unsaturated conditions weremade along sample transects in sub-catchments selected to represent sand/gravel and clay (Fig. 2 and 3).

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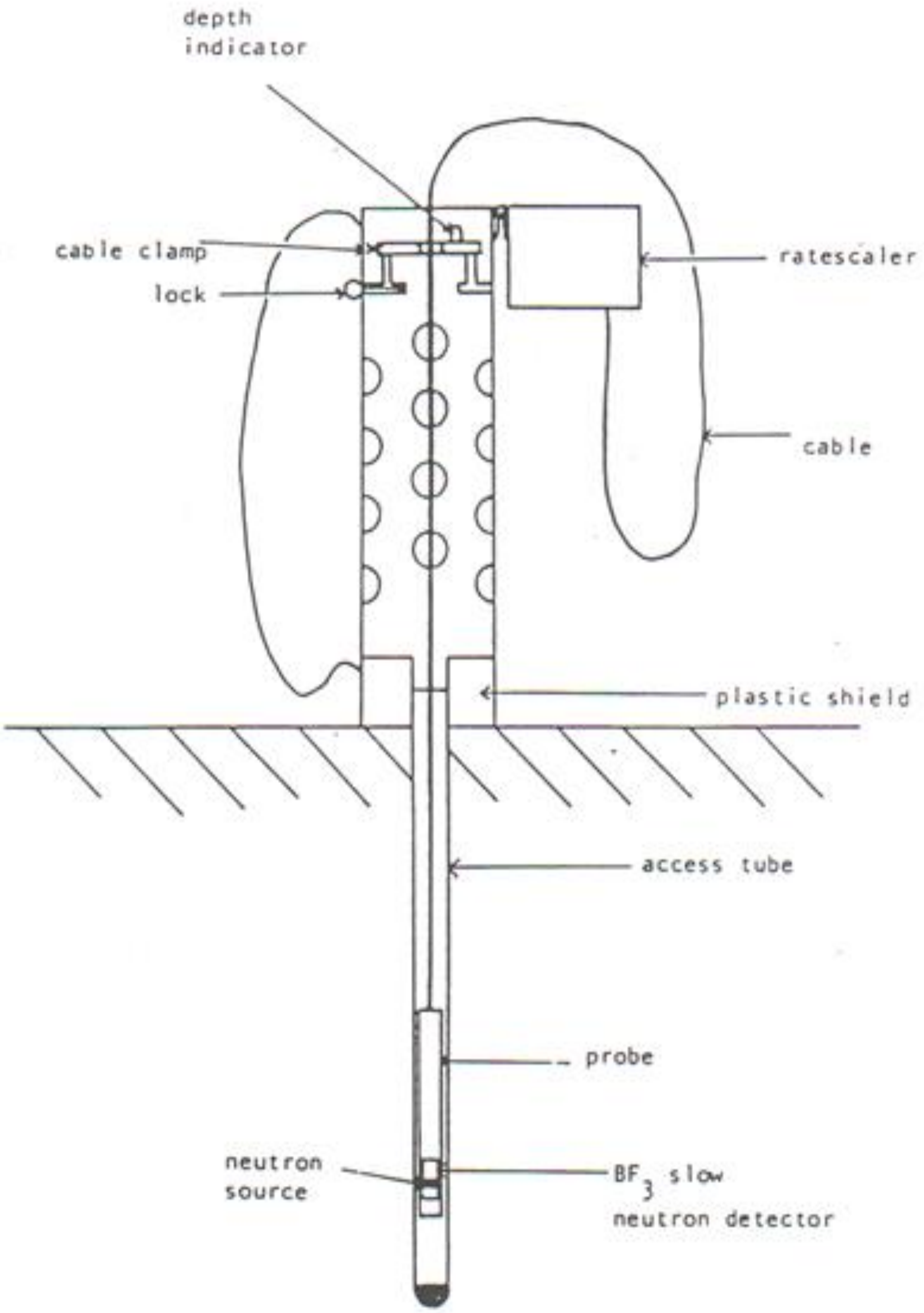

Fig.1 Sketch diagram of the Wallingford neutron probe

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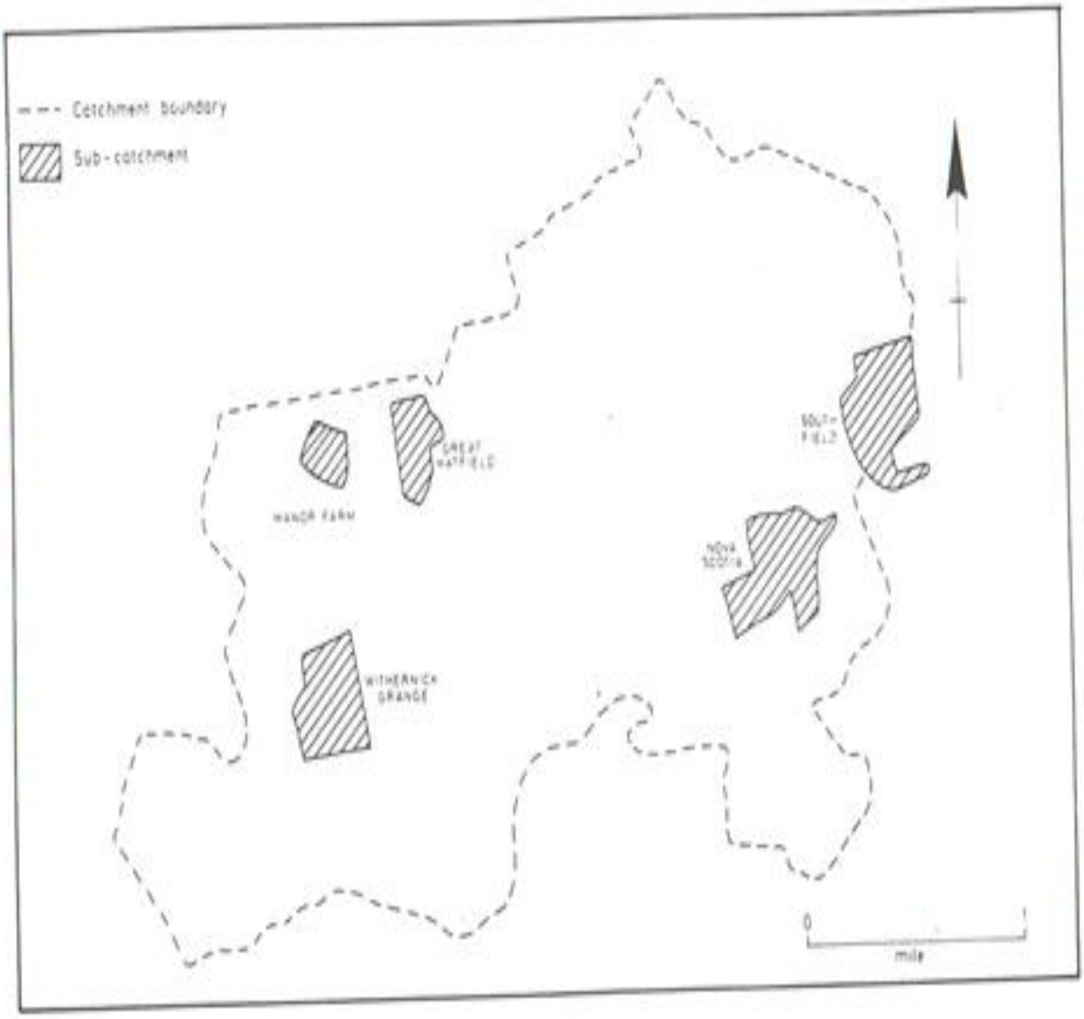

Fig.2 The sub-catchments.

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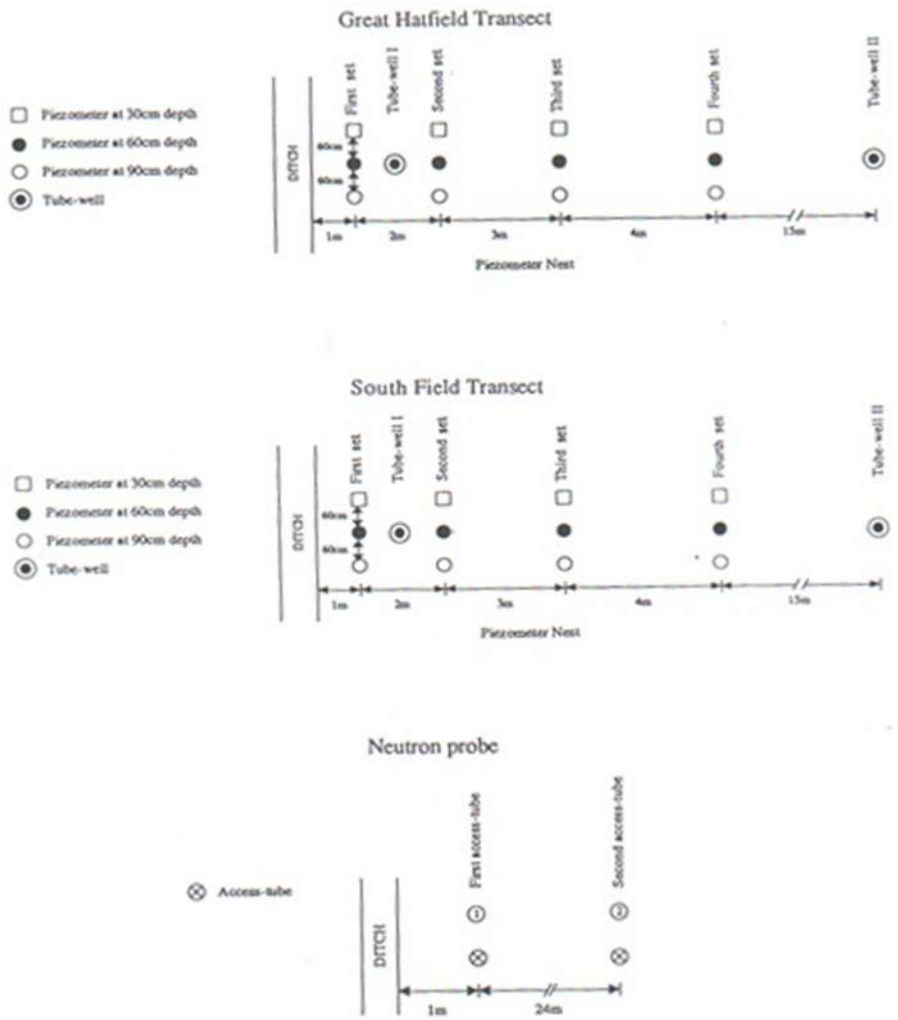

Fig.3 Plan of transects of tube-wells, piezometers, and access-tubes at Great Hatfield and South Field.

In this way it was hoped that the hydraulic gradient and flow patterns which resulted in low flow discharges could be more fully explained and differences in the hydrological and hydrogeological character of sub-catchments will be reflected not only in measurable differences in surface water conditions but also in differences in sub-surface water conditions.

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Although these are capable of measurement, they are sometimes more difficult to determine and often more difficult to interpret. In terms of the persistence of flow during dry weather conditions, it is the variation of sub-surface water storage which it is most helpful to determine.

Soil is an important factor in low flow studies since it holds water in periods of high flow and release it in low flow periods (Vladimirov, 1976). Water dynamics in soil are governed by many factors that change vertically with depth, laterally across landforms and temporally in response to climate (Swarowsky, et al., 2011).

II. LITERATURE SURVEY

The rate at which water is transmitted through soil depends on its texture, the antecedent soil moisture conditions and the imposed flux of water (Price and Banner, 1984). Hodnett and Bell (1986) stressed the role of macropores in a swelling clay soil, especially in increasing infiltration and helping to reduce the incidence of overland flow. Water flowing down macrofissures will bypass, and so fail to wet, the soil matrix and this may mean that less water is available in the surface layers for plants. Macropore flow may thus allow deep percolation and recharge to ground water, even if the overlying soil is dry. There is relationship between soil moisture storage, soil water flow, and soil properties (O̍Green, 2013). The at which redoximorphic features occur is used to describe the extent of saturated conditions within a soil profile (Jacobs et al., 2002).

Agricultural practices have a widespread effect on soil water conditions. Agricultural drainage schemes, for example, comprising ditches or sub-surface pipes may greatly increase the hydraulic gradient. Comer and Zimmermann (1969) associated reduced base flow in a glacial till catchment with the widespread occurrence of fragipan soils that prevent deep infiltration, and retain water in the surface horizons, thereby reducing storage for additional moisture.

Two well known physical features of sandy soils are their coarse texture and their high rate of permeability (Stanford, et al., 2005a). Sandy soils have high infiltration rates varying for sandy clay and sandy loam from 4 to 25 cm/h, but in very permeable sandy soils values as high as 100 to 400 cm/h are easily reached.
The most suitable soils are clay or clay-loamy soils with permeability equal to or less than 0.5 cm/h (Gerba, 2005; Steenhuis and Walter, 2005).

III. VARIATIONS OF SOIL WATER CONTENT

In the context of determining differences in hydrological behaviour between these areas, such soil water data may shed further light on patterns of recharge and discharge of water and so provide corroborative evidence for interpretations reached based on the analysis of the main body of comparative data in this work.
Representative hydrographs of soil water content are show in Fig. 4, 5 and 6 for sites in the Nova scotia, South Field and great Hatfield sub-catchments. Although there are similarities in behaviour, there appear also to be significant differences between the variations of soil water status between the sand and clay areas.

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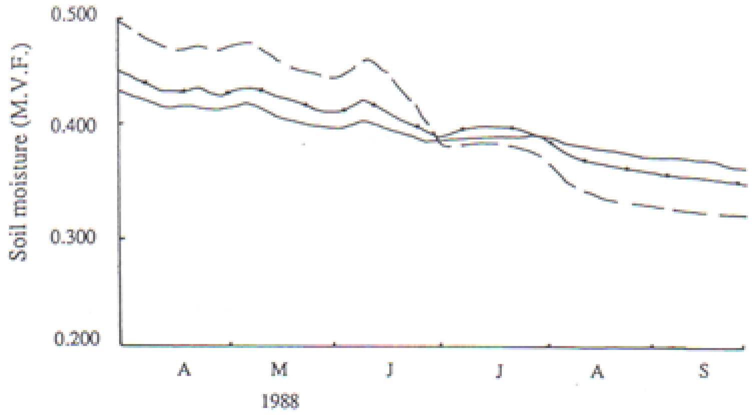

Fig.4 Soil water content, Nova Scotia (site 4, access tube 2),

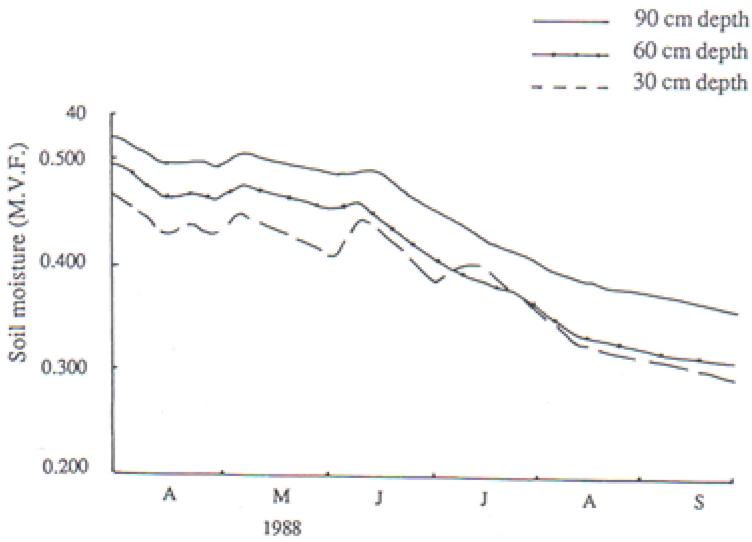

Fig.5 Soil water content, South Field (site 5, access tube 2),

The similarities, as would be expected, are best exemplified by the fact that soil water content declines at all three sites through the summer period, and that the temporal fluctuations of water content in response to the changing balance of rainfall and evaporation, decline markedly with depth below the surface in both sand and clay.

Perhaps the most significant difference is the much smaller overall decline of water content through the summer at the sand site, especially at the 90 cm depth. At Great Hatfield this amounted to 7.7% (mvf) and at South Field 14.4% (mvf) for all access tubes between March and September. When data for the Manor Farm and Nova Scotia sub-catchments are included the average decline of soil water content in the sand areas between these two dates was 5.9% and in the clay areas 10.6%.

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These data broadly support the view that, in the sand areas, the prolonged occurrence of a shallow water table close to the ground surface permitted continuing replenishment of soil water, despite high potential surface evaporation losses, throughout the summer period. In the clay areas on the other hand the depth to water tables increased and the effectiveness of upward capillary movement to the soil layer diminished through the summer.

IV. CONCLUSION

Soil water values, derived from neutron probe measurements at the sand and clay transects, provided some further insight into differences of sub-surface water movement in the two areas. Of significance was the fact that, at the 90 cm depth, the decline of soil water content through the summer was much smaller in the sand areas (5.9%) than in the clay areas (10,6%). This suggests that the prolonged occurrence of shallow water tables in the sand areas permitted continuing replenishment of soil water, despite high evaporation rate losses, while in the clay areas, as water levels declined, the effect of upward capillary movement to the soil diminished through the drier periods.

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