



University of Stuttgart
Germany

Ecohydraulic Engineering of Water Resources

Analysis & Management of Connectivity

Dr. sc. (PhD) Sebastian Schwindt



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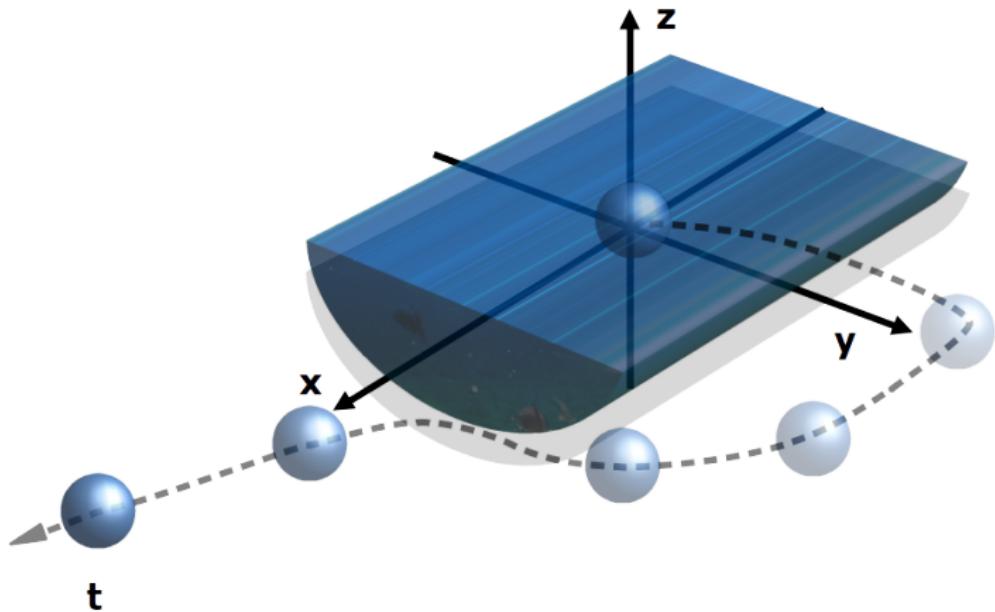
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Connectivity Dimensions

Connectivity Dimensions: Space & Time Axes



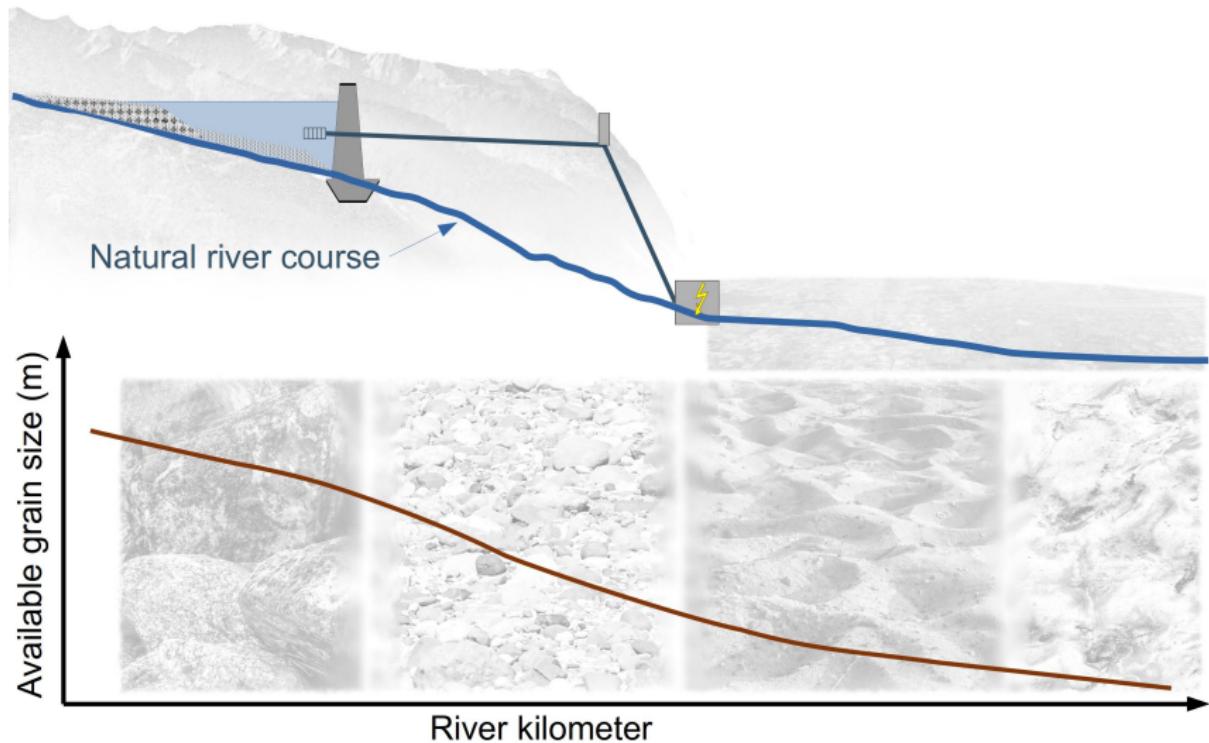
Engineering: Problem & Solution



Engineering: Problem & Solution



Reconnecting the x-axis: harm vs. utility of dams



Inn River, Germany

Challenges & Opportunities

- ⌚ Dams disconnect river ecosystems
- ⌚ No general solution available
- ⌚ Local ecohydraulic engineering actions
- ⌚ Lab & field data for computer simulations to assess fluvial sediment transport processes

Longitudinal Connectivity ✗

Longitudinal Connectivity

Mountain River Engineering



Longitudinal Connectivity

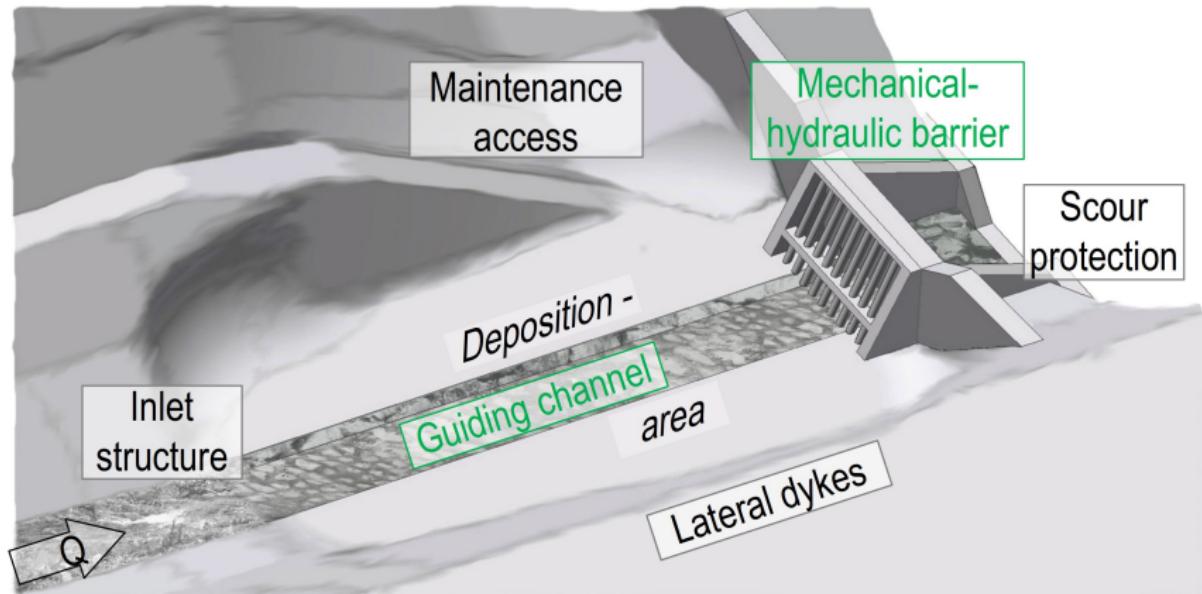


Mountain River Engineering



Longitudinal Connectivity

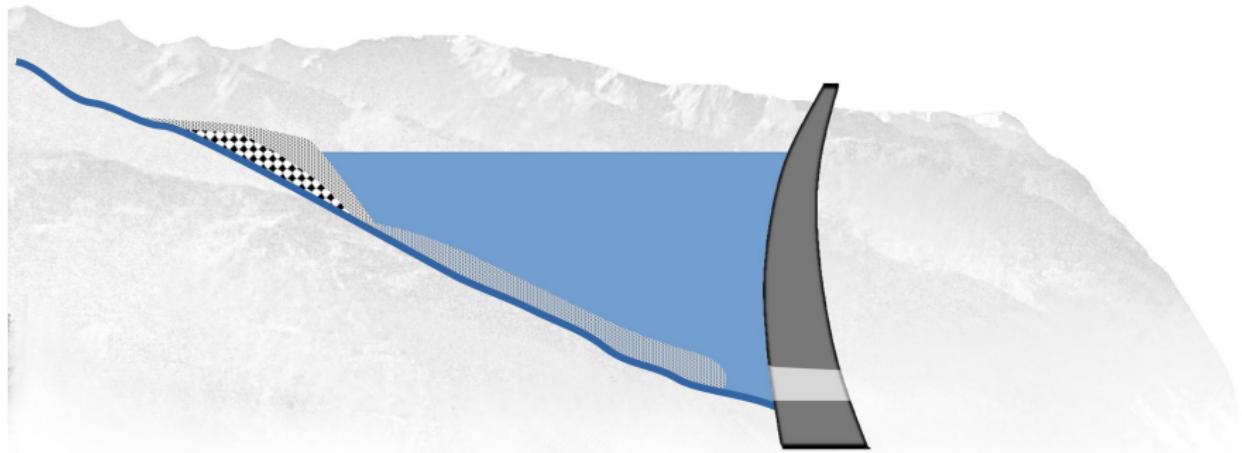
Mountain River Engineering



Longitudinal Connectivity



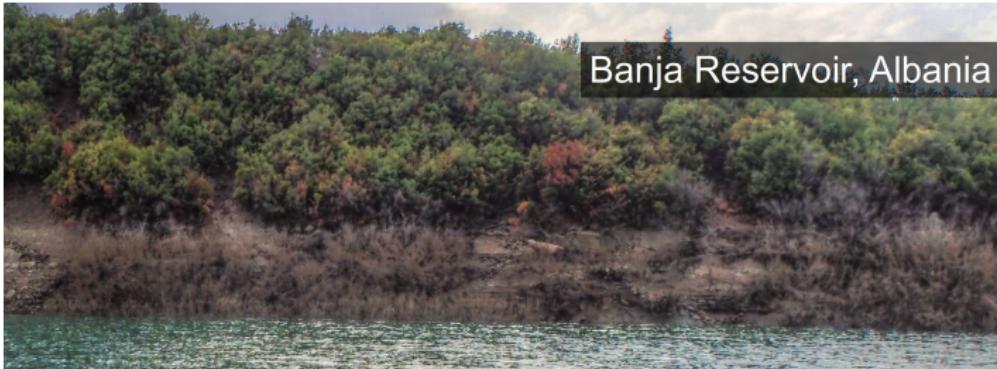
Sediment Management in Reservoirs



- 👉 Coarse & fine sediment deposits in delta regions (reservoir head)
- 👉 Very fine, partially cohesive sediment disperses in the entire reservoir
- 👉 Turbidity currents move suspended sediment close to dams

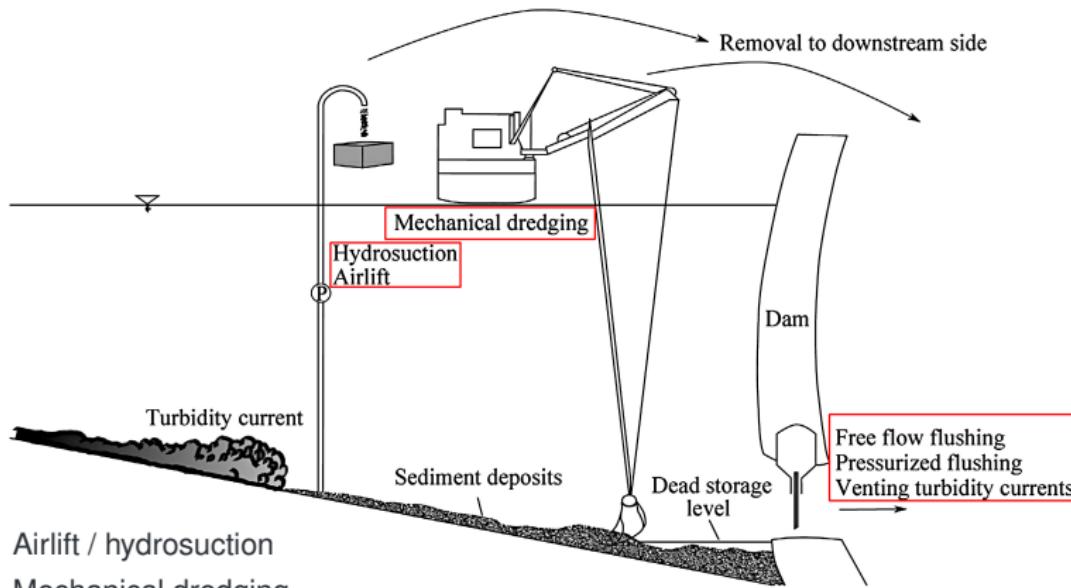
Longitudinal Connectivity ✖

Sediment Management in Reservoirs



Longitudinal Connectivity

Sediment Management in Reservoirs

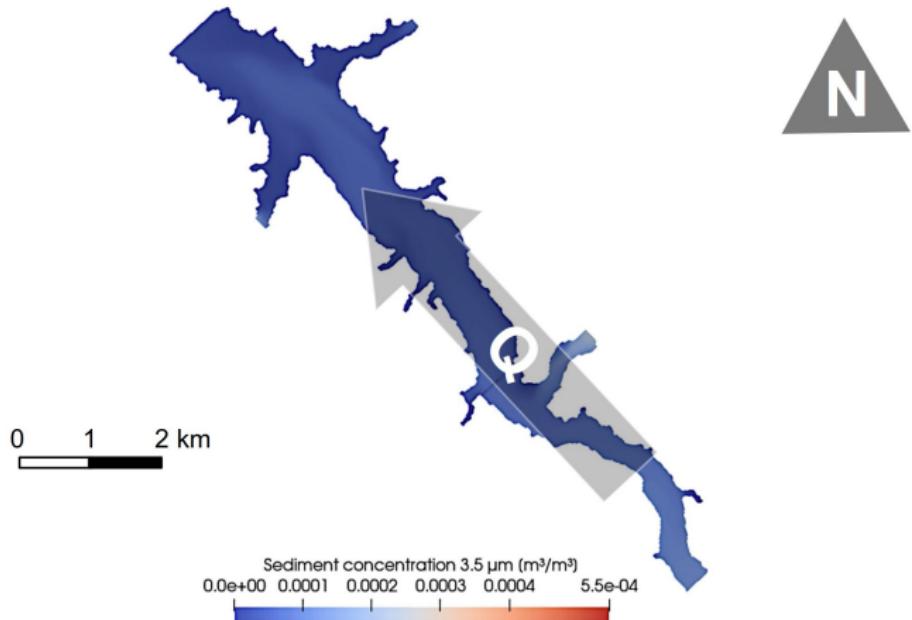


- 👉 Airlift / hydrosuction
- 👉 Mechanical dredging
- 👉 Flushing (free flow, pressurized, venting) & re-suspension
- 👉 Sediment bypass tunnels

Longitudinal Connectivity



Sediment Management in Reservoirs



*Fine particle transport through the Banja reservoir 2016–2019
(Mouris et al., 2023a, Mouris et al., 2023b)*

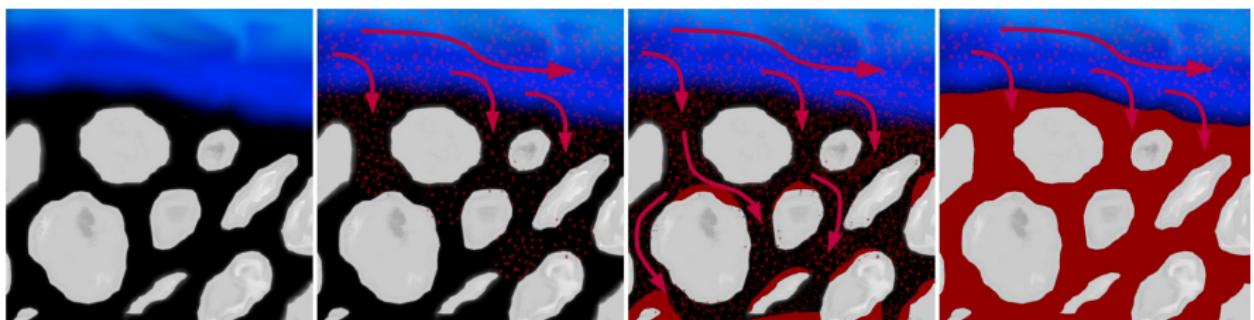
Vertical & Lateral Connectivity



Vertical & Lateral Connectivity

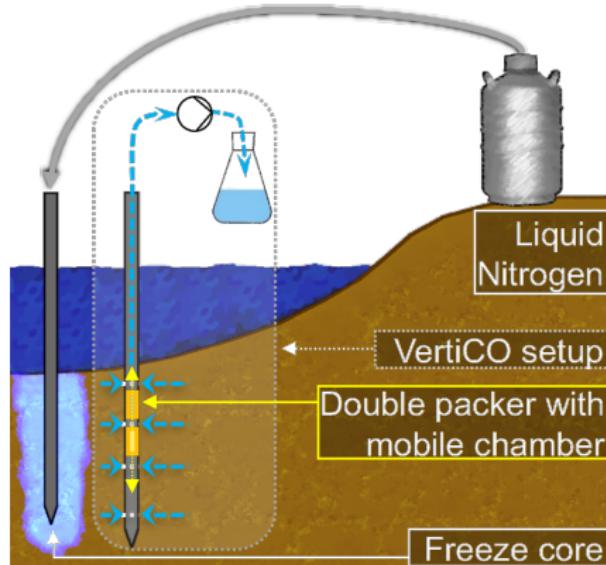


Vertical Disconnectivity: Riverbed Clogging



Vertical & Lateral Connectivity

Riverbed Clogging Measurement Methods



The Multi-Parameter Approach for assessing riverbed Clogging (MultiPAC – Negreiros et al., 2023; Seitz, 2020. Imagery: Schwindt et al., 2023)

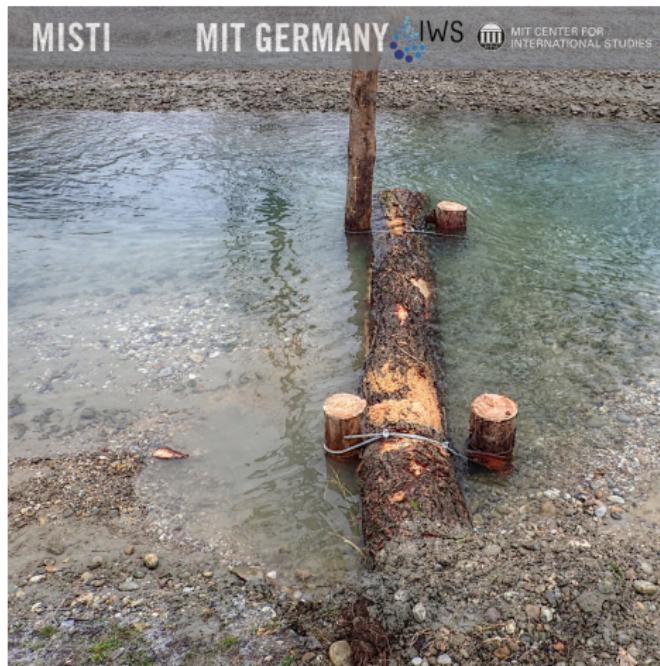


MultiPAC measurements at the Inn
↳ **Grain sizes, porosity, interstitial dissolved oxygen concentration (IDOC), hydraulic conductivity**

Vertical & Lateral Connectivity



Engineering Solutions to Reinstate Vertical Connectivity Locally

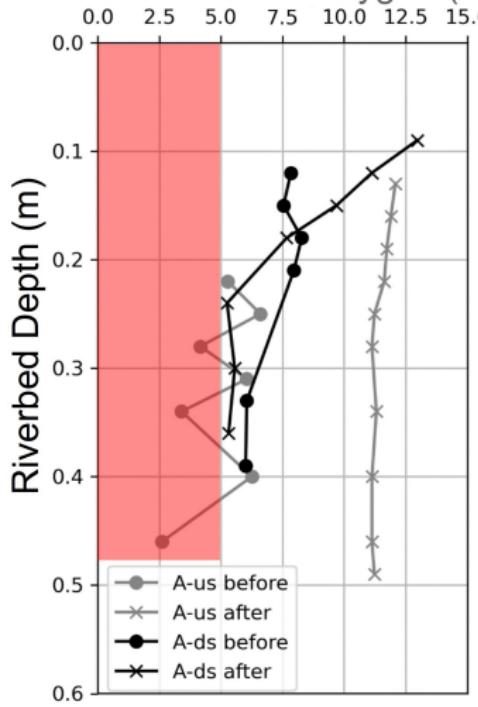


Vertical & Lateral Connectivity

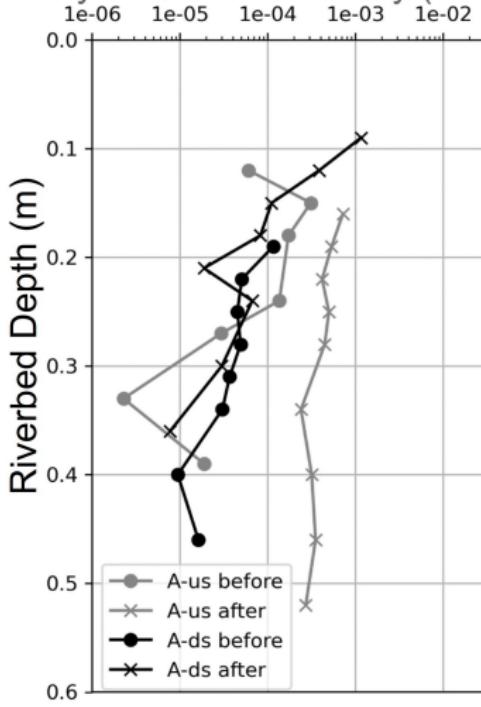


Engineering Solutions to Reinstate Vertical Connectivity Locally

Interstitial Dissolved Oxygen (mg/L)



Hydraulic Conductivity (m/s)



Insights from the Nepf Lab

- Emergent logs have higher declogging effect
- Elevated declogging in the wake of the tip of the logs

Schalko/Ponce, Lassar, Schwindt, Haun, Nepf 2024

Vertical & Lateral Connectivity



Combined Vertical and Lateral Connectivity

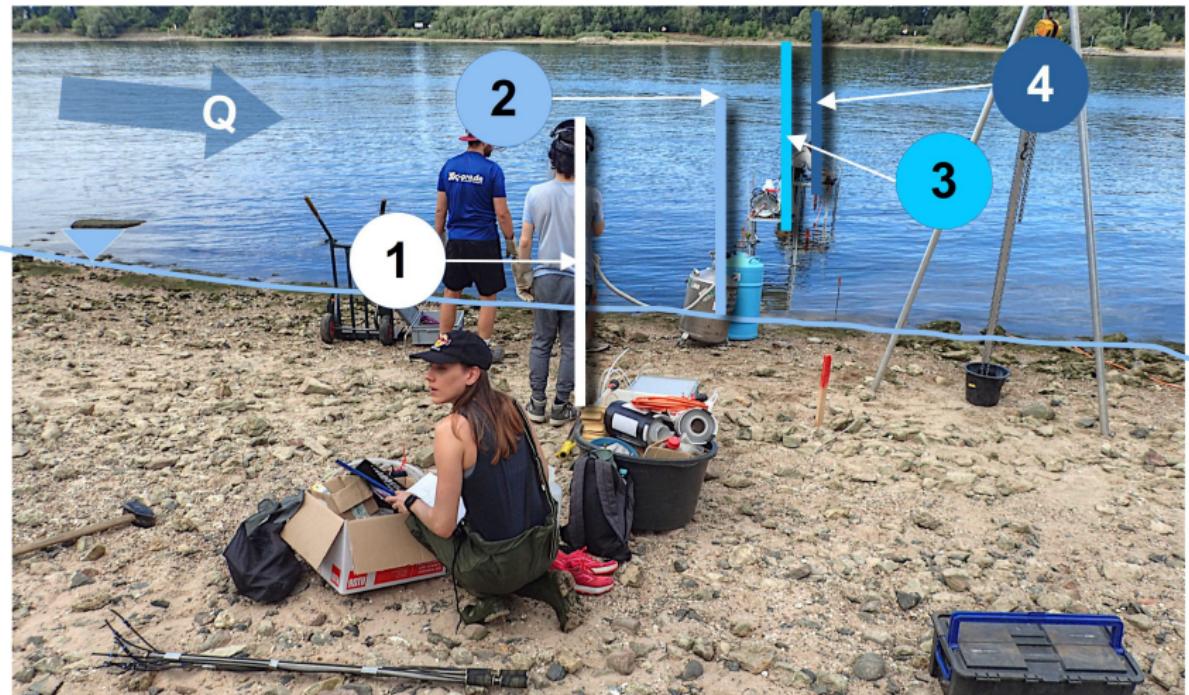
Reconnecting the y-axis: bank removal



Vertical & Lateral Connectivity

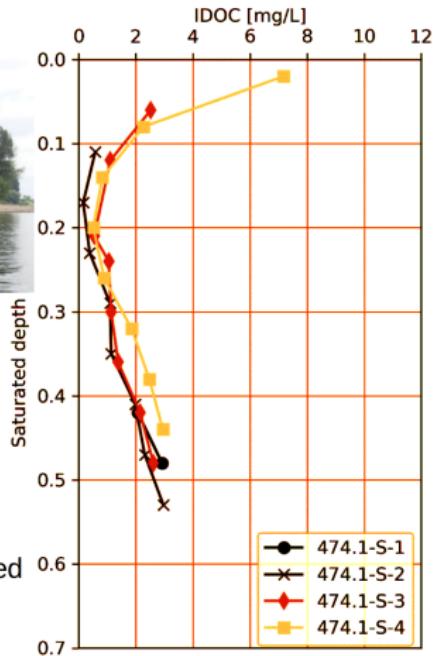
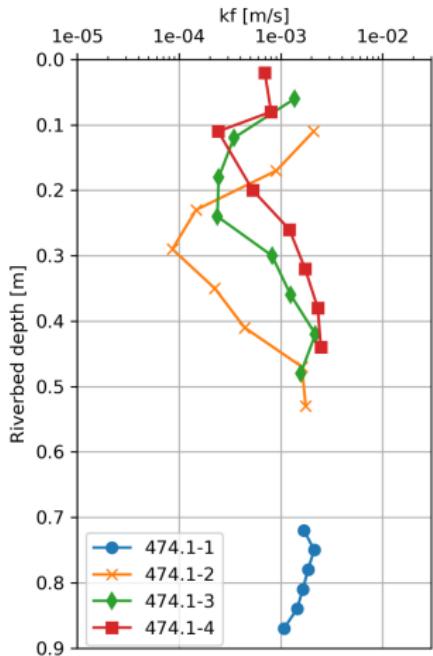


Combined Vertical and Lateral Connectivity



Vertical & Lateral Connectivity

Combined Vertical and Lateral Connectivity

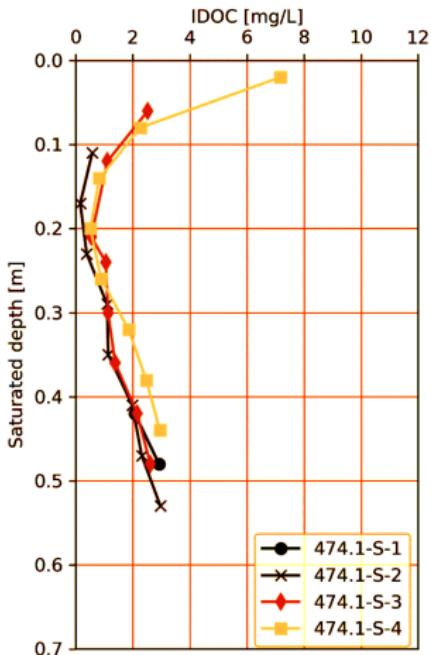


k_f : hydraulic conductivity

IDOC : Interstitial Dissolved Oxygen Concentration

Vertical & Lateral Connectivity

Combined Vertical and Lateral Connectivity



Vertical & Lateral Connectivity



Combined Vertical and Lateral Connectivity



Conclusions



 Wrap-up (Conclusions)

- ❖ Dams block primarily coarse sediment & let pass very fine sediment
 - Downstream of dams: coarse sediment-hungry rivers only get fine sediment
 - Vertical disconnection (riverbed clogging) & lateral disconnection
- 💡 Numerical modeling provides predictive guidance for local actions, but calibration is challenging
- 💡 Local ecohydraulic engineering: improved continuity in mountain rivers & large wood placement



University of Stuttgart
Germany

Thank you



Dr. sc. (PhD) Sebastian Schwindt

sebastian.schwindt@iws.uni-stuttgart.de
<https://www.iws.uni-stuttgart.de>
+49 (0)711 685 64 789

Dept. of Hydraulic Engineering and Water Resources Management
Prof. Dr.-Ing. Silke Wieprecht
University of Stuttgart