Anastomosing rivers are disequilibrium patterns

Eva Lavooi[1], T. de Haas[1], M.G. Kleinhans[2], B. Makaske[3] & D.G. Smith[4]
1) MSc student Physical Geography, Utrecht University, evalavooi@gmail.com
2) Utrecht University, Faculty of Geosciences, Department of Physical Geography
3) Alterra, Wageningen, Netherlands
4) Department of Geography, University of Calgary, Alberta, Canada

Universiteit Utrecht
Research group
River and delta morphodynamics

Introduction

- Anastomosing rivers have multiple interconnected channels:
  But what is the origin of anastomosis?
  - **Equilibrium**: Optimizing water and sediment transport[1].
    Or
  - **Disequilibrium**: Tendency to avulse due to upstream sediment overloading[2].
- Tested on the upper Columbia River with a geological and modelling approach.

Methods

Geological approach:

- Analyzing a trend in bedload deposition by:
  - Investigation of three geological cross-sections (Fig. 1).
  - Derivation of channel and floodplain sediment volumes and sedimentation rates.

Modelling approach:

- Test if multiple channels can be in equilibrium:
  - Schematisation based on measured lengths of channels.
  - 1D network model run[3] (poster Tjalling de Haas).

Downstream trend of decreasing bedload deposition

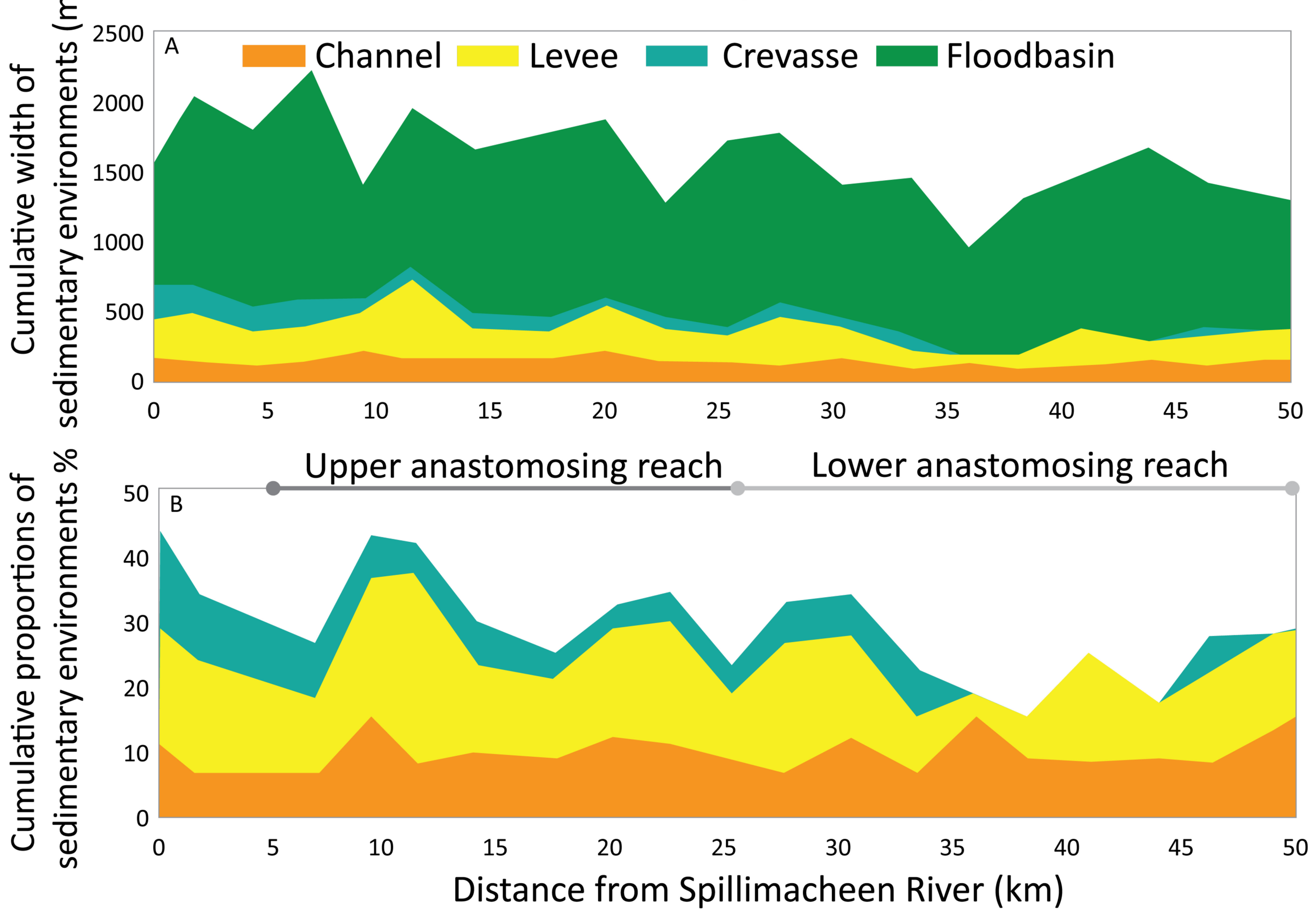

Figure 2. Sedimentary trend, measured with surface mapping. A: all widths of sedimentary environments. B: proportions without floodbasin deposits

Results

Geological approach:

- Downstream trend of decreasing number of channels and decreasing bed sediment deposition (Fig. 2).
- Extensive crevasse splays in the upstream section and an increased bed elevation and gradient demonstrate a tendency to avulse due to overloading of bed sediment (Fig. 2, 3).
- Measured bedload transport indicates bed material overloading (Fig. 3).
- ^{14}C dating confirms a decrease in long-term average floodplain sedimentation rate in downstream direction.

Modelling approach:

- Network always evolves to a single active channel, because multiple channels have more hydraulic resistance.
- Model predicts the main course of the present river when accounting for channel lengths and bends at bifurcations and discounting beaver dams, human interference and presence of a trifurcation (Fig. 4).

Longitudinal profile of the upper Columbia River main channel

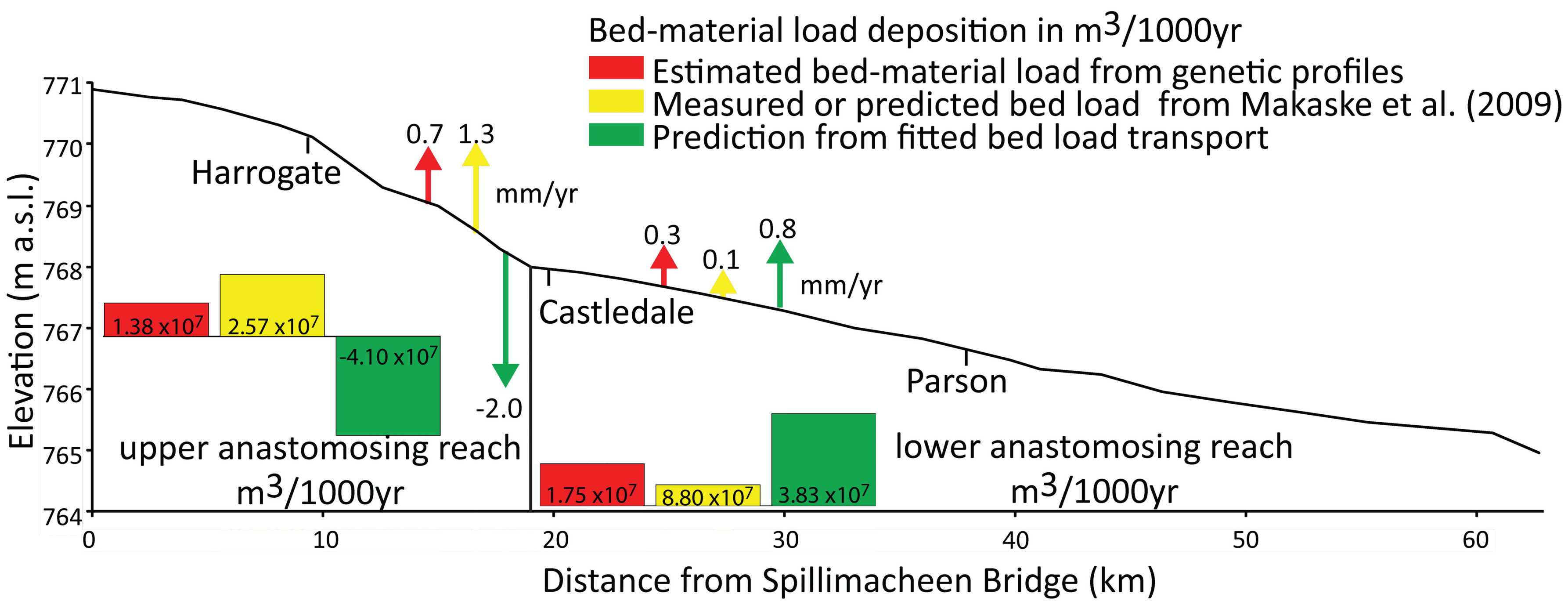

Figure 3. Bed-material load deposition in the upper and lower anastomosing reach. Red: from genetic profiles derived with the geological valley width cross-sections. Yellow: data from Makaske et al. (2009). Green: calculated with a fitted bed load transport predictor.

Modelled discharge division of the upper Columbia River

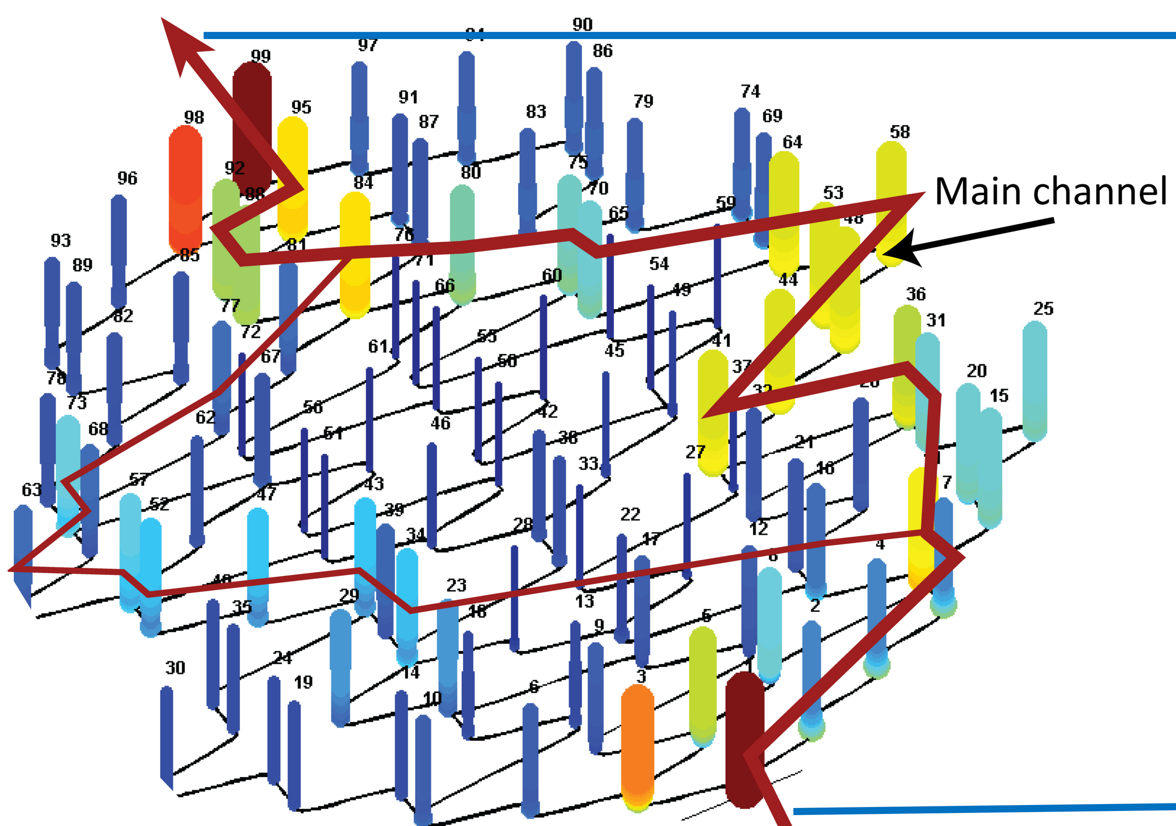

Figure 4. Results of the 1D network model. The predicted main course corresponds with the main course of the present river.

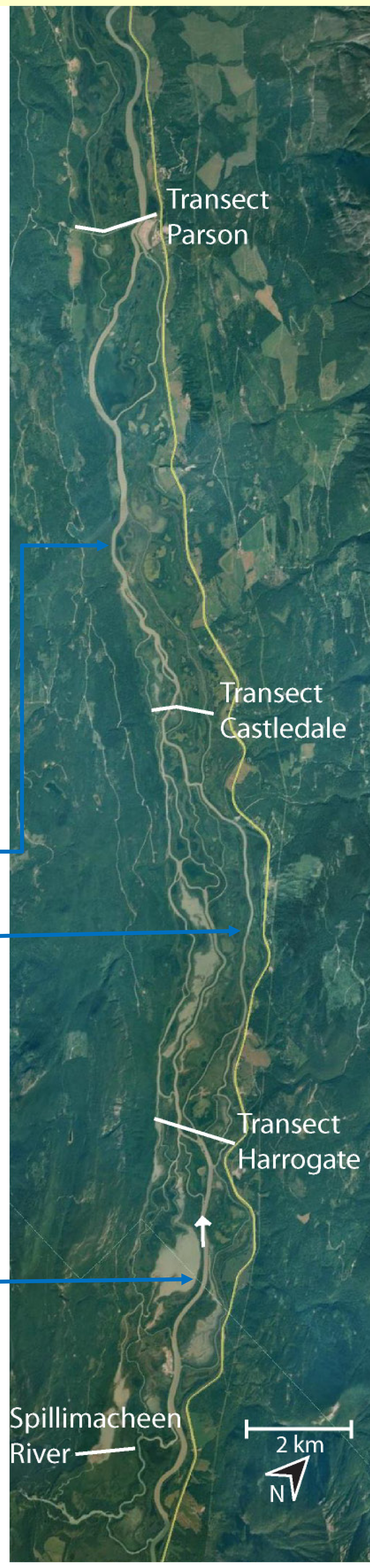

Figure 1. Aerial photograph of the upper Columbia River with the location of the three cross-sections (Source: Google Earth).

Conclusions

- Sediment overloading led to an anastomosing river pattern, so anastomosing rivers are disequilibrium patterns.
- In-channel aggradation and avulsions are followed by slow channel fill so that multiple channels remain open for a long time.
- Morphodynamically the upper Columbia River is a single-channel system, because one channel transports the majority of the sediment, but multiple channels convey flood discharge.

References

1) Huang, H.Q. and Nanson, G.C. (2007). Why some alluvial rivers develop an anabranching pattern. Water resource research 43.
2) Makaske, B., Smith, D.G., Berendsen, H.J.A., de Boer, A.G., van Nielen-Kiezebrink, M.F., Locking, T. (2009). Hydraulic and sedimentary processes causing anastomosing morphology of the upper Columbia River, British Columbia, Canada. Geomorphology 111.
3) Kleinhans, M.G., Jagers, H.R.A., Mosselman, E., Sloff, C.J. (2008). Bifurcation dynamics and avulsion duration in meandering rivers by one-dimensional and three-dimensional models. Water resources research 44.

Acknowledgements

- Netherlands Organisation of Scientific Research (NWO, grant ALW-Vidi-864.08.007 to M.G. Kleinhans)
- Molengraaff Foundation (Delft University of Technology)