Hyporheic Geophysics: D.C. Resistivity Imaging of Valley-bottom Alluvium in a 3rd-order Mountain Stream, HJ Andrews Experimental Forest, Oregon, USA (H51D-0524)

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Introduction

Stream-groundwater (hyporheic, HZ) interactions are critical to understanding the transport and fate of materials (e.g., nutrients) in watersheds, and the biophysical processes that regulate the export of materials. However, uncertainties plague predictions of stream-groundwater interactions, leading to questions about how individual watersheds regulate material export. These sub-surface uncertainty factors are the depth of saturated alluvium and spatial heterogeneity of that alluvium.

Objective

Use continuous electrical resistivity imaging and topographic surveys to overcome the two uncertainty factors and quantify the valley-bottom alluvial aquifer and HZ.

Study Site

- Valley-bottom of an existing HZ study site in Mack Creek, an old-growth Douglas Fir watershed, HJ Andrews Experimental Forest, western Cascades, Oregon, USA (Figure 1).
- 3rd-order, steep, step-pool stream with prevalent large woody debris (LWD) sediment and water retention structures.

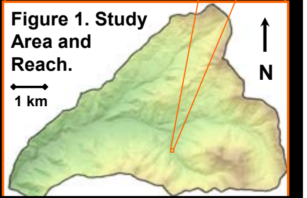
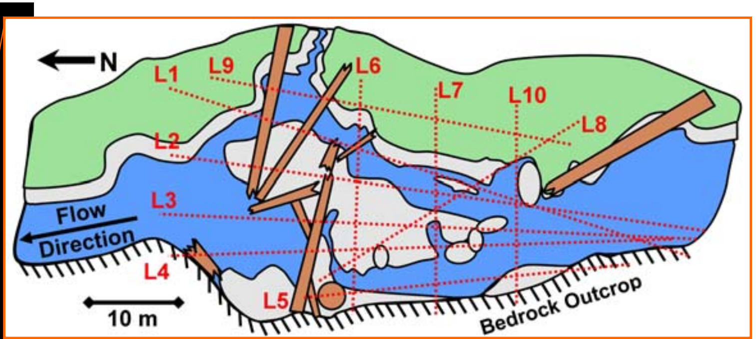
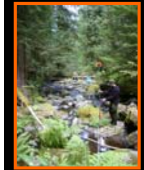


Figure 1. Study Area and Reach.



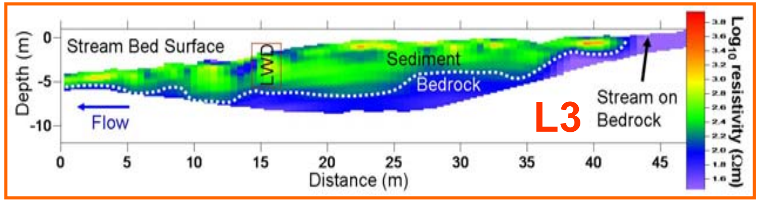


Methodology

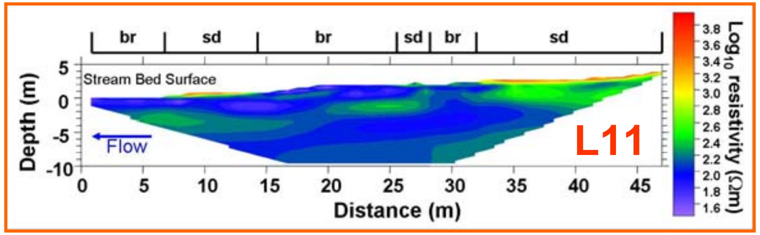
- Extensively imaged one 50 m x 28 m area; survey consisted of 10 direct current resistivity lines (Figure 1); electrode arrays were varied to achieve maximum resolution and depth penetration. Details:
  - Lines 1 to 4: 1m electrode separation: Wenner; Pole-Pole and Dipole-Dipole electrode array configurations used; Maximum depth imaged – 18m (Pole-Pole configuration).
  - Lines 5 to 10: 0.5m electrode separation; Wenner and Pole-Pole electrode array configurations used (Dipole Dipole only for lines 5 and 6); Maximum depth imaged–11m (Pole-Pole configuration).
- Reciprocal error checks typically rejected errors above 2%.
- Inverted using Profiler software, inversions converged with RMS errors between calculated and observed apparent resistivities <1%.
- An additional line (11), located immediately downstream of main site, lies over an exposed bedrock channel and provided a means for groundtruthing.
- Topographic surveys of channel surface, water levels, and lines were collected concurrent with resistivity surveys.
- Limitations: 1.) typical groundtruthing (e.g., augering) was not possible, 2.) electrode lines were confined to near channel because dry organic layers or fallen trees across much of the forest floor prevented good electrode contact.

Results

Longitudinal Profiles



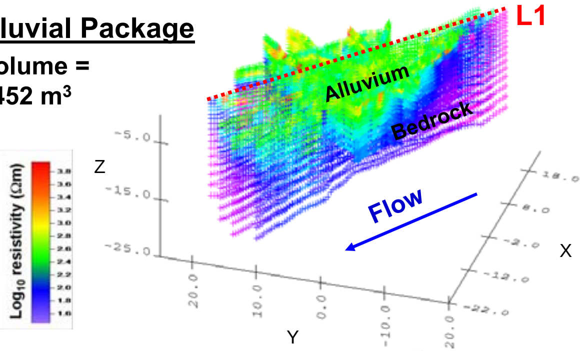
- Saturated alluvial sediment (basalt) is represented by shades of red to green, while the weathered bedrock (andesitic tuff) is blue. Mean alluvial thickness is 4.1 m with a maximum and minimum observed thickness of 0 and 8 m, respectively.



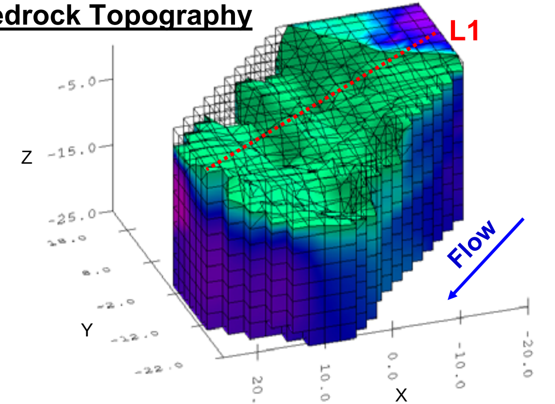
- Located immediately downstream of L3, L11 (groundtruth survey) illustrates strong contrast between the saturated alluvium and bedrock resistivity signatures. Along this transect the average alluvial thickness was 0.3 m.

Alluvial Package

Volume = 5452 m^3



Bedrock Topography



Looking Forward…

- Couple geophysical characterizations with biochemical measurements in a hydrodynamic HZ model to elucidate the factors controlling the distribution and concentrations of a model pollutant (nitrogen) through stream networks.
- Geophysically detectible tracers (e.g., NaCl, which decreases resistivity) will be injected into the sediments and subsurface flow pathways will be mapped with time-lapse resistivity surveys.
- Provide quantifications of valley-bottom alluvial volumes important to understanding watershed morphology dynamics (e.g., sediment budgets).

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