Bed Roughness and Hydraulic Geometry

Teaching Geomorphology
Cutting Edge Workshop

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Description: In this field exercise, students measure channel cross sections in a rough alluvial and smooth bedrock-floored reach in a local stream. This exercise is hypothesis-driven. The hypothesis states that increasing roughness decreases average stream velocity, and so the depth and/or width must increase for the rougher bed. Working in groups, students use hand levels, tape measures, and surveying rods to document channel geometry. They then must reduce the data and plot it as distance-elevation on a chart. Finally, they analyze and compare the results to the predicted roughness-hydraulic geometry relation.

Goals: Students learn simple surveying methods to collect field data. Students compare real world data to theoretical predictions. Students gain insight into how bank and bed roughness influences water flow, and thus can also influence flood heights.

Activity: Bed roughness and hydraulic geometry

1. *Problem*: Why are floodwaters deeper in some areas than others along the same stream?
2. *Setting*: 2^{nd}-3^{rd} order stream with alluvial and bedrock sections adjacent to each other
3. *Approach*: Students identify the high water mark, either bankfull or the height of a recent flood, and measure channel geometry using simple surveying tools.
4. *Evaluation*: Students are required to plot the reduced data on a chart, and write a short paragraph about the exercise. They must introduce the hypothesis they are trying to test, describe the observations and methods used to collect the data, and provide an assessment of how well their measurements fit with the hypothesis. A rubric is handed out with the assignment awarding a range of points for how well the student performs the various tasks.
5. *Working in groups*: For larger classes, grading individual reports and field notes represents an overwhelming workload for the teacher. One way around this is to have all students take field notes, but then permit them to submit a joint report.

Project overview

a. *Learning outcomes*
   i. Introduces students to the sensitivity of river geometry to roughness, and leads directly to understanding flood heights.
   ii. Students gain experience collecting field data, and reducing the data in a spreadsheet.

b. *Setting*
   i. Small (2^{nd} -3^{rd} order) channel close to campus
   ii. Channel bed exhibits alluvial and bedrock reaches

c. *Hypothesis*
   i. Smooth channels have lower boundary friction, so flow velocity is higher, and so the hydraulic cross sectional area (width and/or depth) must decrease. Is this what we observe?

d. The *test*
   i. Determine bankfull depth (or use recent flood evidence)
   ii. Measure cross sections up to bankfull depth using surveying tools (hand site level, tape, rod; or autolevel and rod; or total station and reflector)

e. The *analysis*
   i. Reduce the survey data so cross sections can be readily compared
   ii. Write a description of the project, including the hypothesis, the data collection methods, and the results of the comparison

f. *Rubric* Assessment of student efforts is based on a ranking system for categories, given below. Each category receives a rank from 0 to 4, where 0 = unacceptable; 1 = poor, needs a lot of improvement, but passing; 2 = fair, but could use some improvement; 3 = good, and only has very minor problems; 4 = excellent; needs no improvement
   i. *Hypothesis statement*
   ii. *Field Measurements*
   iii. *Data reduction*
   iv. *Analysis and conclusions/summary*