New element for optimizing the functioning of sediment traps

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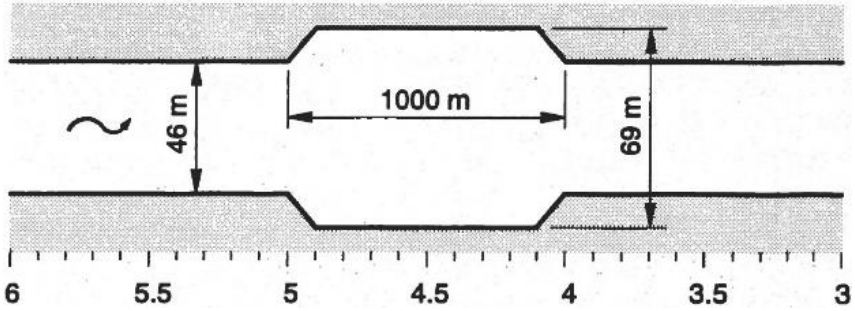
LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES
http://lch.epfl.ch

Working principles

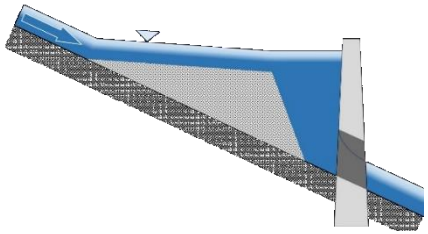
River widening (retention basin)



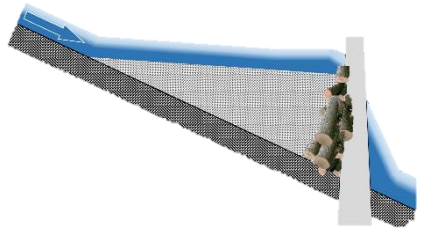
source: Hunzinger (1995)

Retention volume & slope reduction

Open sediment check dam



Hydraulic obstruction



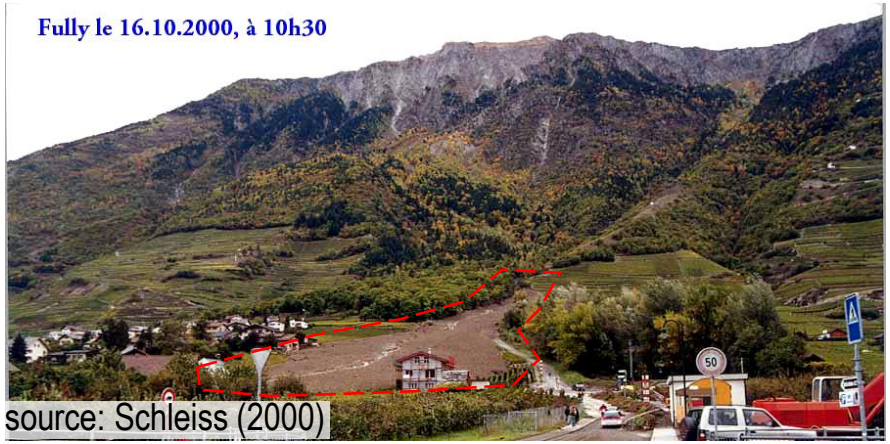
Mechanical obstruction

Piton & Recking (2016)

Obstruction → sediment retention

Sediment retention vs. continuity

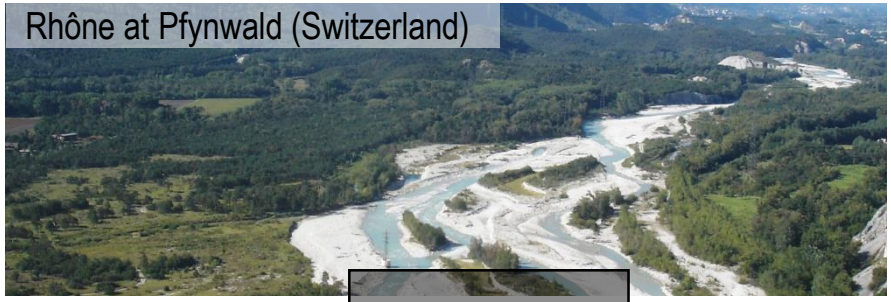
Insufficient retention: risk at floods



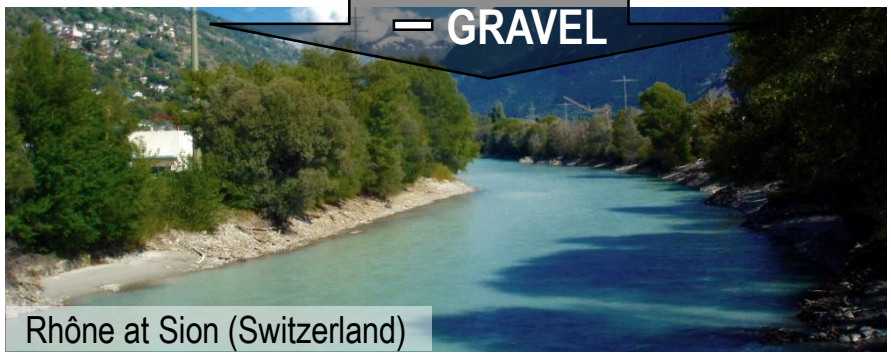
source: Schleiss (2000)

source: Theophilus (2013)

Too much retention: channel incision



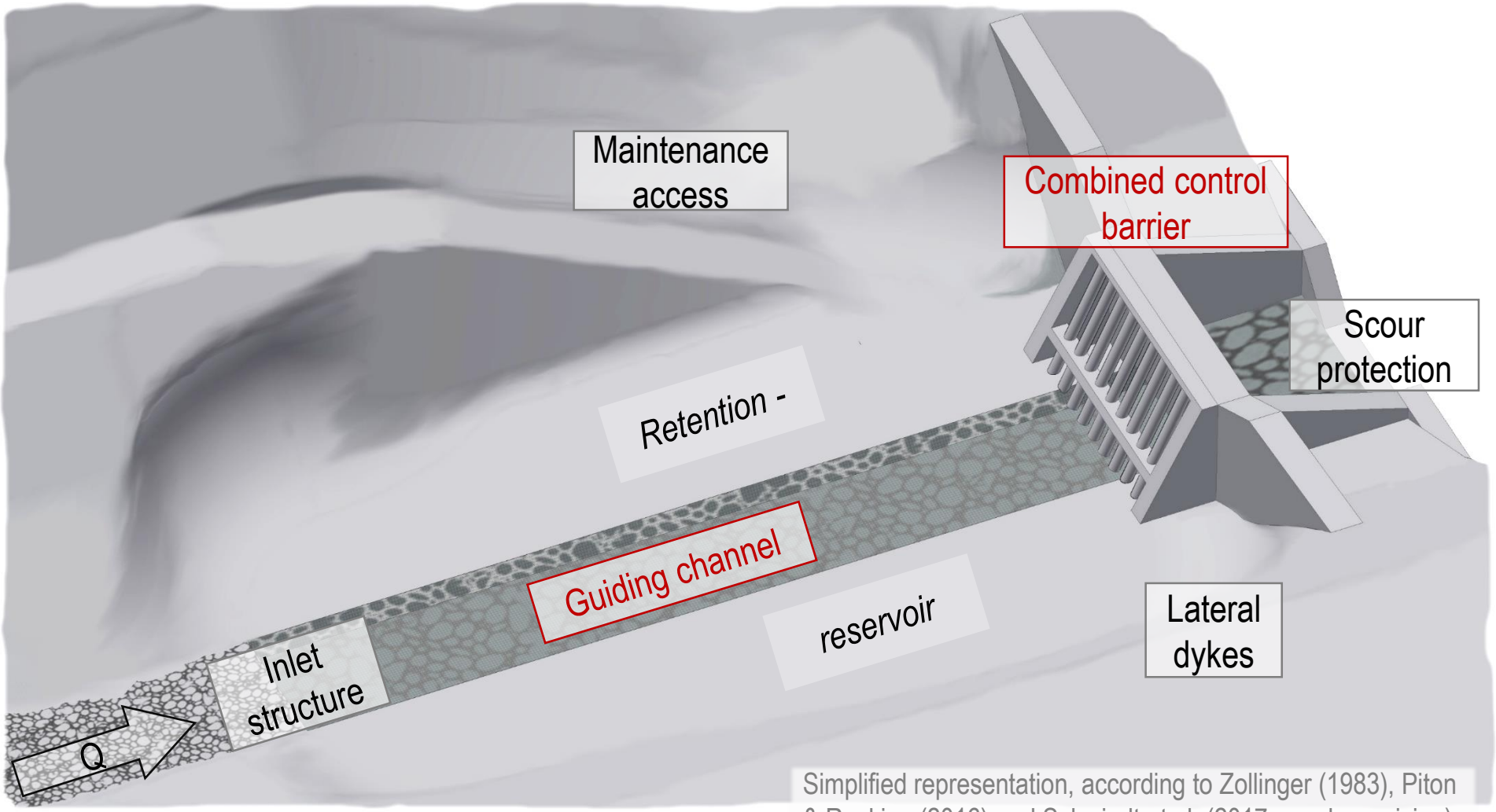
Rhône at Pfynwald (Switzerland)



Rhône at Sion (Switzerland)

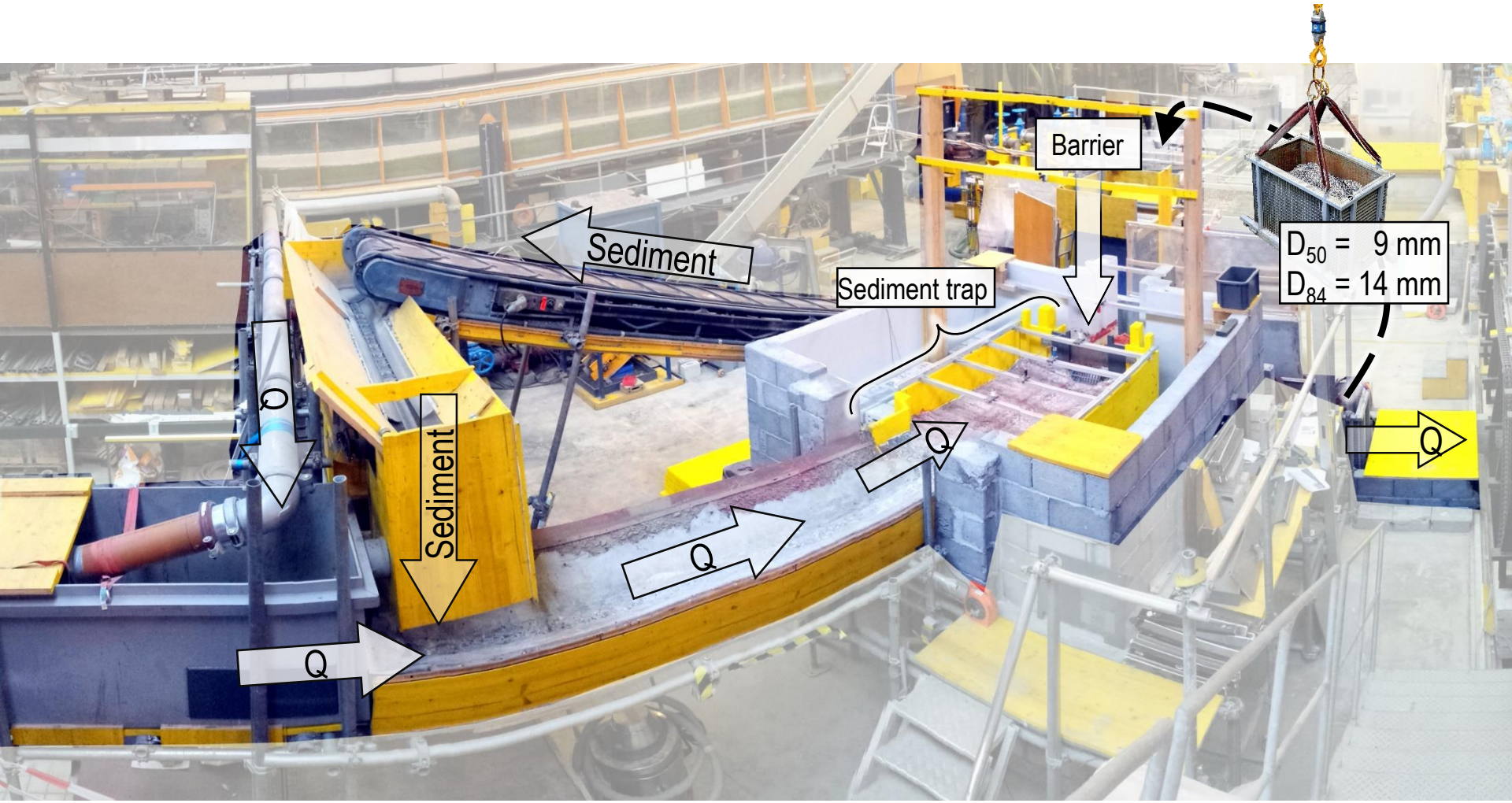
Seti Gandaki River (Nepal)

Updating the concept for sediment traps

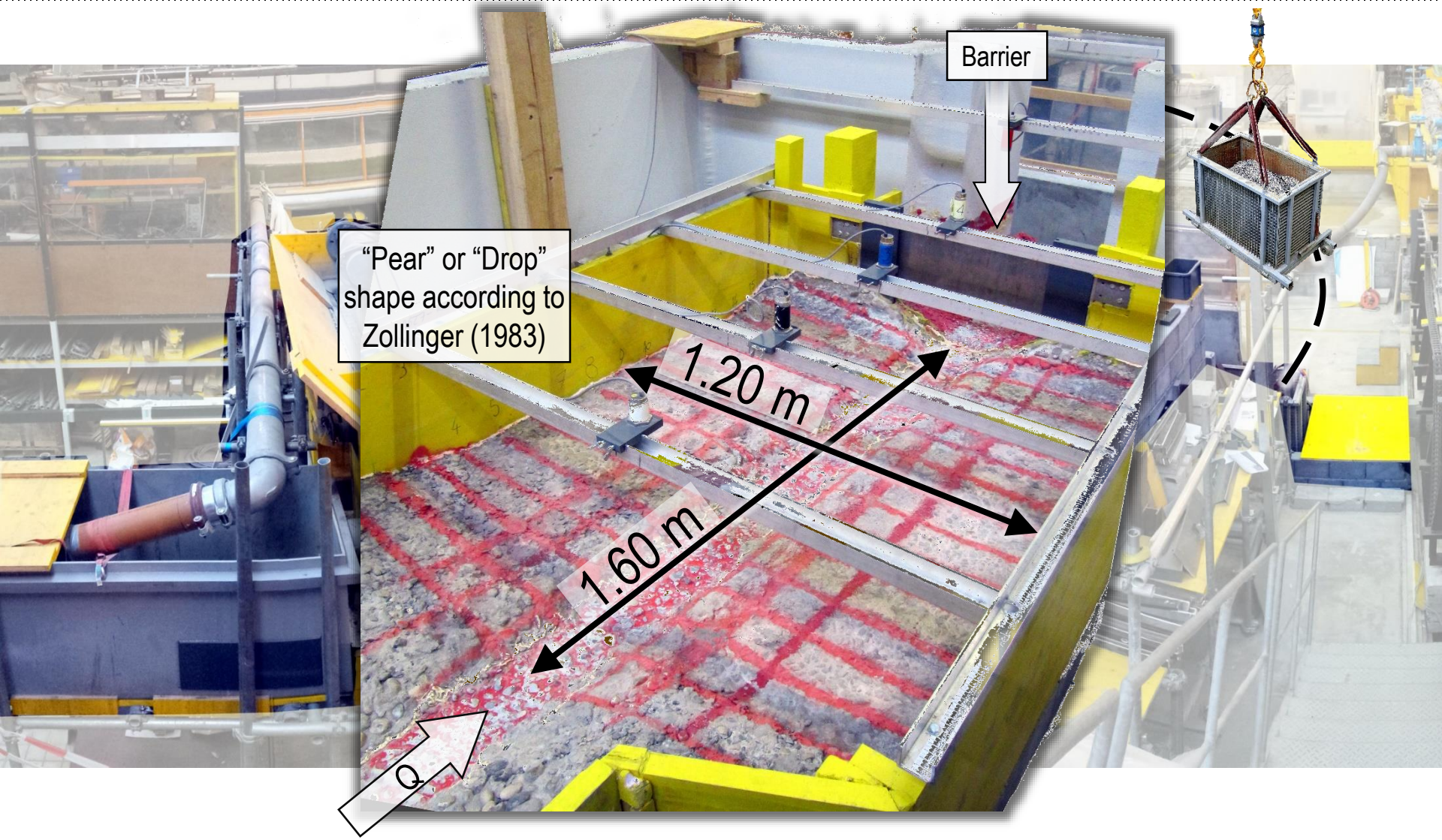


Simplified representation, according to Zollinger (1983), Piton & Recking (2016) and Schwindt et al. (2017c, under revision)

Design of a physical model

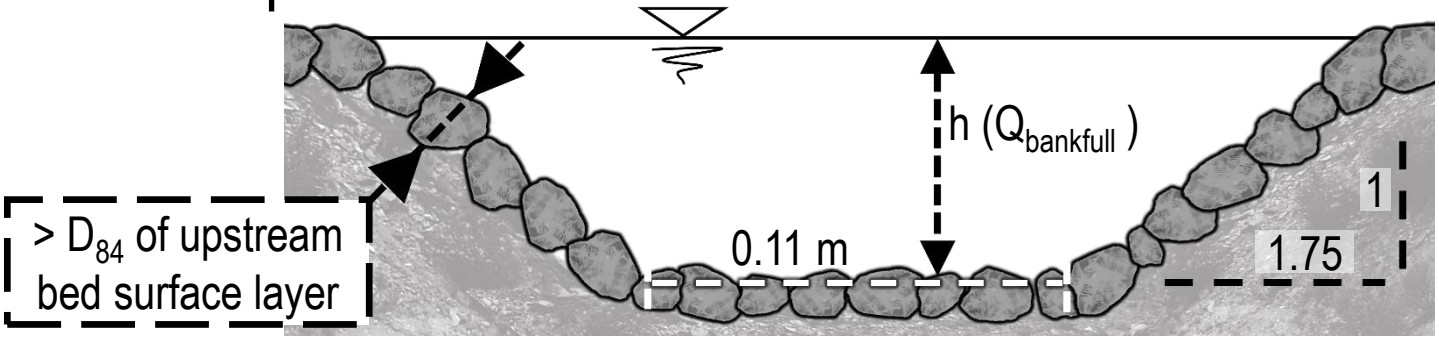


Design of a physical model



Design of the Guiding Channel

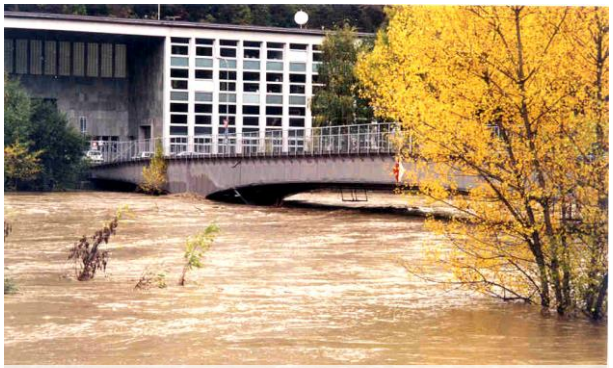
- Hydraulic requirements



- Trapezoidal shape (132 datasets), slope oriented at downstream reaches (experiments: 5.5 %)
- Bankfull discharge $Q_{bankfull}$ > morphologically effective, dominant discharge (Wolman & Miller, 1960)
- Verification of the discharge & bed load transport capacity of downstream bottlenecks (bridges)

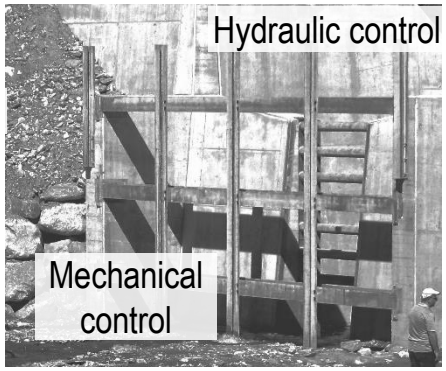
→ Smart & Jaeggi (1983) for bed load transport capacity

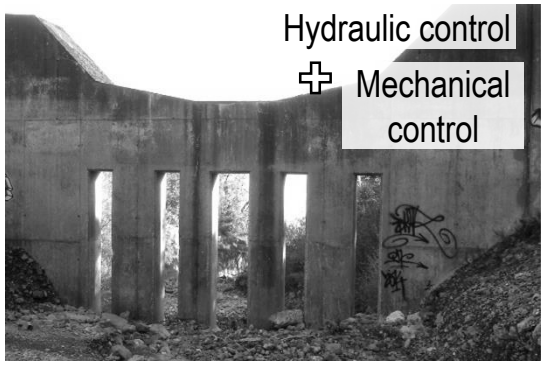
→ apply D_{84} of "travelling bed load" (Piton&Recking 2017)

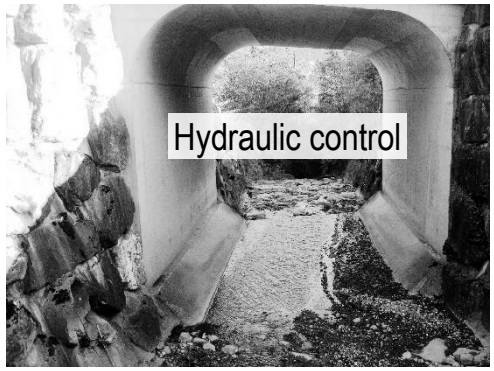


Rhône flood in 2000 (Switzerland, source: LCH, 2000)

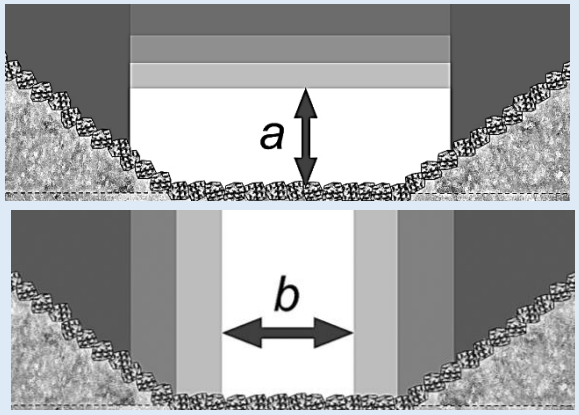
Open sediment check dams







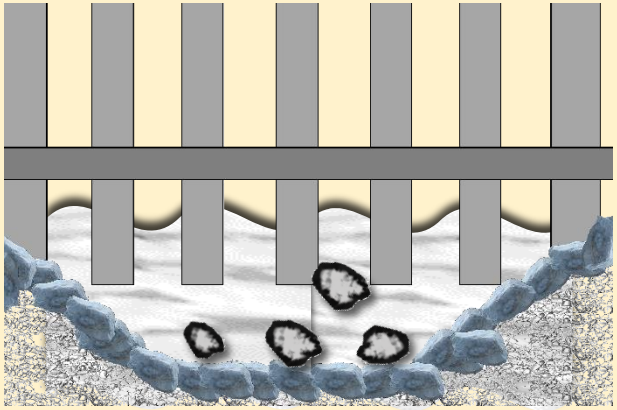
Hydraulic control



Problem:

Unwanted sediment flushing!

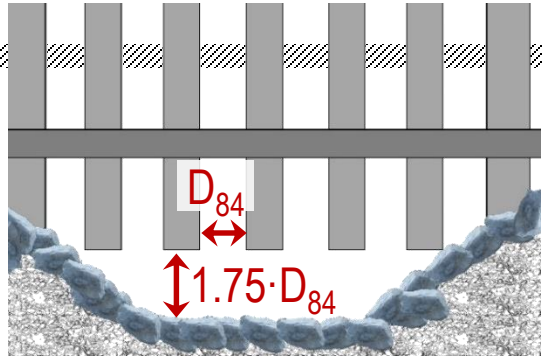
Mechanical control



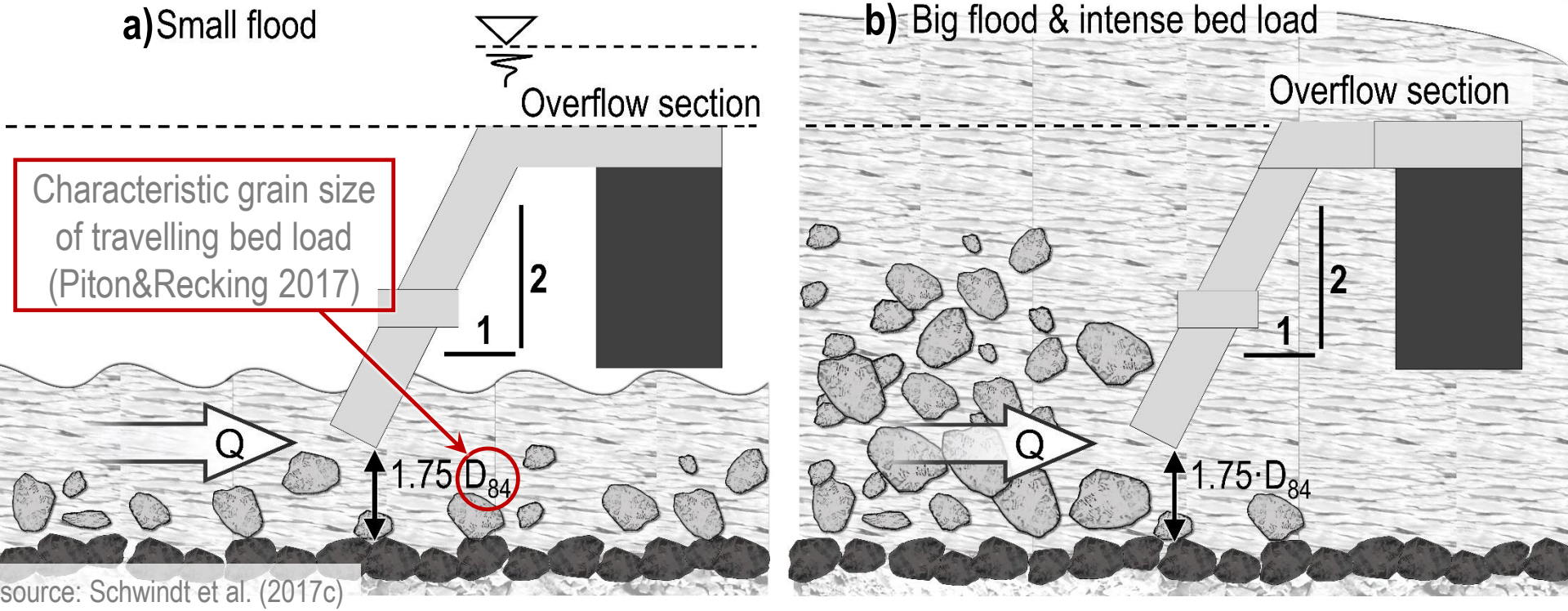
Problem:

Uncertainties in grain sizes!

Updating the concept for sediment traps



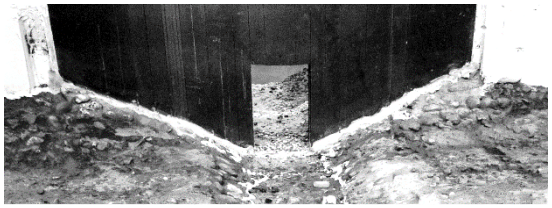
- Combination of barriers (Schwindt et al. 2017c, under review)
  - screen with vertical bars for mechanical control
  - open sediment check dams (flow constriction) for hydraulic control



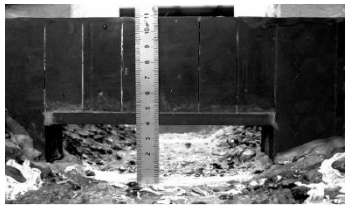
source: Schwindt et al. (2017c)

Experimental design

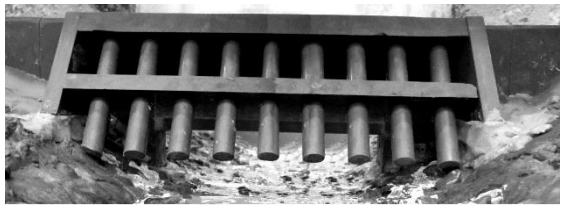
- Comparison of deposition control barriers:



non-overflown barrier (hydraulic deposition control only)

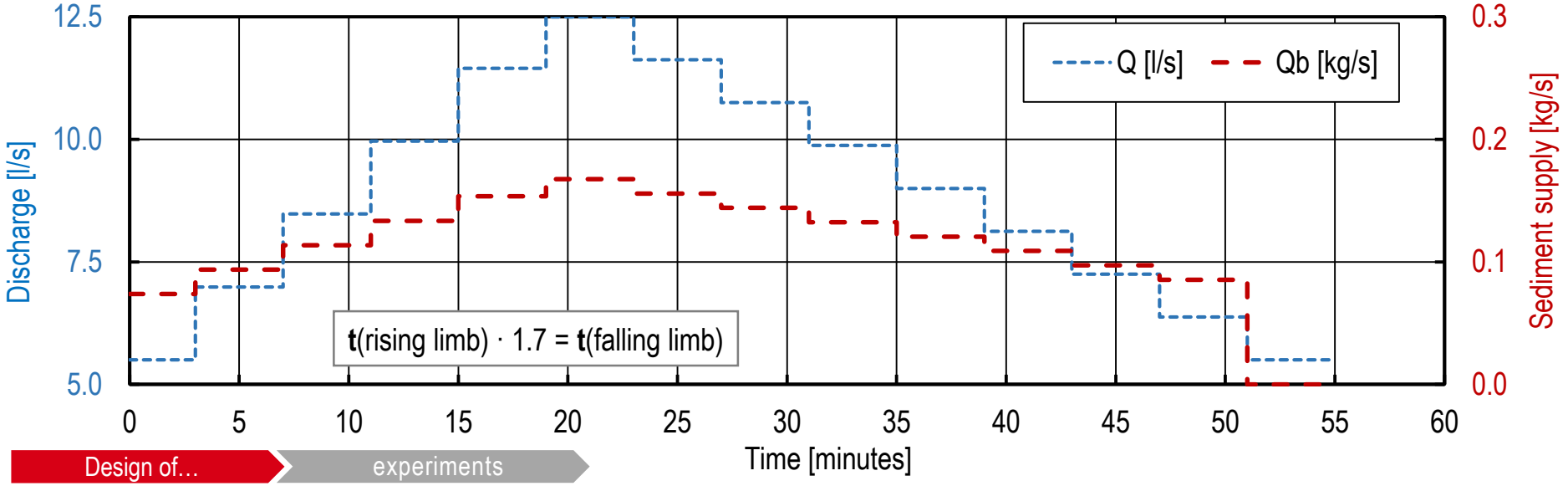


overflown barrier (hydraulic deposition control only)



overflown barrier + bar screen (combined controls)

- Steady-state experiments: $Q_{bankfull} \approx 5.5$ l/s + Q_b (Smart&Jaeggi)
- Application of a standardised Hydrograph (2 repetitive runs)



Measuring devices

- Outflowing discharge:

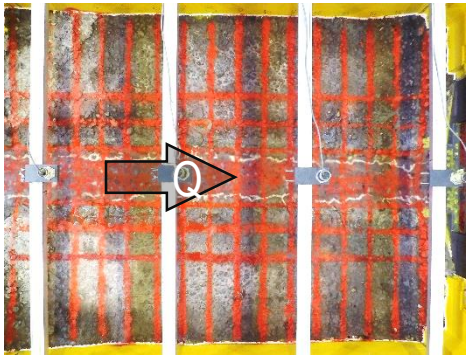
→ minute-wise

- Sediment deposit pattern

→ continuously from the top (GoPro)

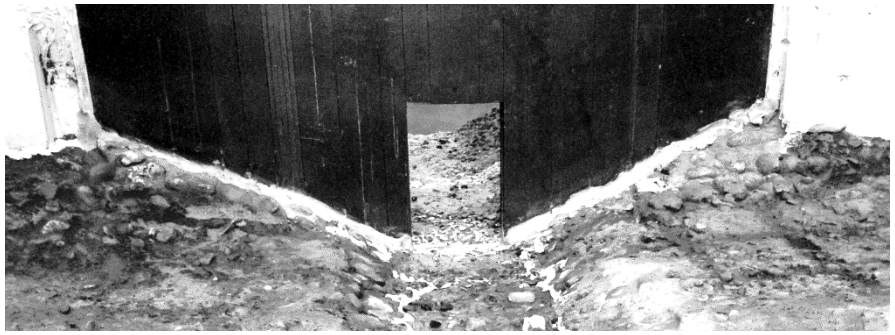
→ at the end of every experimental run

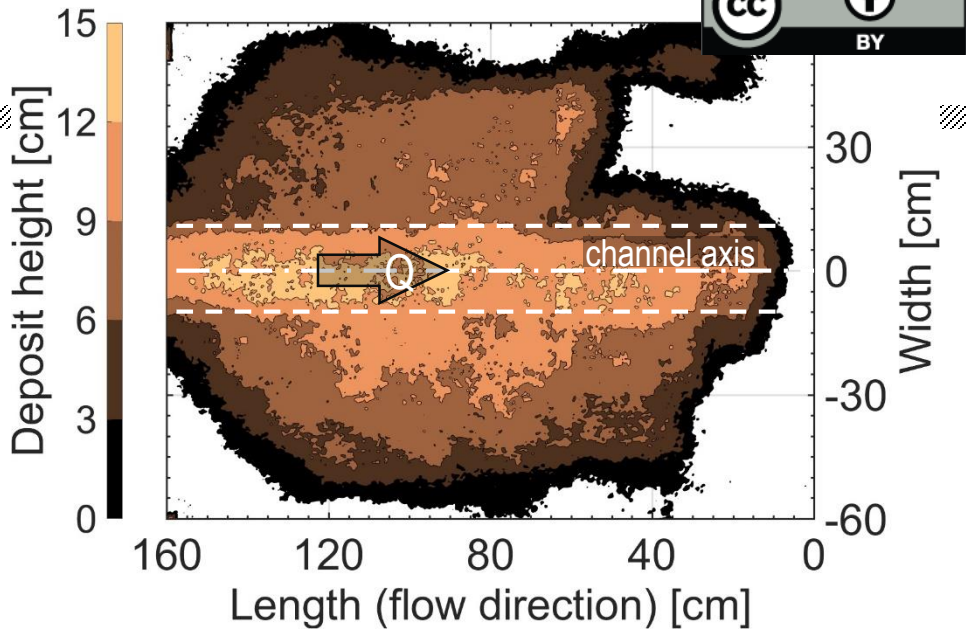
⇨ motion sensing camera (type: Microsoft Kinect V2)

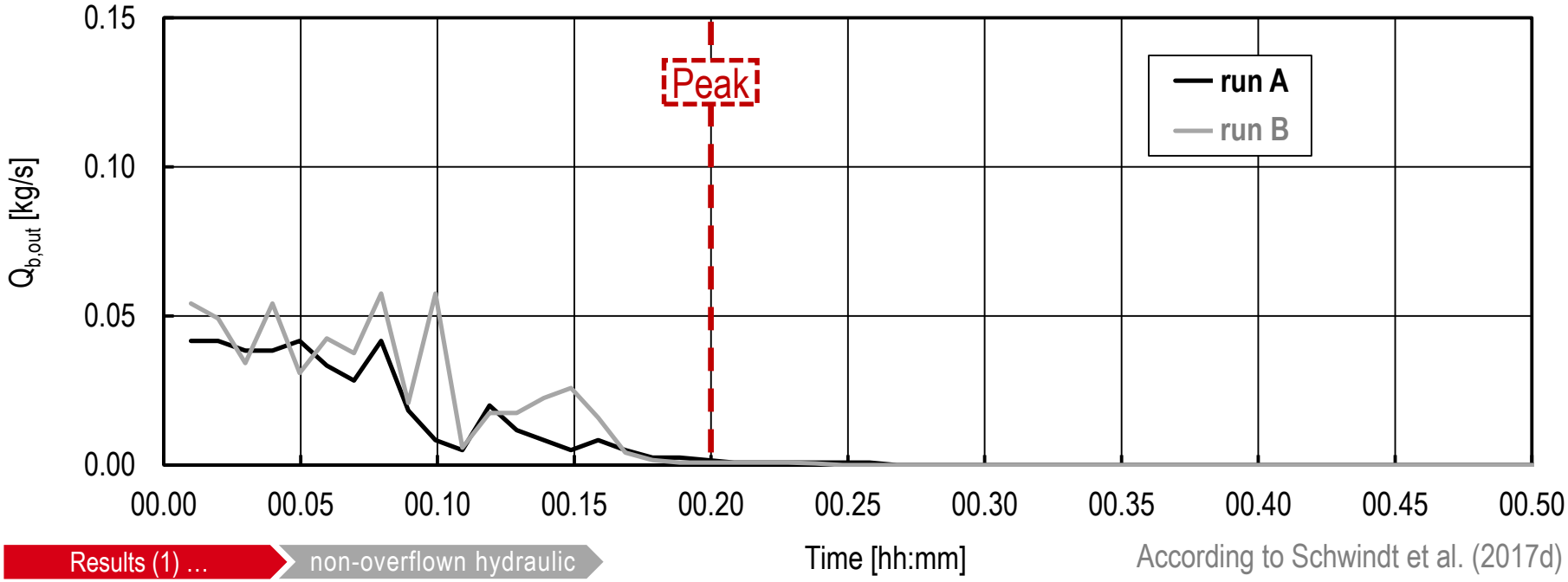


Principal results (1)

Non-overflown hydraulic barrier



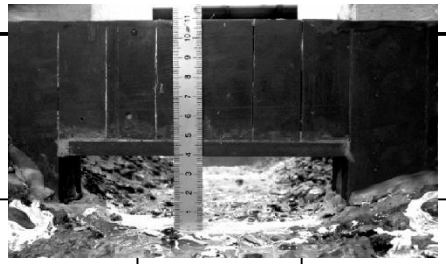


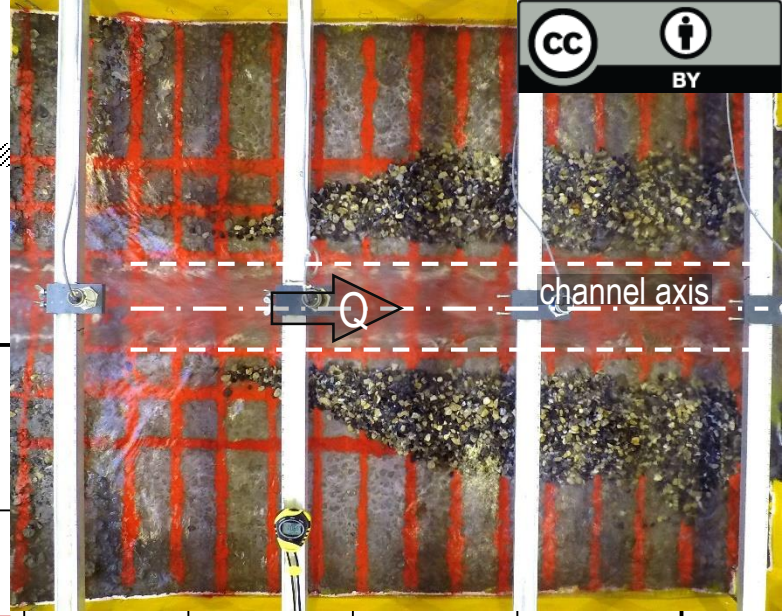


According to Schwindt et al. (2017d)

Principal results (2)

Overflown hydraulic barrier

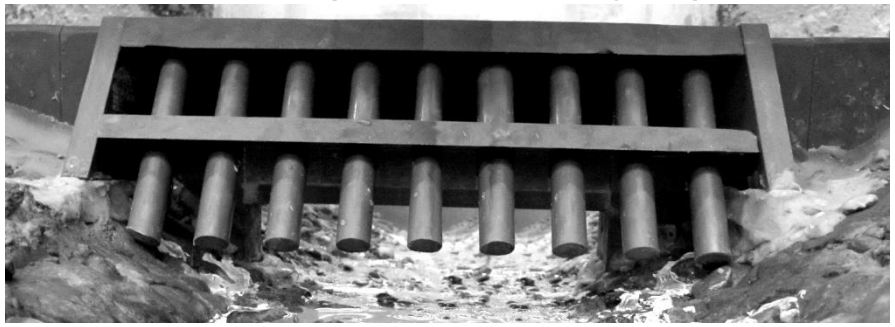


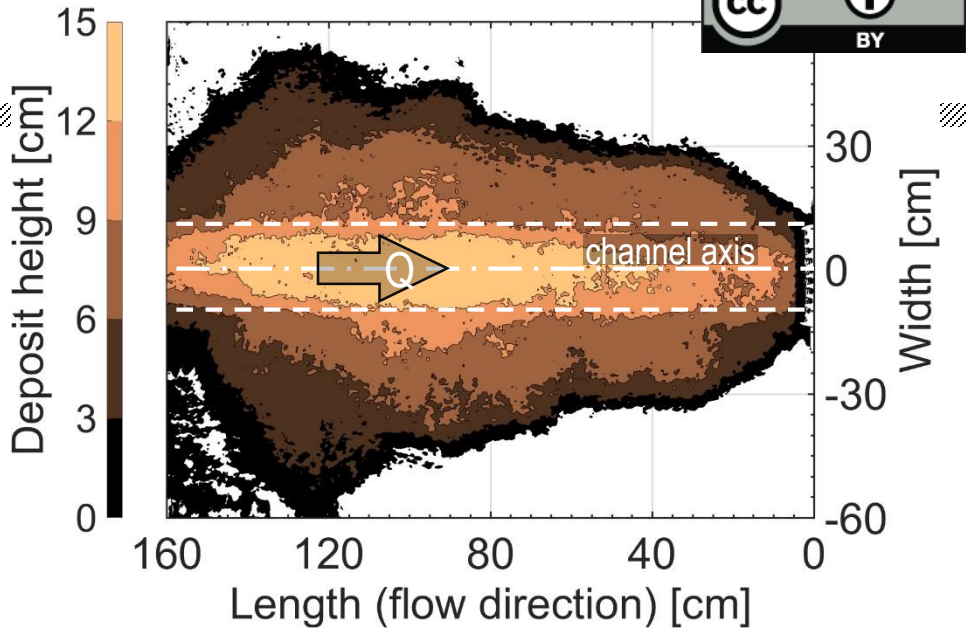


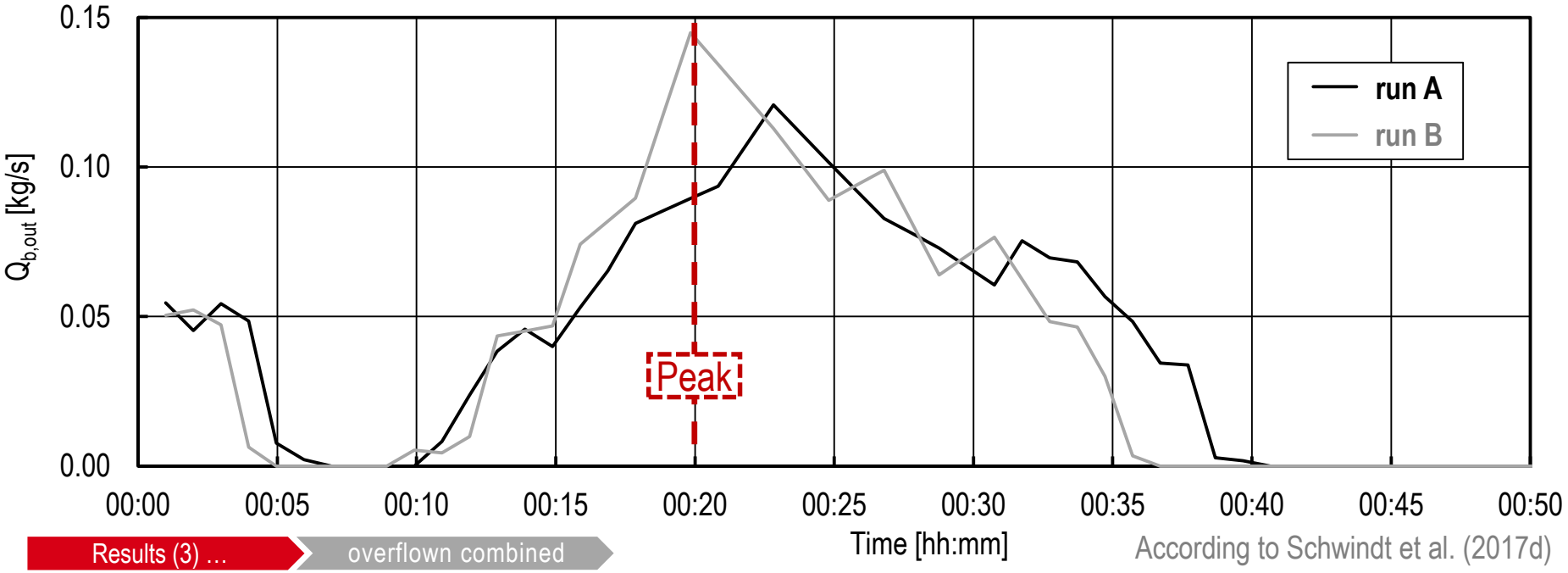
According to Schwindt et al. (2017d)

Principal results (3)

Combined (mech. + hyd.) barrier







According to Schwindt et al. (2017d)

A case study . . .

Drance, upstream of Martigny (Valais, Switzerland)

→ Optimization of a filter check dam

→ 1:42 scaled Froude model

→ Test of a flood hydrograph + sediment supply

Adapted from LCH (2016)

Orifice for hydraulic only: sediment flushing (falling limb)

- Literature: Mechanical clogging impossible when the clearance is > 2.0·D_{84}
- Combined barrier: clogging is still possible for the vertical clearance height of 2.6·D_{84} !

→ reduction of the sensitivity with respect to D_{84}

Conclusions

- Guiding channel allows for sediment transfer up to its bankfull discharge
- Combined deposition crontrol barrier:
  - The backwater of the hydraulic control orifice reduces the sensitivity of the mechanical retention devices (e.g., bar screens) with respect to the expected characteristic grain diameter;
  - The mechanical control in terms of a bar screen prevents unwanted sediment flushing;

Scientific papers:

- Schwindt S., Franca M.J. & Schleiss, A.J. (2017c): Analysis of sediment deposition control measures in steep rough channels, *Geomorphology*, (under review).
- Schwindt S., Franca M.J. & Schleiss, A.J. (2017d): Experimental Concept Study of partially permeable Sediment Traps (under review).

Thanks to …

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Confederaziun svizra

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