

How do floodplain hydrological processes drive river bank erosion dynamics?

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Abstract:

The aim is to achieve a step-change in understanding of the impact of floodplain groundwater-surface water interactions on river bank erosion dynamics. Despite considerable bank erosion research, the modelling of erosion rates is problematic, partly because of inadequate process knowledge, especially the crucial but presently unknown impacts of channel-margin hydrological processes on erosion *events*. Consequently, the driving relationships and the process combinations for bank failure and fluvial scour remain unclear. This is the first Knowledge gap the project will address. Knowledge gap 2 is that field data are urgently needed for validation and advanced understanding of the 'groundwater ridging hypothesis' that might explain the delivery of 'pre-event' water to rivers and also preferential flow (Bradley et al. 2007a; 2007b). Knowledge gap 3: There still lacks an event-basis for process explanations. Given that bank erosion proceeds as a discrete series of removal *events*, unless we understand the destabilizing process combinations at the *erosion-event* timescale, then a fully predictive model will not be achievable. Further project novelty lies in applying our new PEEP 3T and TCT (Thermal Consonance Timing) continuous erosion monitoring systems developed by Lawler (2005a; 2005b, 2008), which, for the first time, quantify bank erosion dynamics *continuously*, including crucial event *timings*, magnitude and duration. This project will couple direct monitoring systems for both bank erosion dynamics and a range of hypothesized water-flux 'triggers' to test a range of moisture-flux and bank stability models including SEEP/w and SLOPE/w. Different bank erosion processes can be revealed by different timing signatures. The student will test a range of bank erosion hypotheses on the efficacy of positive and negative pore water pressures and drawdown. The student will join a thriving PhD within the active and internationally-recognized Water Sciences Group. Please see full project description on website: www.gees.bham.ac.uk

1. Research Gaps. The aim is to achieve a step-change in the understanding of the impact of riparian groundwater-surface water interactions within channel margins on river bank erosion dynamics. Despite considerable research on the processes of bank erosion, the modelling of erosion rates is problematic, partly because of inadequate process knowledge and specification. Indeed, there has been little process research on the crucial impacts of channel-margin hydrological processes on erosion *events*, as opposed to erosion rates over longer timescales. Although subsurface riparian

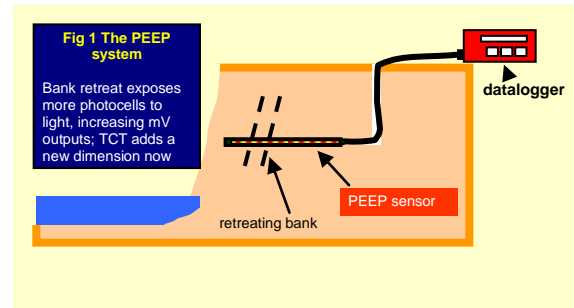


hydrological processes are *suspected* to be a key to bank instability, there is a dearth of full floodplain hydrology studies. Consequently, the driving relationships, the triggers and the process combinations for bank failure and fluvial scour remain unclear. This is the first Knowledge gap the project will address. Knowledge gap 2 is that field data are urgently needed for validation and advanced understanding of the 'groundwater ridging hypothesis' that might explain the delivery of 'pre-event' water to rivers and also preferential flow (Bradley et al.

2007a; 2007b). Knowledge gap 3: Despite encouraging progress recently on Italian rivers by the Florence (Rinaldi) and Southampton (Darby) groups, there still lacks an event-basis for process explanations. Given that bank erosion proceeds as a discrete series of removal *events*, unless we understand the destabilizing process combinations at the *erosion-event* timescale, then a fully predictive model will not be achievable. Seepage rates through cohesive sediments are likely to affect bank erosion rates, demonstrating the need to quantify sub-surface water movement through

floodplains, by analysis of water-table response and modelling the mixing of different water sources within the floodplain.

2. Methodology. Further novelty in the project lies in applying new PEEP 3T (Photo-Electronic Erosion Pin Mark 3) and TCT (Thermal Consonance Timing) continuous monitoring systems [see Figure] (Lawler, 2005a; 2005b, 2008), to quantify bank erosion *dynamics continuously*, including the dynamic system properties crucial for strong process inference (e.g. event *timing*, magnitude and duration, all with respect to fluctuations in the driving forces). The project will be based in the



nearby Severn catchment for rapid-reaction field monitoring. Driving riparian moisture fluxes are also a key focus of this initiative. This project, **for the first time**, will couple in the field direct monitoring systems for both bank erosion event dynamics and a range of hypothesised water-flux 'triggers' to validate a range of moisture-flux and bank stability models. Information on bank retreat **event timing**, in relation to changes in destabilising forces, is crucial to strong process inference, because different bank erosion processes can have characteristic timing signatures. This approach thus develops a very novel and powerful platform for the rigorous testing of geotechnical and geomorphological bank stability models. The student will test a range of bank erosion hypotheses on the efficacy of positive and negative pore water pressures and drawdown processes generated by recent international work. Subsurface flows will be modeled over a 12-month period using the powerful 3D finite element seepage model SEEP-3D to input into SLOPE model. Output from the annual model for periods corresponding to individual events will be analysed to determine the contribution of specific hydrological processes triggers to river bank erosion. The student will join a thriving postgraduate group within the active and internationally-respected Water Sciences Group.

3. Selected references of key significance for the project

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