



University of Stuttgart
Germany

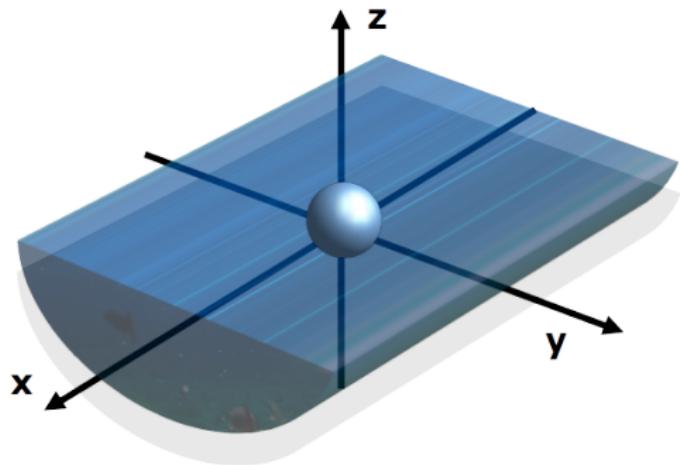
Ecohydraulic Engineering of Water Resources

Analysis & Management of Connectivity

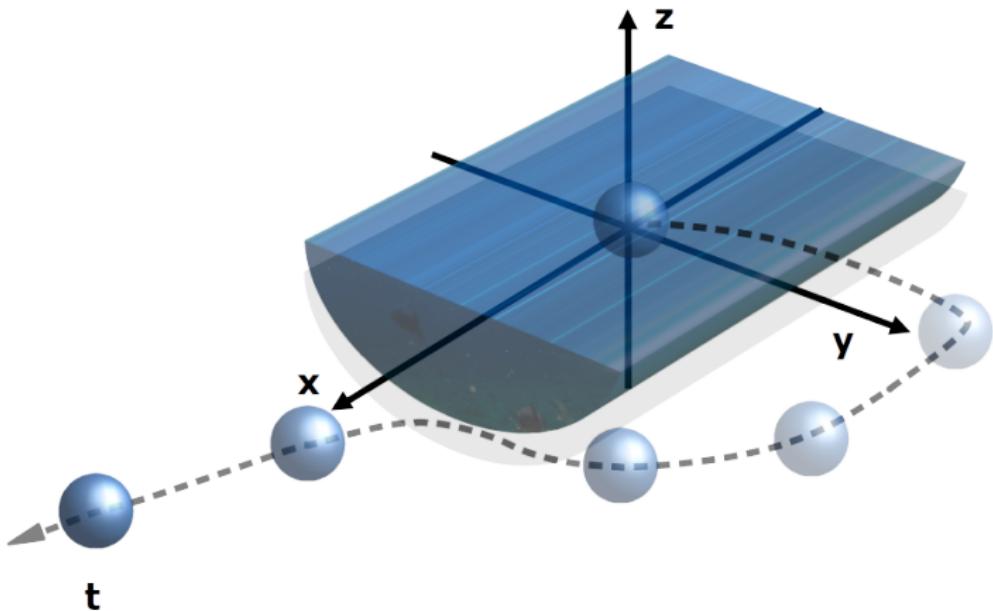
Dr. sc. (PhD) Sebastian Schwindt



Connectivity Dimensions: Space & Time Axes



Connectivity Dimensions: Space & Time Axes



Engineering: Problem & Solution



Devoll River, Albania



Engineering: Problem & Solution



Engineering: Problem & Solution



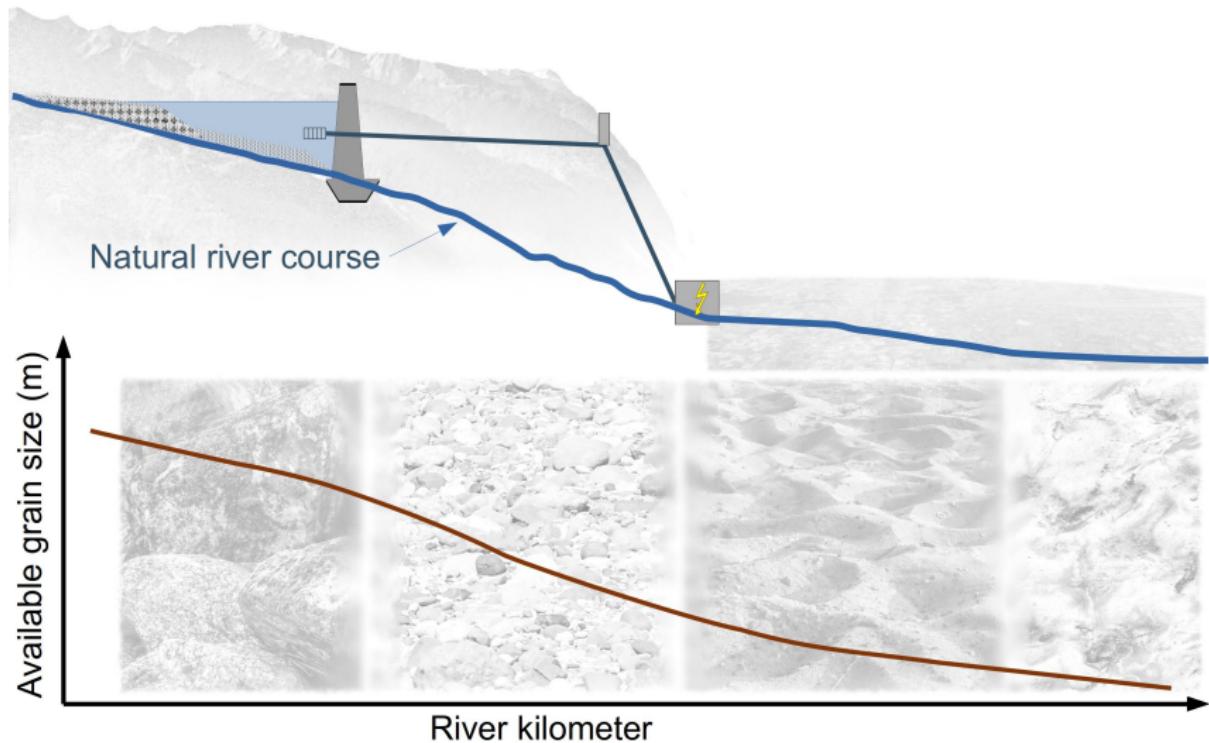
Reconnecting the x-axis: harm vs. utility of dams



Engineering: Problem & Solution



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



Inn River, Germany



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

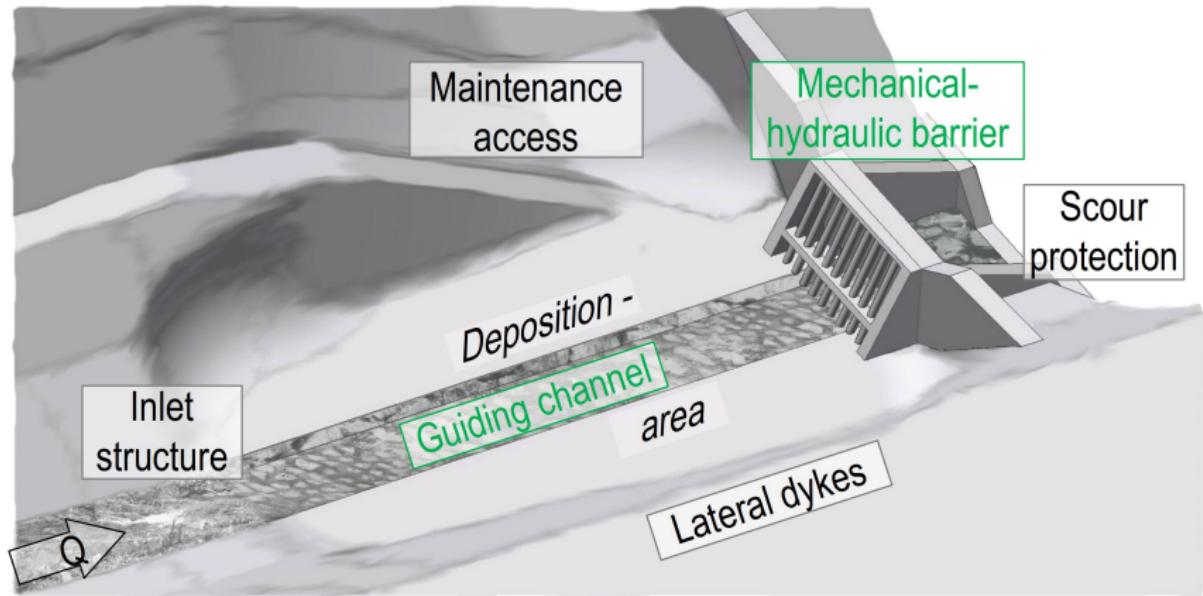


Mountain River Engineering



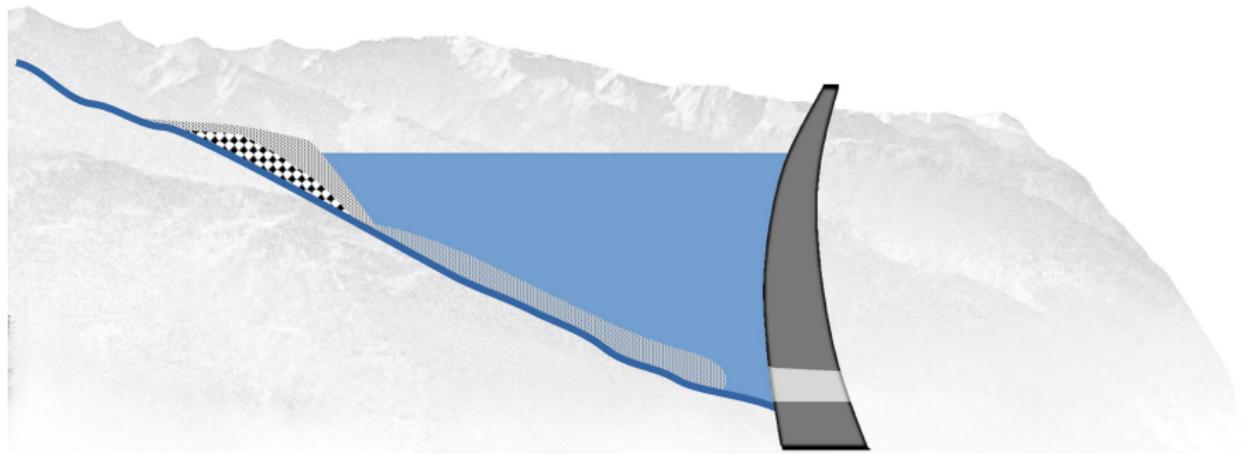
Longitudinal Connectivity

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

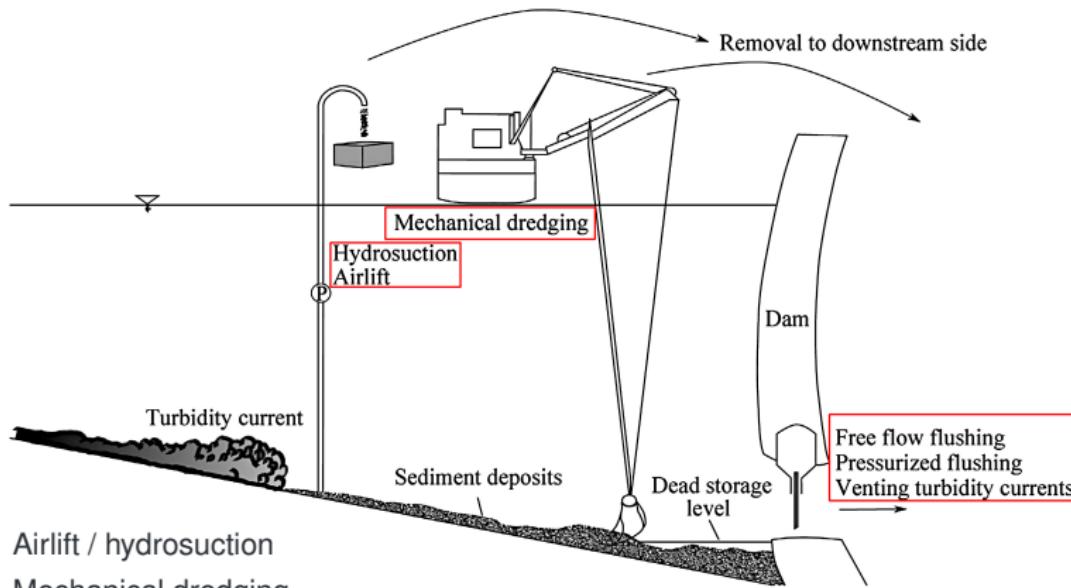
Longitudinal Connectivity ✖

Sediment Management in Reservoirs



Longitudinal Connectivity

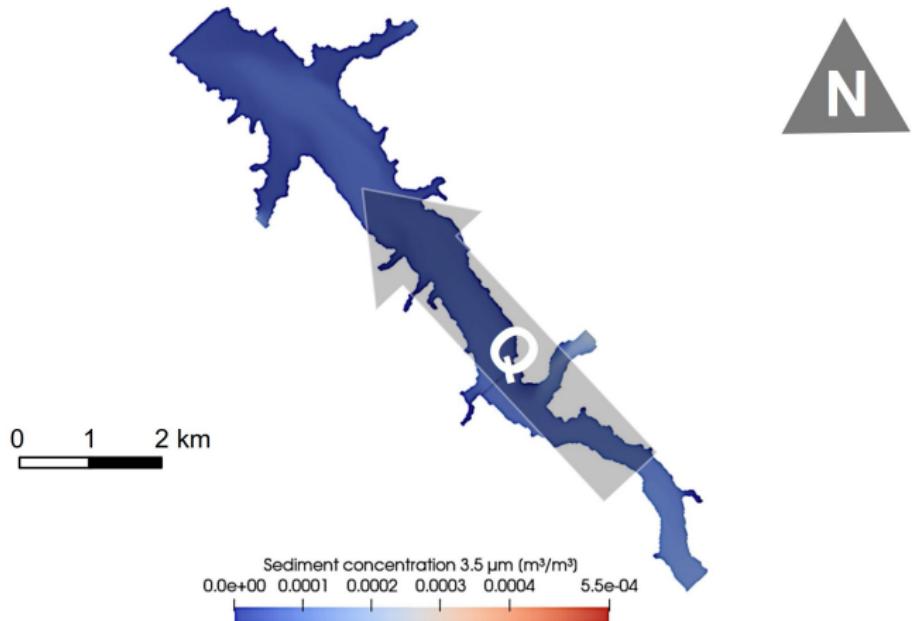
Sediment Management in Reservoirs



- 👉 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



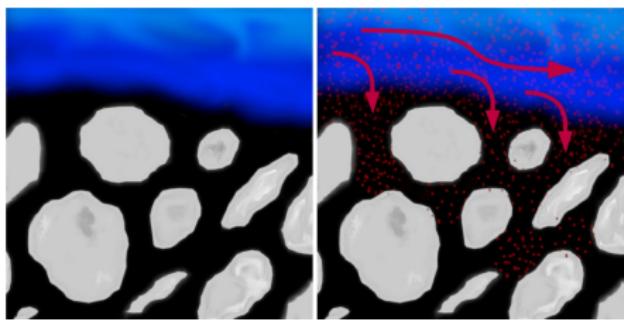
Inn River, Germany



Vertical & Lateral Connectivity



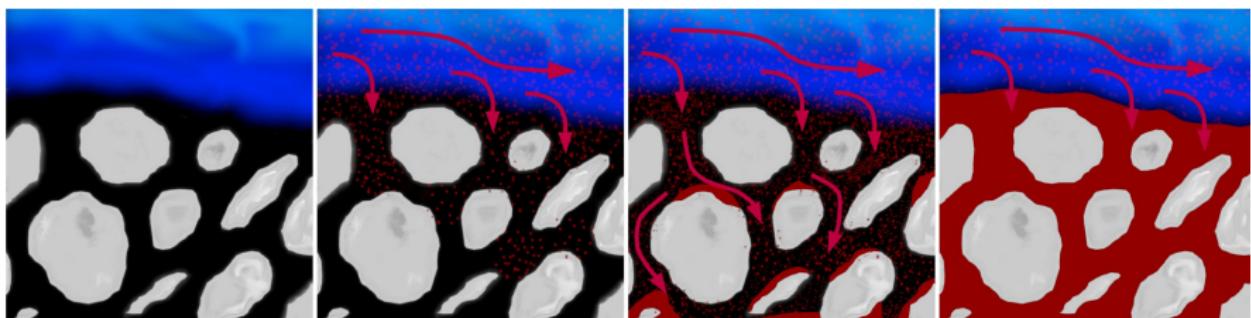
Vertical Disconnectivity: Riverbed Clogging



Vertical & Lateral Connectivity

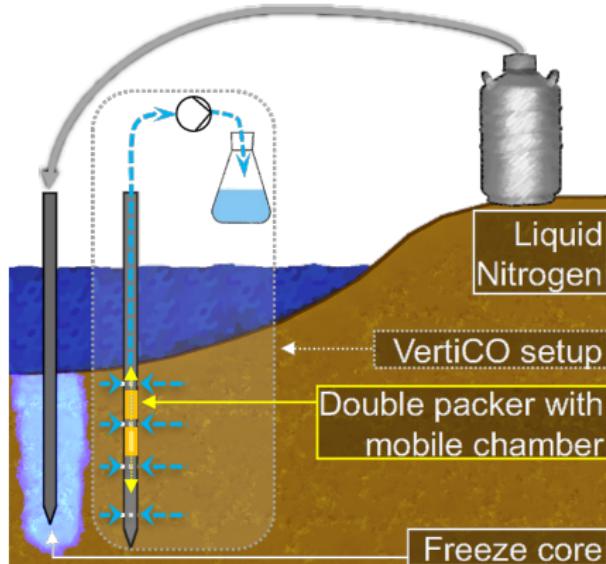


Vertical Disconnectivity: Riverbed Clogging



Vertical & Lateral Connectivity

Riverbed Clogging Measurement Methods



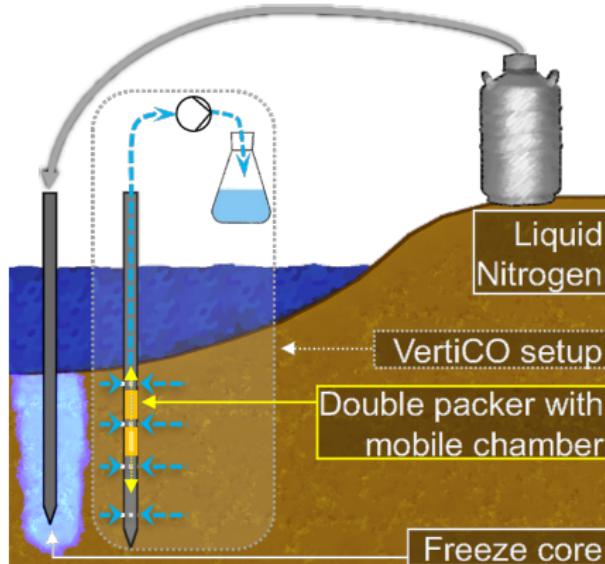
The Multi-Parameter Approach for assessing riverbed Clogging (MultiPAC – Negreiros et al., 2023; Seitz, 2020. Imagery: Schwindt et al., 2023)



MultiPAC measurements at the Inn

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)

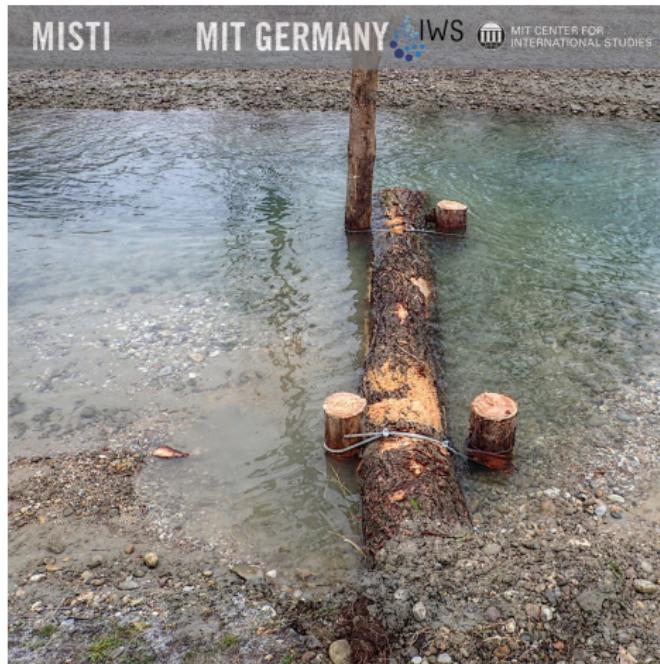


MultiPAC measurements at the Inn
↳ **Grain sizes, porosity, interstitial dissolved oxygen concentration (IDOC), hydraulic conductivity**

Vertical & Lateral Connectivity



Engineering Solutions to Reinstate Vertical Connectivity Locally

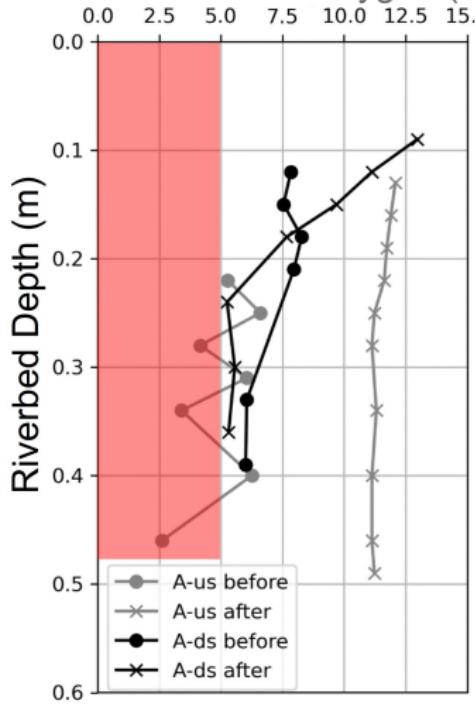


Vertical & Lateral Connectivity

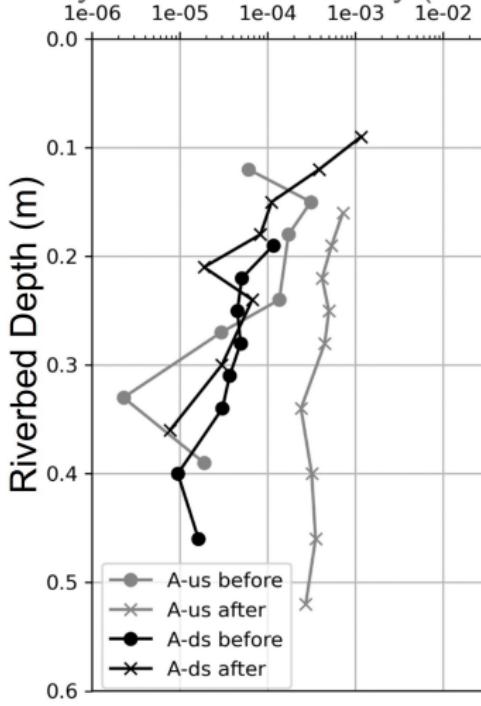


Engineering Solutions to Reinstate Vertical Connectivity Locally

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

Reconnecting the y-axis: bank removal



Vertical & Lateral Connectivity

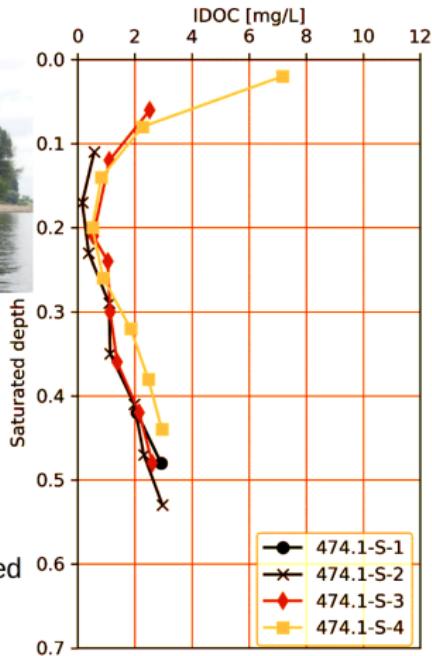
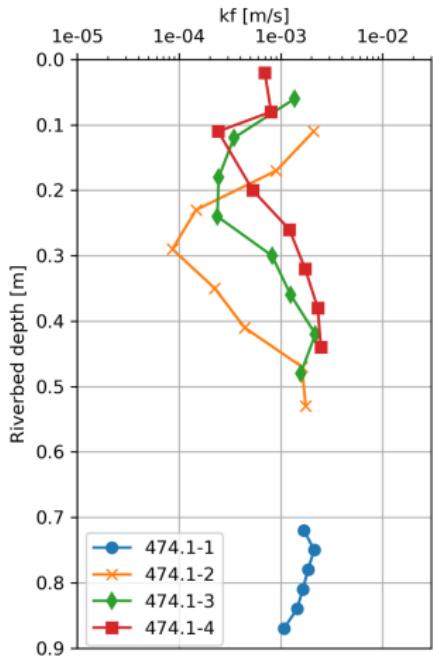


Combined Vertical and Lateral Connectivity



Vertical & Lateral Connectivity

Combined Vertical and Lateral Connectivity

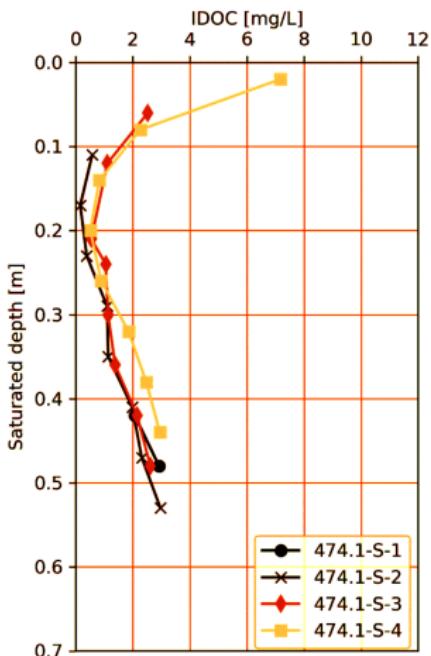


k_f : hydraulic conductivity

IDOC : Interstitial Dissolved Oxygen Concentration

Vertical & Lateral Connectivity

Combined Vertical and Lateral Connectivity



Vertical & Lateral Connectivity



Combined Vertical and Lateral Connectivity



 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



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Thank you



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