CE 203 Comp Question 2014

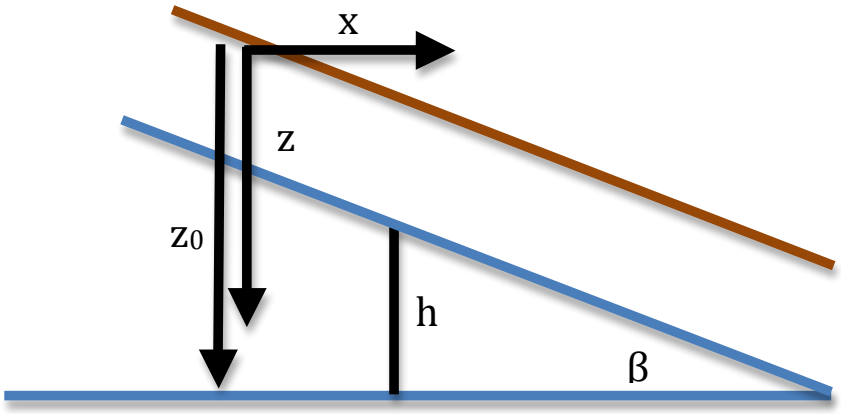
TOPMODEL has been called the "last great modeling breakthrough" in hydrology. The goal of this question is to apply mass balance and Darcy's law to arrive at the TOPMODEL formulation.

Saturated flow is occurring in a hillslope with slope β.
Axes are shown below. A water table with depth h(x) relative to some datum at z=z0 is present a distance (z0-h(x)) below the surface.

The hydraulic conductivity is allowed to vary with depth such that

$K_{sat}(z) = k_o \exp(-z/m)$

Where k_o is the conductivity at the surface, and m is a known constant.



(a) Compute the hydraulic gradient at a point (x) with respect to direction x, expressing your answer in terms of the slope gradient β (1.5)

(b) Write the expression for the Darcy flux in the x direction at some height z (within the water table) using your answer to (a) (1.5)

(c) Let the water table be located at $z = z_1(x)$. Integrate your answer for (b) from $z = z_1(x)$ to $z=\infty$ to obtain Q(x) – the total flux of water flowing horizontally at location x. (2)

(d) Assume that at location x there is an upslope accumulating area of A(x). If rainfall occurs with intensity I, and the hillslope is at equilibrium (no changes in

storage occurring, i.e. steady state), write the condition relating the upslope rainfall inputs to the local groundwater flux (1)

(e) Solve (d) to obtain the water table height at which this condition is met. (2)

(f) Let z* be the water table height at which saturation starts to occur. Using the condition that your solution to d must be >z*, solve for a term that should look like a natural logarithm and combines the upslope area A and the slope β. You will have defined the so called "Topographic Wetness Index" which is widely used to predict the risk of local saturation. (2)