

# FE 537 Hillslope and Watershed Hydrology

## Lab 2: The hillslope scale

**Instructor: Luisa Hopp**

### **Motivation**

This lab is designed to provide some hands-on experience with hillslope scale hydrological processes and experimental techniques. Hypotheses about water flow on a hillslope with irregular surface and subsurface topography will be tested by conducting sprinkling and tracer experiments on a scale model of the Panola hillslope (discussed in class). The model is an 1:11 copy of a hillslope at the Panola Mountain Research Watershed (PMRW) in Georgia, operated by the USGS Water, Energy, and Biogeochemical Budgets Program. Extensive research has been done at the PMRW on the role of topography and bedrock permeability for the generation of subsurface flow and the non-linear hydrologic response to natural storm events. The characteristics of the “real” Panola hillslope have been discussed in class (e.g. highly irregular bedrock topography, permeable bedrock, soil pipes, sandy loam, variable soil depths, etc.). The bedrock of “Little Panola” is made of concrete while the soil layer consists of Accusand 12/20 (the same material that was used in the Plot Scale Lab). The dimensions of Little Panola are: length 3.96 m, width 1.72 m (+ 0.18 m control strip on the right), slope 13°.

### **Learning Objectives**

- Observe and analyze hillslope scale water and tracer fluxes.
- Determine how surface and subsurface topography influence lateral flow behavior
- Measure tracer breakthrough at the hillslope scale and compare to lateral water flux rates.

### **Activity (to be discussed in a hands-on lecture in the lab):**

- 1) Make sure that cups for checking the input are placed on the hillslope and empty (diameter of the cups: 5.3 cm).
- 2) Make sure that each trench section is equipped with a graduated cylinder.
- 3) Apply the tracer solution (saturated dyed salt solution) as a line source (10 cups à 10-11 g) across the width of the hillslope on the surface immediately below the rocky outcrop (2.03 m upslope from trench).
- 4) Turn on irrigation (sprinklers 2+3+4) – record time sprinkler on (time zero; start stop watch).
- 5) Record times when subsurface flow starts for each section.
- 6) Record time and volume when a specified volume in a cylinder is reached (temporal resolution as high as feasible; recommended volume for fast trench sections: 400-500 ml)
- 7) Empty cylinders into a beaker (let beaker overflow to flush previous sample out) and measure electrical conductivity with the handheld EC probe. Record EC value.
- 8) Turn off the sprinklers after 16 min.
- 9) Continue steps 6 and 7 until drainage ceases (approx. 1.5 hr).
- 10) Collect “rain gauges”, weigh the cups (take tare weight into account) and record the weight. Combine collected water into a beaker and measure EC of the input. Put cups back on the hillslope.
- 11) Flush the tracer out of Little Panola by turning on sprinklers 2+3+4+5 until EC in the trench discharge is back to background value (background EC value: approx. 130  $\mu\text{S cm}^{-1}$ ).

## Suggested Reading

M. H. Schroth, S. J. Ahearn, J. S. Selker, and J. D. Istok (1996). Characterization of Miller-Similar Silica Sands for Laboratory Hydrologic Studies. *Soil Science Society of America Journal*, vol. 60, pp 1331-1339.

Freer, J., J.J. McDonnell, K. J. Beven, N. E. Peters, D. A. Burns, R. P. Hooper, B. Aulenbach, and C. Kendall (2002). The role of bedrock topography on subsurface storm flow. *Water Resources Research*, 38(12): 5-1 - 5-16.

[http://www.cof.orst.edu/cof/fe/watershd/pdf/2002/Freer\\_et\\_al\\_%202002\\_WRR.pdf](http://www.cof.orst.edu/cof/fe/watershd/pdf/2002/Freer_et_al_%202002_WRR.pdf)

Tromp-van Meerveld, I. and J.J. McDonnell (2006). Threshold relations in subsurface stormflow 1: A 147 storm analysis of the Panola hillslope trench. *Water Resources Research*, doi:10.1029/2004WR003778.

[http://www.cof.orst.edu/cof/fe/watershd/pdf/2006/Tromp\\_van\\_Meerveld\\_Threshold\\_WRR\\_2006A.pdf](http://www.cof.orst.edu/cof/fe/watershd/pdf/2006/Tromp_van_Meerveld_Threshold_WRR_2006A.pdf)

Tromp-van Meerveld, H.J. and J.J. McDonnell (2006). Threshold relations in subsurface stormflow 2: The fill and spill hypothesis: an explanation for observed threshold behavior in subsurface stormflow. *Water Resources Research*, doi:10.1029/2004WR003800.

[http://www.cof.orst.edu/cof/fe/watershd/pdf/2006/Tromp\\_van\\_Meerveld\\_Threshold\\_WRR\\_2006B.pdf](http://www.cof.orst.edu/cof/fe/watershd/pdf/2006/Tromp_van_Meerveld_Threshold_WRR_2006B.pdf)

## Questions/Assignment

1. Plot time series of total subsurface flow and of subsurface flow for each section together with the input and explain the results. Is the discharge uniform along the trench? What are the lag times between start of irrigation and start of trench flow? If you analyze the recession of the hydrographs like e.g. Harr (1977) did – can you distinguish between different drainage periods?
2. Compute the subsurface runoff response ratio for the total trench and each section.
3. Compute the mean and the standard deviation of the total input in  $\text{mm h}^{-1}$ . The input will most likely be not spatially uniform (due to the technical setup). In the field, what reasons could there be for spatially non-uniform infiltration?
4. Plot the tracer breakthrough for each section. Is it uniform across the trench? Compute subsurface flow velocities by dividing the travel distance by the time from start of irrigation to peak. What is the range of measured subsurface flow velocities? How do the tracer results compare to the water flow results?
5. Compare results from sprinkling experiments on Little Panola to the hydrologic response to natural rainfall on the real Panola hillslope as discussed in class. What differences would you expect in terms of the shape and timing of the subsurface stormflow hydrographs?
6. Put together your results of subsurface flow and tracer breakthrough (recorded times, flow volumes and EC values for each section and total, including input rate assessment) in a spread sheet and email it to [luisa.hopp@oregonstate.edu](mailto:luisa.hopp@oregonstate.edu).

### How the EC probe (Combo pH+EC, Hanna Instruments) works:

Remove protective cap, turn probe on by pressing MODE. Check that probe is set to “ $\mu\text{S}$ ” in the upper right corner (if not press SET/HOLD). Submerge probe in the sample. Values should be read when the clock symbol on the top left of the display disappears. The unit is  $\mu\text{S cm}^{-1}$ . Turn the probe off when you are finished with measurements and put the cap back on.