OCCURRENCE OF PERCHED SATURATION AND INTERFLOW OVER AN ARGILLIC HORIZON IN A LOW RELIEF HILLSLOPE

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REFERENCE: *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27–29, 2007, at the University of Georgia.

Abstract. Many of the soils in the southeastern US are characterized by an argillic, or clay horizon, that largely parallels the soil surface at depths ranging from a few centimeters to 100 centimeters. The degree to which these argillic horizons alter subsurface movement of infiltrated water is not well known. Interflow, or throughflow, is shallow lateral subsurface flow that moves over a horizon that restricts percolation. This research investigates how often and under what conditions a relatively deep (20-150^{+}cm) argillic horizon on low slope (2-6%) hillsides causes interflow to occur. Research is being conducted at the Savannah River Site, Aiken, South Carolina, on a small zero-order watershed. In the first phase of this research, a high resolution topographic map of the clay layer was developed. This map will be used to instrument designated "low" spots with max rise piezometers in order to determine if there is channelized subsurface flow. In situ conductivities of the clay layer and the surface horizons were measured using an Amoozegar meter, and bulk density samples were taken and measured. Along with soil topographic measurements, data-logging piezometers have been installed to measure the piezometric head above, in, and below the argillic horizon to further investigate interflow as a potential hydraulic routing mechanism. The stream that drains the catchment was instrumented with a 2' H flume and data-logging pressure transducer to measure stream flow. Climate data including precipitation, barometric pressure and temperature, are being continuously collected in an open area approximately ¼ mile from the study site. Combining the shallow surface and subsurface piezometric heads with stream flow rates, we should be able to determine if and when the clay layer is contributing to interflow.

INTRODUCTION

While it is widely known that interflow cannot occur unless there is an impermeable or semi-impermeable layer in a sloping soil (Jackson, 1992), little research has been done to give insight on how the topography of the subsoil (argillic clay layer) can contribute to interflow. Many modern hillslope hydrology investigations have focused on discovering and characterizing anisotropy in soils with respect to saturated hydraulic conductivity (Ks) and soil layering (Zaslavsky and Rogowski 1969, Weyman, 1973, Zaslavsky and Sinai 1981a, Wallach and Zaslavsky, and Jackson, 1992), there has been little consideration of the differences in surface and subsurface topography, specifically the differences in the subsurface topography of an argillic or clay layer and thickness of the clay layer (Zaslavsky and Sinai 1981b). There have been studies where subsurface topography has been looked into, such as the work by Freer et al. (1997) and Meerveld and McDonnell (2006), however, these studies site the topographical differences between the soil and bedrock interfaces. The research presented here, intends to detail the subsurface topography of the argillic layer and identify "low" spots with a high resolution map covering about 6500m^2. Using the map in conjunction with Ks values from surface and subsurface soils, piezometric data from above, in, and below the clay layer, max rise piezometric data from low points, stream flow, climate data, should inform us as to whether the argillic layer contributes to interflow and under what conditions interflow may form.

SITE DESCRIPTION AND METHODS

Research is being conducted at the Savannah River Site, Aiken South Carolina. The study site is a small zero-order watershed with low slope (2-6%), characterized by deep (0.5-1.5^{+}m) sand to sandy loam soils overlying a thick (approximately 3.1m) argillic clay layer. Surface and subsurface Ks data has been collected using an Amoozemeter at several random points across the hillslope. The subsurface topography was mapped at a high resolution (2m x 2m), using a tile probe to determine the depth of the top of clay layer. This map will be used in the near future to install max-rise piezometers in "low" spots of the clay layer and install more piezometer nests to be outfitted with dataloggers.

Datalogging piezometer nests have been installed in an orthogonal network across the hillslope where each nest has a set of three piezometers, (above, in, and below the clay layer) as well as a datalogging piezometer in the floodplain of the small stream draining the hollow. The stream has been instrumented with a 2' H-flume, and a datalogging pressure transducer to measure stream stage. Climate data is being collected at a location about ¼ mile east of the hillslope site, where there are two raingauges (datalogging and manual check guage) and a pressure transducer to measure temperature and barometric pressure.

RESULTS AND DISCUSSION

Figures 1 and 2 show in detail the surface topography and the variability of the clay layer with respect to the soil surface. From the clay depth map, there are distinct areas where the clay depth is over 1m deep and others where the depth to clay is no more than a few cm to 16cm deep. It is hypothesized that the variability of the clay layer is providing controls on interflow causing a channelized flow in the low spots.

Surface soil Ks values averaged 22.3 cm/h, while subsurface soil Ks values averaged 1.6 cm/h. These differences in Ks between surface and subsurface soils were expected as surface soils are largely sand. These differences in Ks could contribute to the development of perched water in the clay and above the clay layer. The data collected thus far probably is not indicative of how the hillslope will respond when saturated conditions occur in closer proximity to the clay layer (i.e. the seasonal water table is closer to the soil surface).

Preliminary results indicate for some storms, the clay layer contributes to saturated conditions above and in the clay, while unsaturated conditions remain below. (Fig.3) and (Fig.4). Stream flow and water surface elevation at the alluvial piezometer are shown (Fig.5). This graph shows that peaks in stream flow are observed with saturated conditions in the floodplain from water flowing from higher hillslope elevations.

CONCLUSIONS

Preliminary data suggest that sauturated conditions occur above and in the clay layer, while unsaturated conditions remain below. Given the large differences in saturated conductivities between the surface soils and the argillic horizon, the occurrence of interflow is likely during storms that cause saturated perching to occur. Field mapping of the argillic surface indicates substantial deviation from the surface topography.

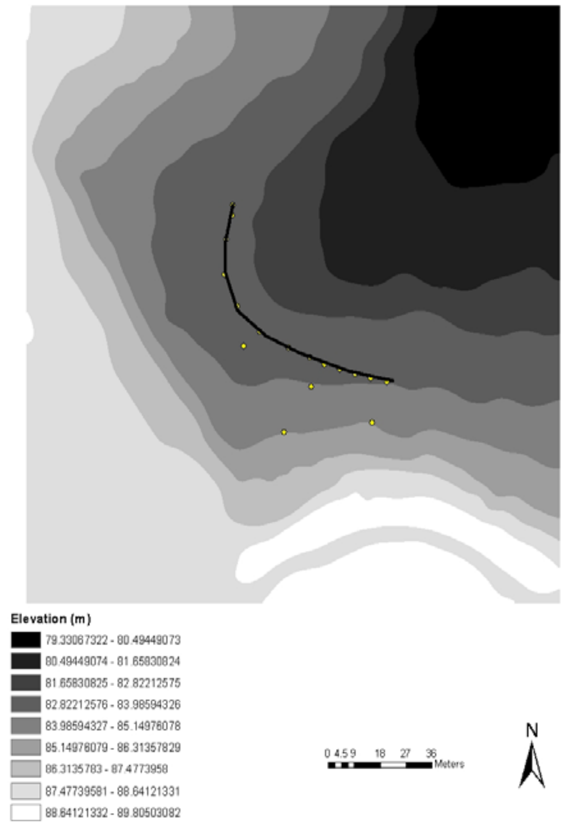

Figure 1. Topographic map of hillslope

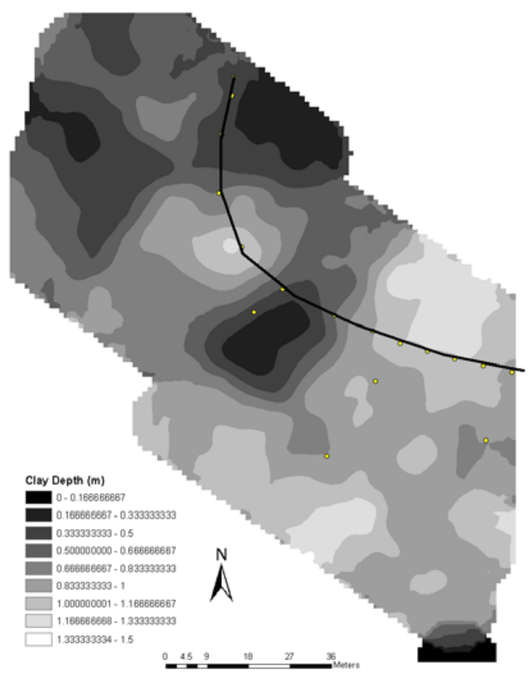

Figure 2. Map detailing clay depth variability

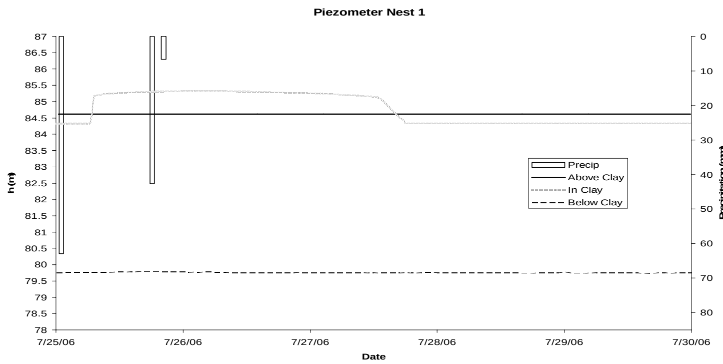

Figure 3. Piezometer and Precipitation data from nest 1.

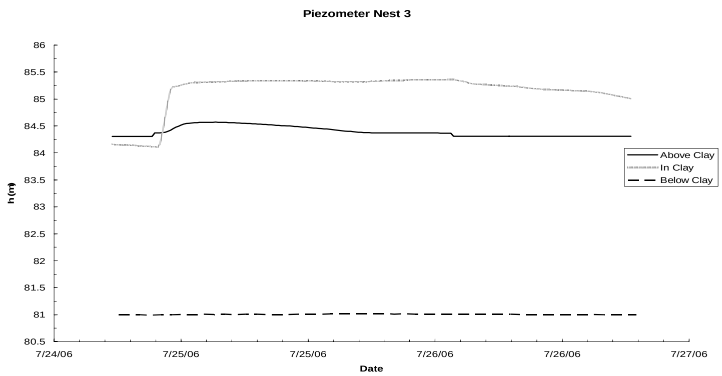

Figure 4. Piezometer data from Nest 3. Graph shows saturated perching water conditions in clay and unsaturated conditions below clay.

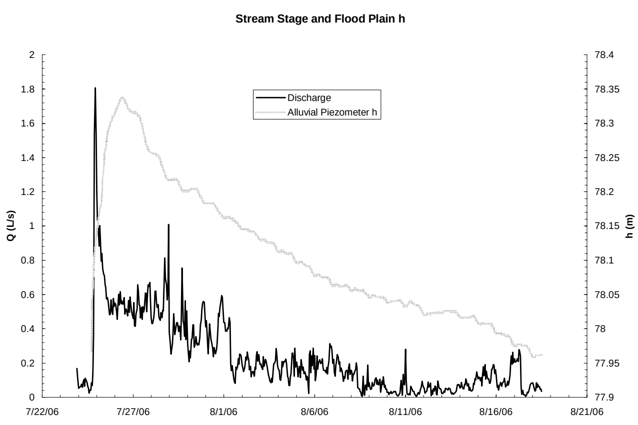

Figure 5. Alluvial piezometer and stream stage.

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