Physical Hydrology for Ecosystems

BEE 3710

Assignment #4: Soil Moisture and Infiltration (Due 2/214)

1) Experiment: In lab we will measure the properties for a sandy soil and experimentally measure the sand's infiltration amount, and the depth of the wetting front (a lot could go wrong). (a) Using the infiltration amounts we measured at different times, calculate the expected depth of the wetting front and compare to the measured wetting front depths. (b) Calculate and graph the observed infiltration rates against time and estimate the soil parameters needed to fit the Green and Ampt equation to your data:

$$t = t_p + \frac{1}{K_s}\left[F - F_p + |\psi_f|(\theta_s - \theta_i)\ln\left(\frac{|\psi_f|(\theta_s - \theta_i) + F_p}{|\psi_f|(\theta_s - \theta_i) + F}\right)\right]$$

Fit the above equation to your data by guessing b and ψ_e (see Soil Properties handout).

2) Real World Application 1: Use the on-line Web Soil Survey hosted by the US Department of Agriculture's Natural Resource Conservation Service:

http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Look-up the saturated hydraulic conductivities (a.k.a. Ksat, K_s or permeability) of the soils just west of campus (choose an area between 100 and 500 acres). Calculate the area-weighted average saturated hydraulic conductivity.

(a) Assuming that the infiltrating water saturates the soil above the wetting front (not always a good assumption), how deeply does the average soil get wet when the rain intensity equals K_s? (assume the initial water content before the storm is 0.05), estimate saturated moisture content as either field capacity (moisture content at 0.3 bar) or based on the soil properties handout using the texture classifications from the soil survey website. Assume a 1 hour rainfall.

(b) If the infiltrated water was funneled into preferential flow paths that constituted about 25% of the landscape, how deeply would the infiltrating water penetrate into the soil (assume the preferential flow paths run at saturation)?

Use the Northeast Regional Climate Center's (http://www.nrcc.cornell.edu/) NYS Precipitation Extremes information to determine 1, 2, 5, 10, 25, 50, and 100-year, 1-hour rainfall intensities.

(c) How frequently does the 1-hour rainfall intensity exceed the saturated hydraulic conductivity [if more frequently than the 1-yr event or less frequently than the 100-yr event, just note as such]?

3) Real World Application 2: Consider sand, silt loam, and clay soils. Use the class handout, **Some Useful Soil Physics Relationships**, to determine which soil has the most available water capacity, assuming they are all 30 cm deep. Assume each soil receives 3 cm of rain that infiltrates, (a) assuming the soil saturates above the wetting front, how deeply does the wetting front penetrate? (b) Assume the water redistributes to a uniform water content over 30 cm; what is this uniform θ for each soil? (c) After the water redistributes, which, if either, of the soils have a uniform water content greater than field capacity? (d) Assume water above field capacity drains and saturates the bottom of the soil profile; how deep is this saturated layer? (e) Assume the saturated layer drains out the bottom of the soil profile until the water content everywhere is at field capacity; how much water (cm) drains.

4) Show conceptually, using algebra, that $n = 1 - \rho_b/\rho_p$ [recall: n =(vol. Pores)/(/vol. Soil)]

5) Use the Green and Ampt equation, in conjunction with the soil properties handout for a sand loam and clay loam, and estimate how much infiltration you get from a 4.5 cm, 1.5 hr storm.

Extra Credit:

(1) Calculate the largest diameter tube possible that will hold a drop of water on its end. Test your answer. Hint: a drop will have two surfaces attached to the tube, one on the inside of the tube and one clinging to the end of the tube.

(2) For question 2(c), determine the fraction of the area for which the 1-hr rainfall intensity exceeds the saturated hydraulic conductivity for each return period, 1, 2, 5, 10, 25, 50, and 100 yrs.