Airborne Laser Bathymetry im Dienste der Europäischen Richtlinien für ein integratives Fließgewässermanagement

Priv.-Doz. Dipl.-Ing. Dr. Christoph Hauer

Outline

- Legal aspects
- Environmental processes
- Scaling in the river environment
- Case study Pielach
- Possible future aspects in ALB
- Summary and Conclusion

Legal aspects (Directives)

EU – HW-Richtlinie

Directive 2007/60/EC

Ziele

- Wirksame HW-Vorsorge
- Begrenzung HW-Schäden

Umsetzung

- Bewertung HW-Risiko
- Erstellung HW-Risikokarten
- HW-Risikomanagement

EU – WRRL-Richtlinie

Directive 2000/60/EC

Ziele

- Guter ökologischer Zustand
- Gutes ökologisches Potenzial

Umsetzung

- Hydrologische Maßnahmen
- Gewässerrückbau

EU – EE-Richtlinie

Directive 2009/28/EC

Ziele

- Erhöhung des Anteils an erneuerbarer Energie auf 20%

Umsetzung

- Zunahme der Wasserkraftnutzung

Conflicts of interests **Conflicts of interests**

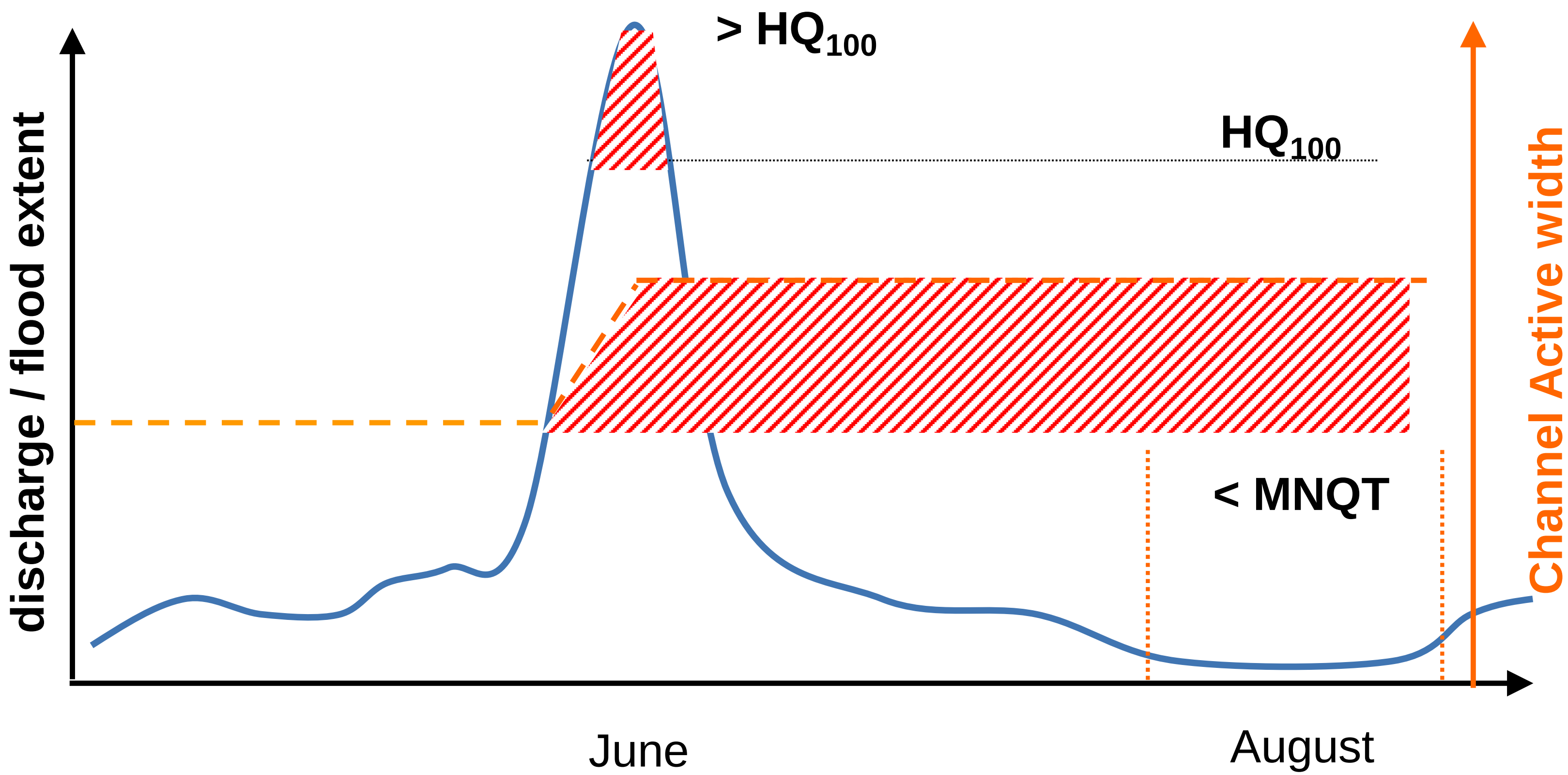
solutions **solutions**

Environmental processes

⇨ ***Dynamic component*** is crucial!

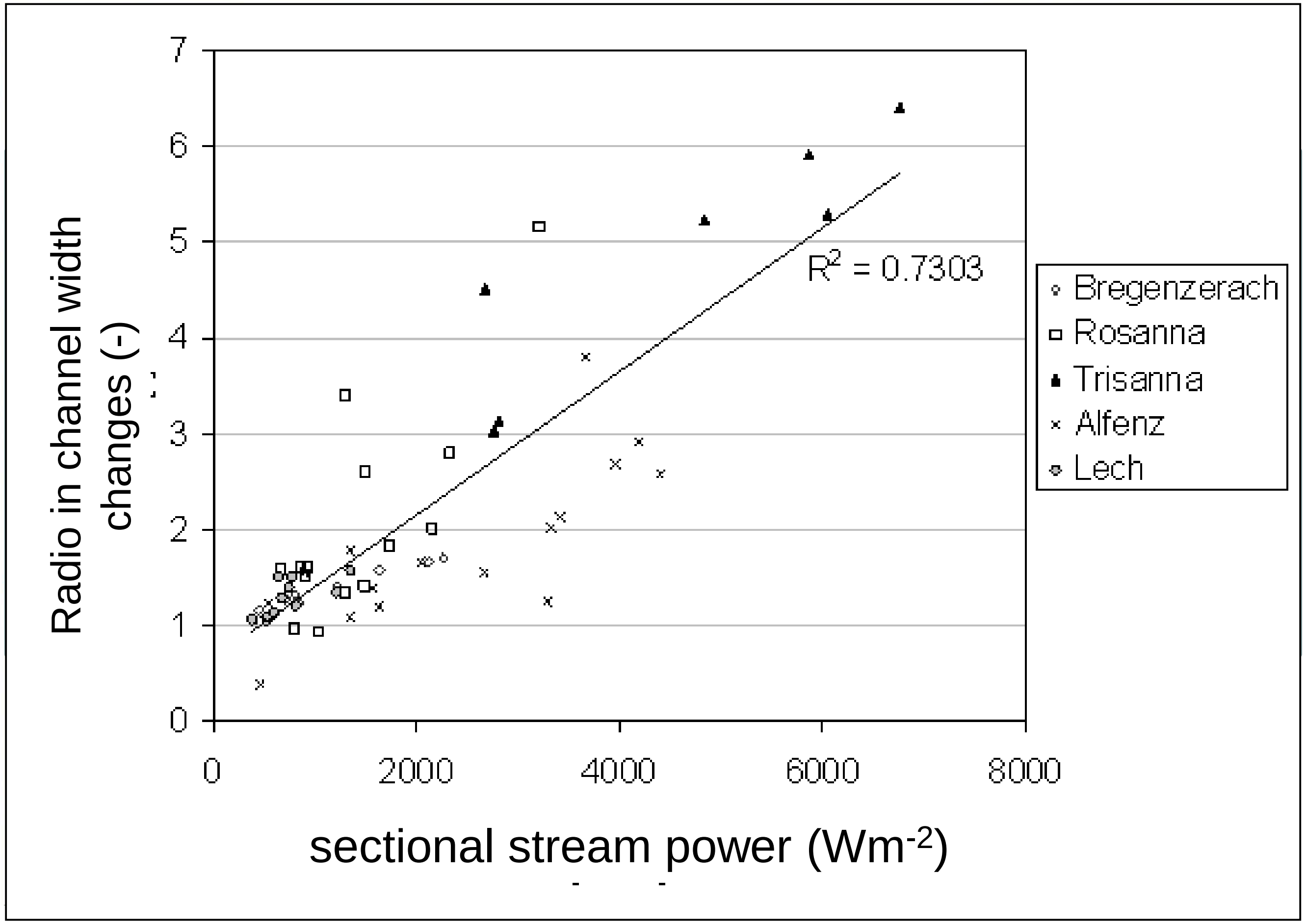
Year 2013

technical HE-solutions



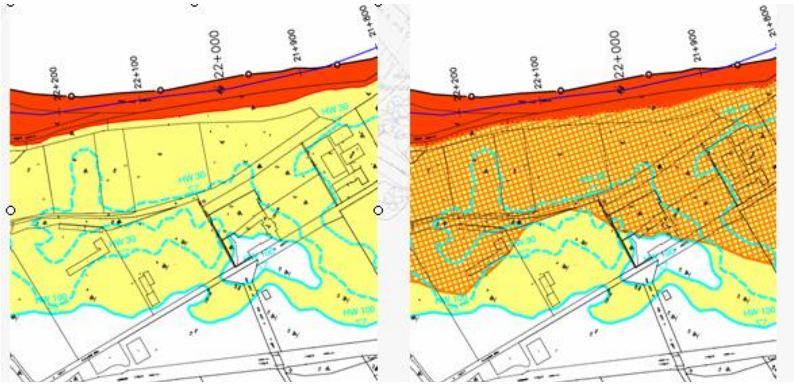
Improved process understanding required

floodings 2005 / Tyrol, Vorarlberg



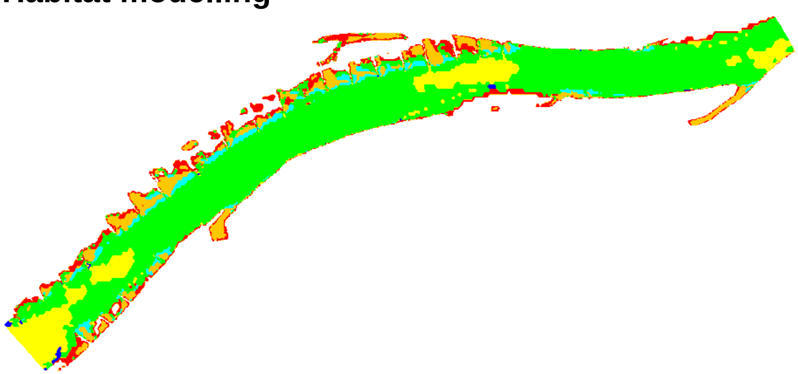
Integrative Analysis Floods Directive / Water Framework Directive

Flood hazard maps



©Hinterleitner, 2004

Habitat modelling



DIRECTIVES

DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 23 October 2007

on the assessment and management of flood risks

(Text with EEA relevance)

(17) Development of river basin management plans under ***Directive 2000/60/EC*** and of ***flood risk management plans*** under this Directive are elements of ***integrated river basin management***. The two processes should therefore use the ***mutual potential for common synergies and benefits***, having regard to the ***environmental objectives of Directive 2000/60/EC***, ensuring efficiency and ***wise use of resources*** while recognising that the competent authorities and management units might be different under this Directive and Directive 2000/60/EC.

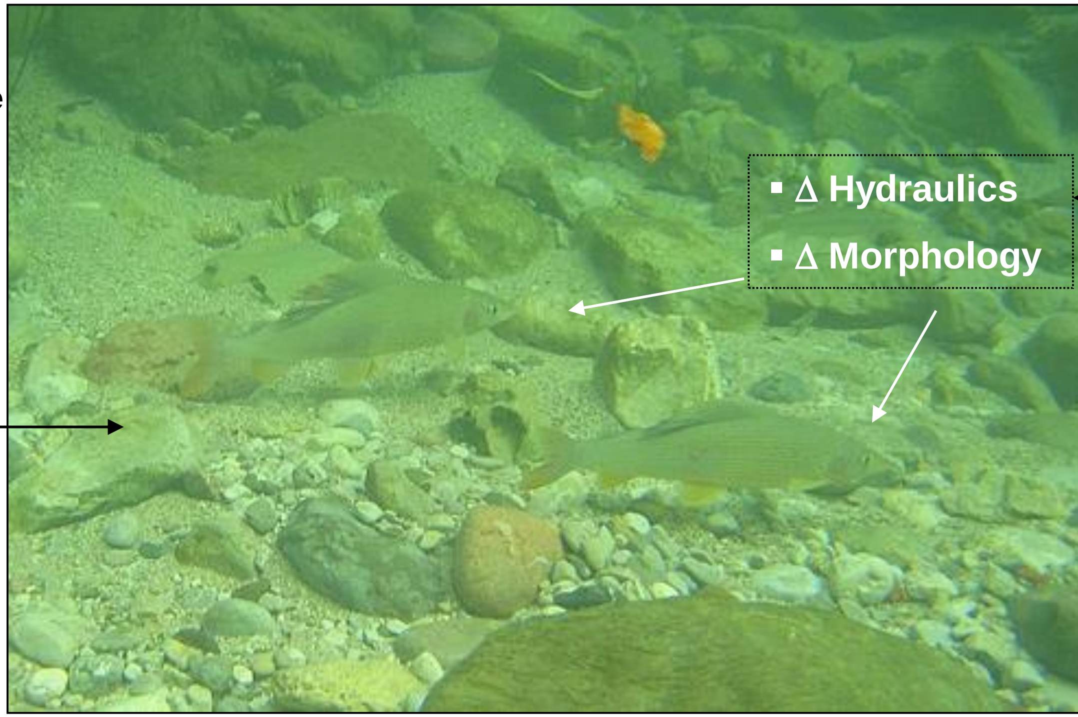
(18) Member States should base their assessments, maps and plans on appropriate ‘best practice’ and ***‘best available technologies’*** not entailing excessive costs in the field of flood risk management.

L 288/28 EN Official Journal of the European Union 6.11.2007

(1) OJ L 311, 14.11.2002, p. 3.

Ecohydraulics / Habitatmodelling

- **water quality**
- **water temperature**
- **light**
- **usw.**

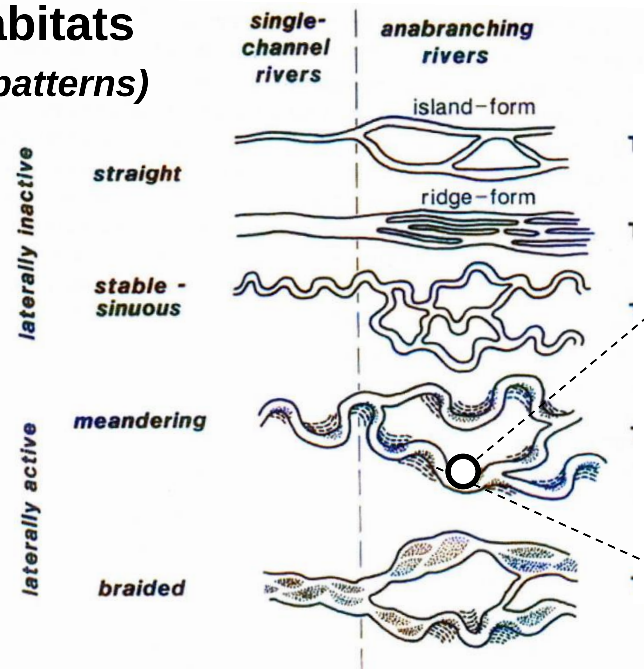


Δ Hydrology

Main advantage: quantitative, objectively comparable data of habitat distribution (e.g. fish, macroinvertebrates) related to changes in hydraulics and morphology

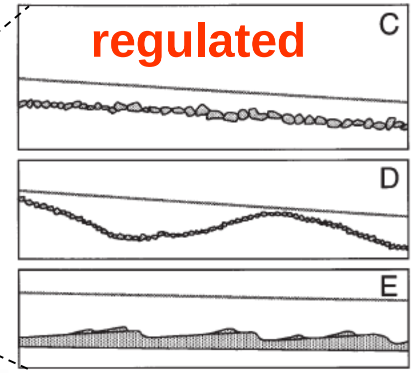
Scaling: river morphology / habitat

macrohabitats
(planform patterns)

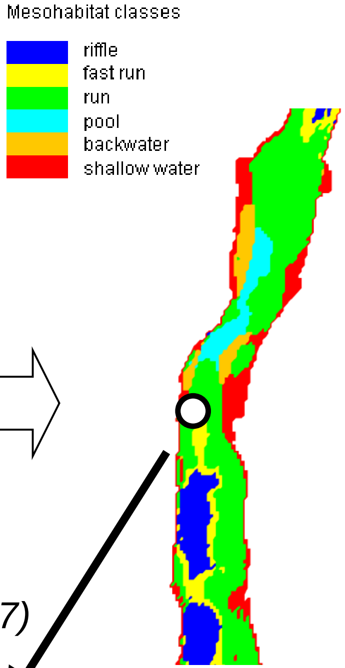


(Nanson & Knighton, 1996)

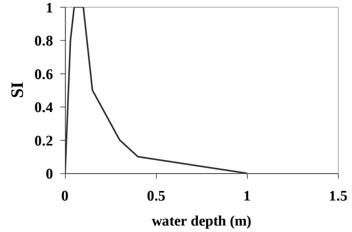
mesohabitats
(hydro-morphological units)



(Montgomery & Buffington, 1997)



microhabitats
(e.g. local flow-velocity, sediment size)



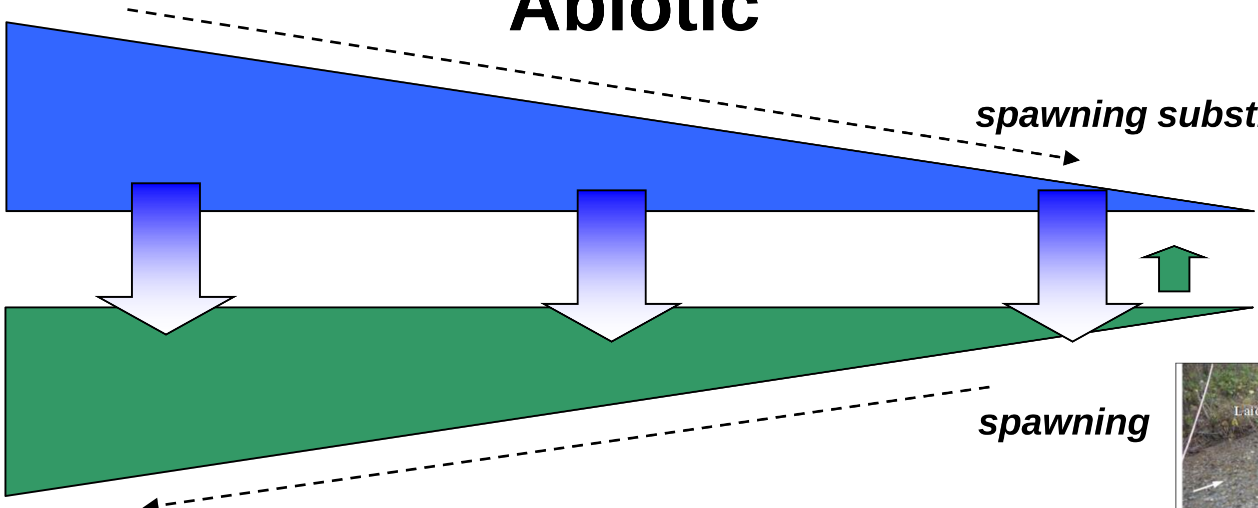
Downscaling / Upscaling

macrohabitats mesohabitats microhabitats **ALB**

sediment continuum

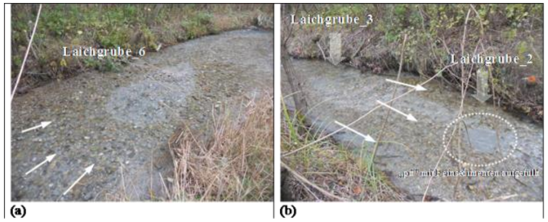
Abiotic

spawning substrate



z.B. digging of spawning redds

spawning



Fish population

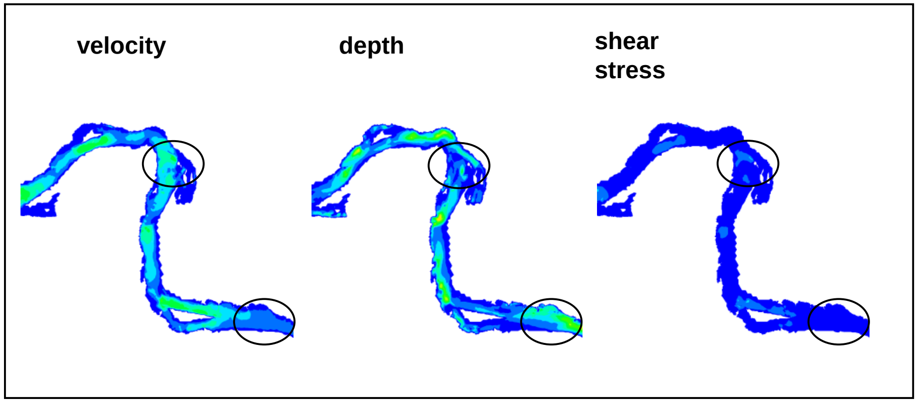
Biotic

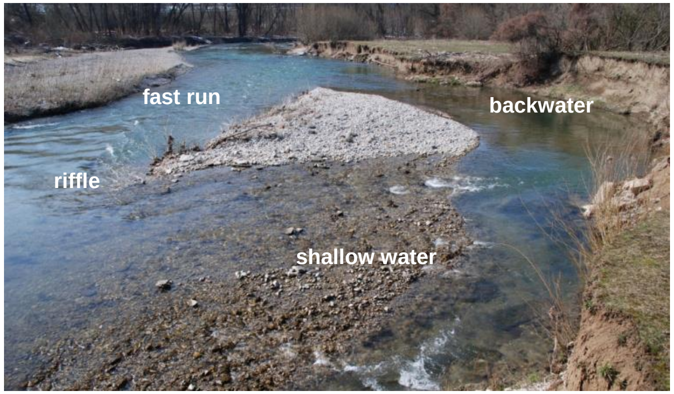
macrohabitats mesohabitats microhabitats

→ ***ALB – case study Pielach***
(Mandlburger et al., 2015)

Model setup Pielach

- ➡ Model April = 105766 nodes / 210498 elements
- ➡ Model May = 172701 nodes / 343941 elements
- ➡ Model October = 121910 nodes / 242701 elements
- ➡ HN - modelling = depth-averaged two-dimensional model (finite volume / unstructured grid)
- ➡ Computational time for steady state conditions ($Q_{input} = Q_{output}$) = 3.5 h (HQ_1) - 6.25 h (MJNQT)
- ➡ Total computational time = 9.25 h
- ➡ Calibrated roughness (low flow) Manning´s n = 0.043
- ➡ Calibrated roughness (high flow) Manning´s n = 0.033 (main channel); n = variable for overbank areas (0.067 – 0.017) *data source: FHS – Pielach*





x,y <vel.dat>

x,y <depth.dat>

x,y <shear.dat>

1. routing:

$MH = [NC_{(d)} + NC_{(v)}] * NC_{(\tau)}$

<riffle> <pool> <run> <fast run> <low flow velocity*>

2. routing:

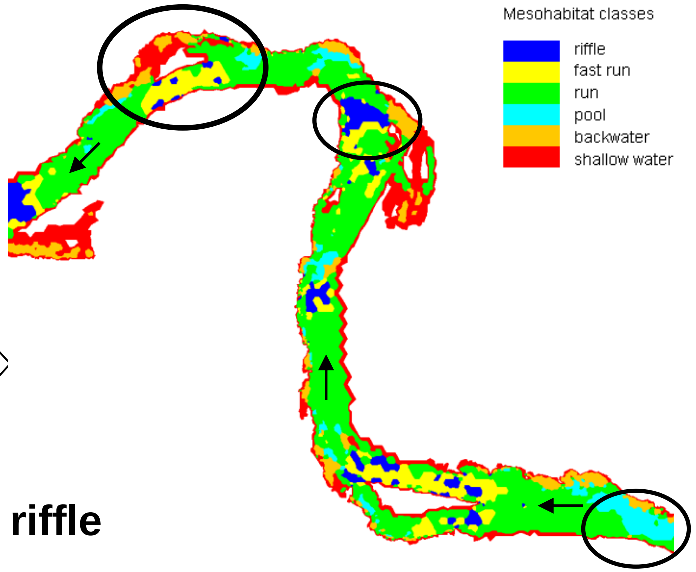
depth criteria: $NC(d) < g_{(4)}$; $NC(d) >/= g_{(4)}$

<shallow w.> <backwater>

3. routing:

x,y <shear.dat> / x,y <τ_{cr} of d_m>

NhmU/AhmU **<riffle>** stable [%,A] unstable [%,	NhmU/AhmU **<pool>** stable [%,A] unstable [%,A]	NhmU/AhmU **<run>** stable [%,A] unstable [%,A]	NhmU/AhmU **<fast run>** stable [%,A] unstable [%,A]	NhmU/AhmU **<shallow w.>** stable [%,A] unstable [%,A]	NhmU/AhmU **<backwater>** stable [%,A] unstable [%,A]

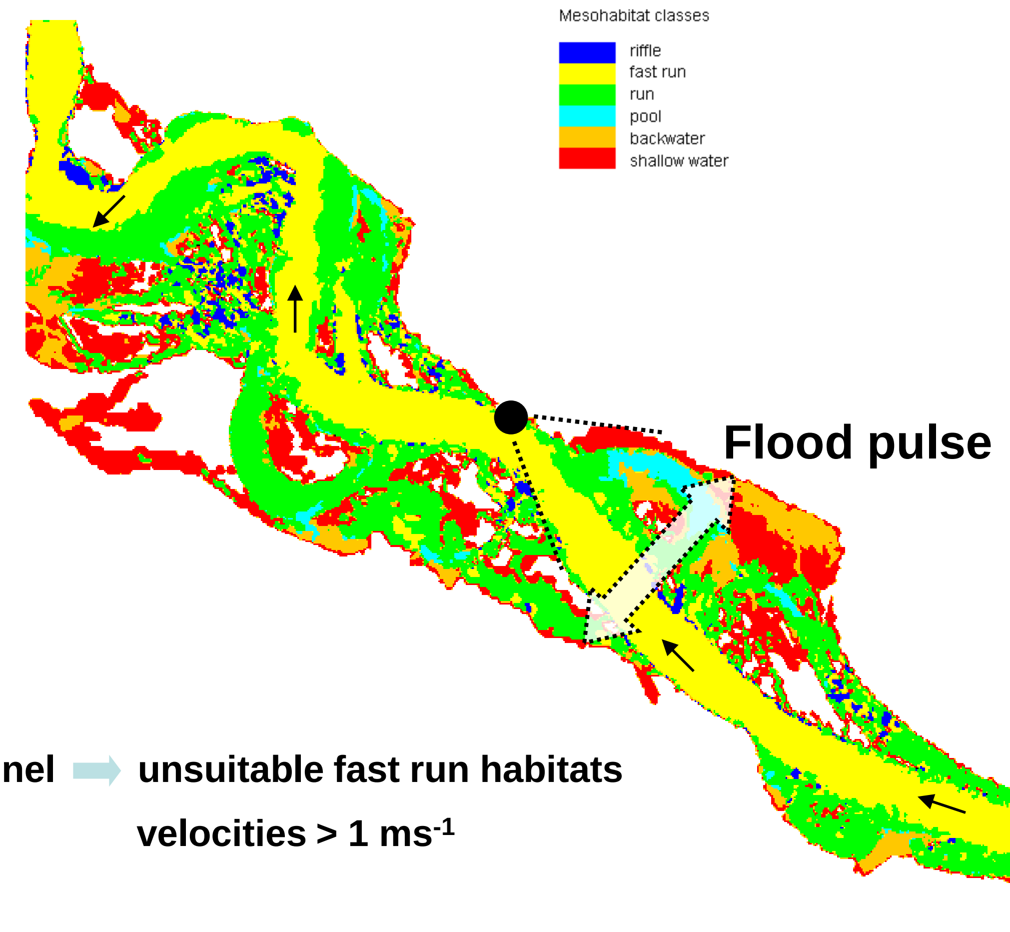


➡ **riffle**

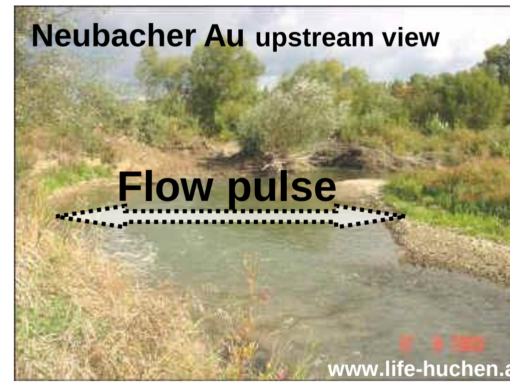
➡ **pool**

Variability in habitat distribution according to discharge

Low flow → ***Mean flow*** → ***Annual Flood (HQ_1)***



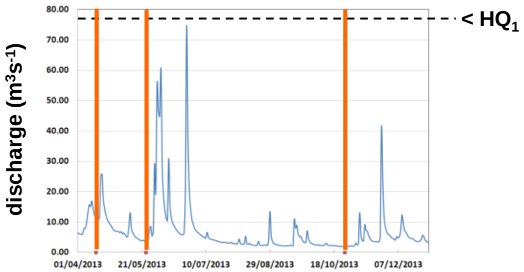
$Q = 121\ m^3s^{-1}$



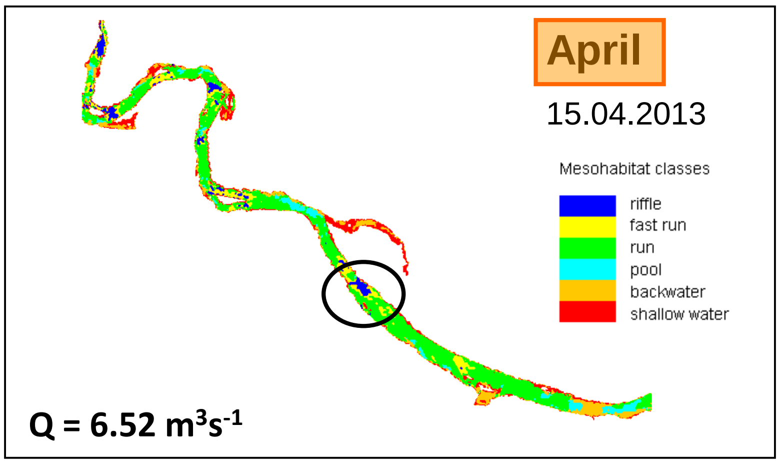
main channel → **unsuitable fast run habitats**

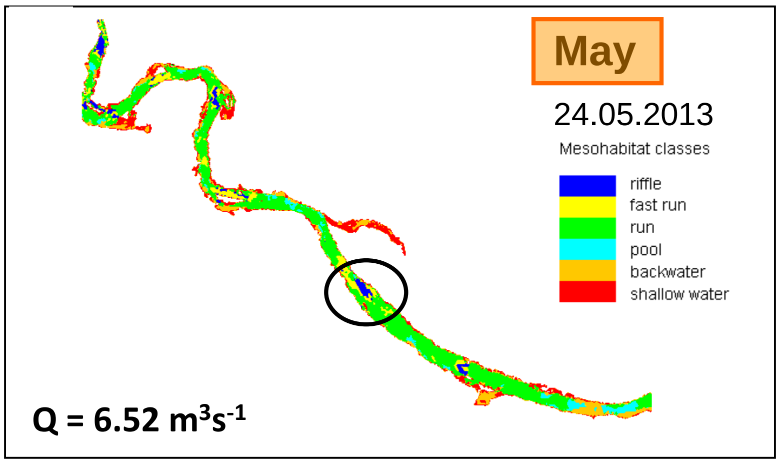
velocities > 1 ms^{-1}

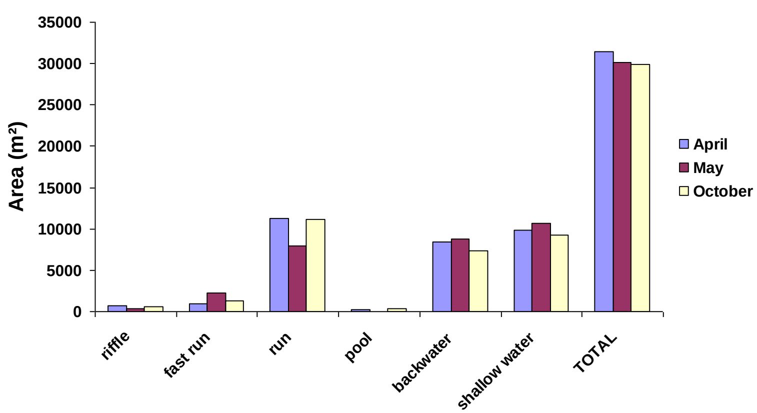
Variability in habitat distribution according to morphological changes

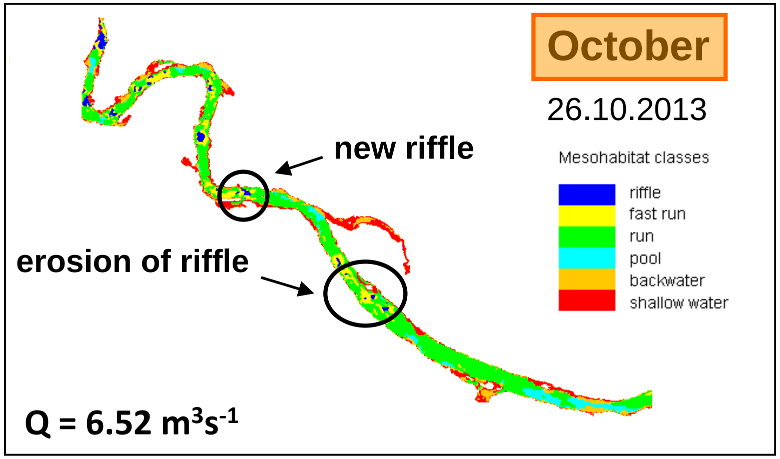


⇨ **high quality sediment dynamics!**



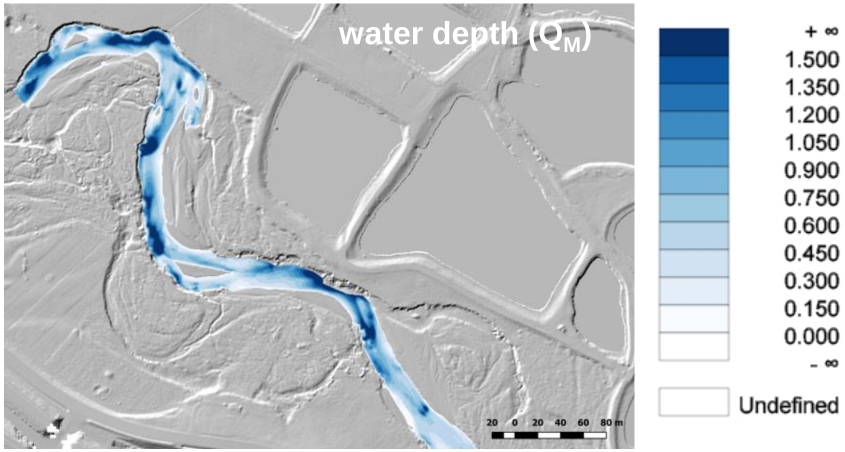


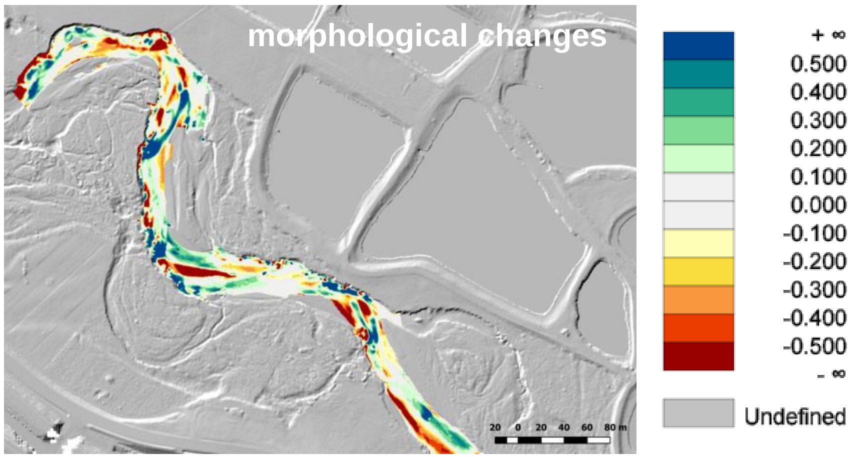


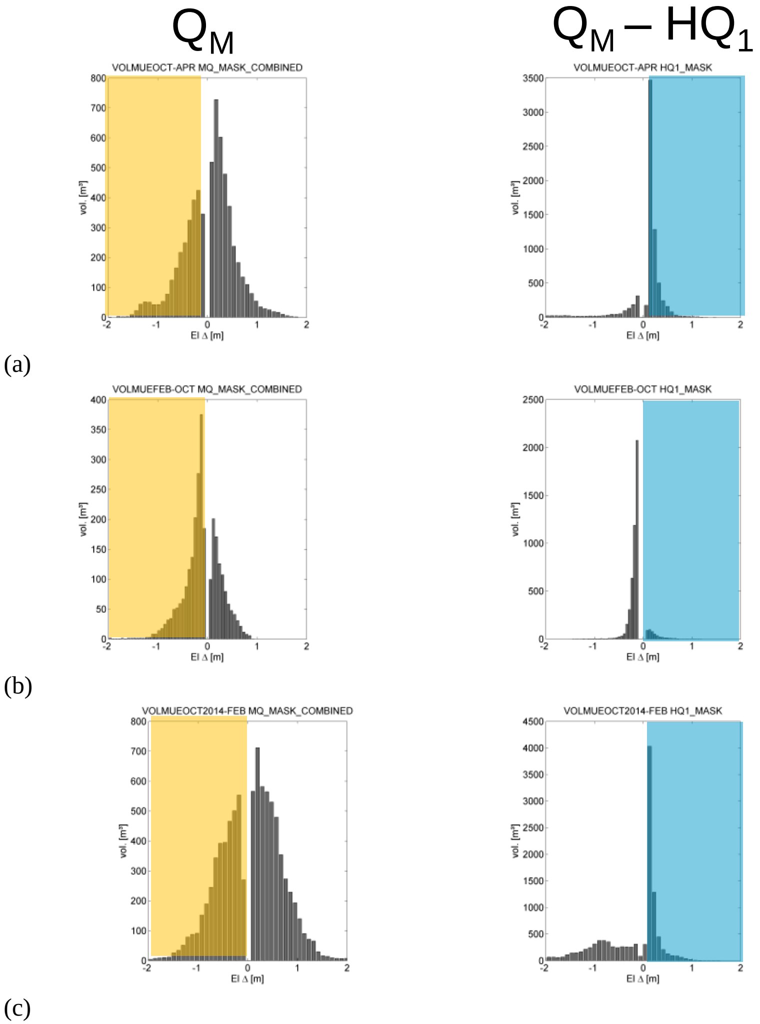


Analysis and interpretation

DOD (a) elevation change for the period April 2013 – October 2013, (b) October 2013 – February 2014, (c) February 2014 – October 2014.







only incision *only aggradation*

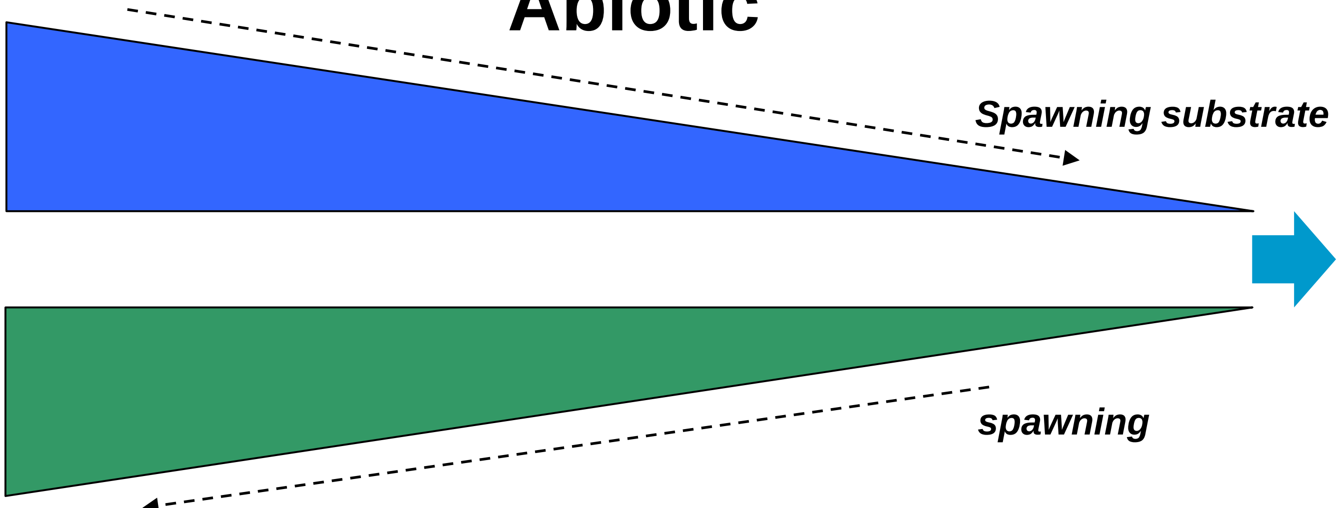
Downscaling / Upscaling

macrohabitats mesohabitats microhabitats

Sediment continuum

Abiotic

Spawning substrate



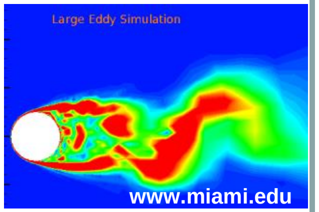
spawning

Fish population

Biotic

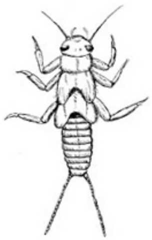
macrohabitats mesohabitats microhabitats

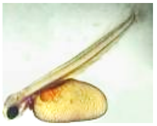
turbulence



grain roughness!

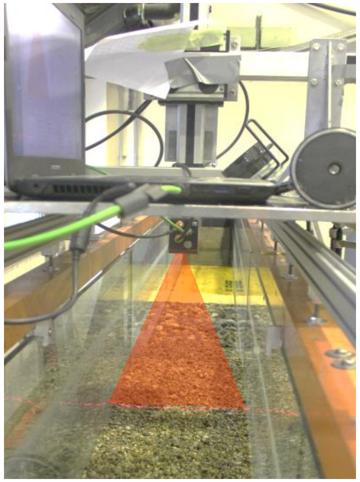
Macroinvertebrates, fish larvae





Turbulence studies on sediment transport processes

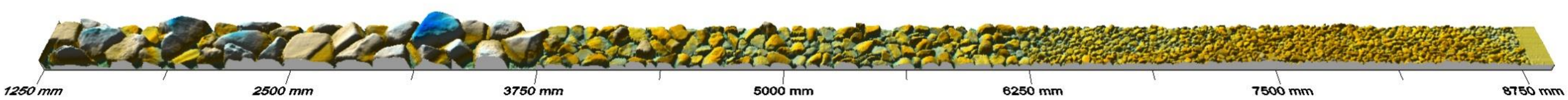
➡ Physical laboratory flume IWHW

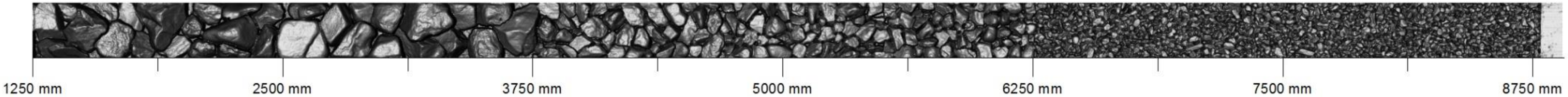


Hydraulic flume studies (IWHW)

Master thesis: Jacob Holzinger

bed without coarse sand

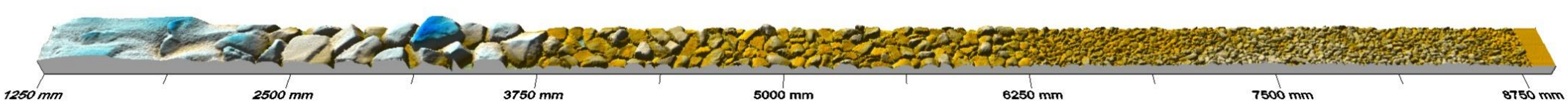


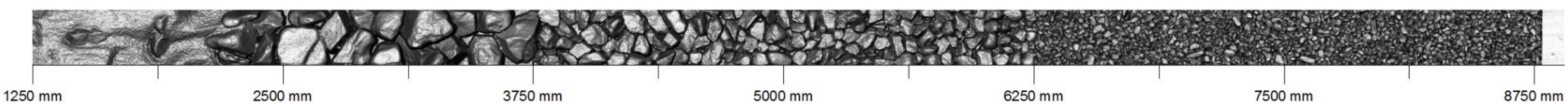


Bereich A	Bereich B	Bereich C

Hydraulic flume studies (IWHW)

coarse sand infiltration 15 minutes

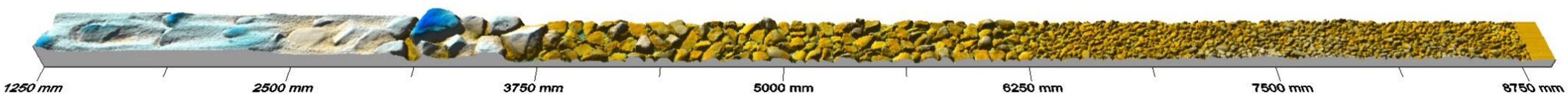


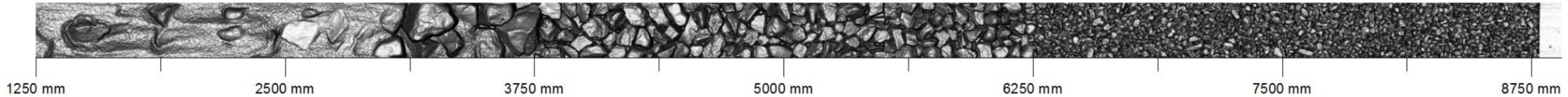


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 30 minutes

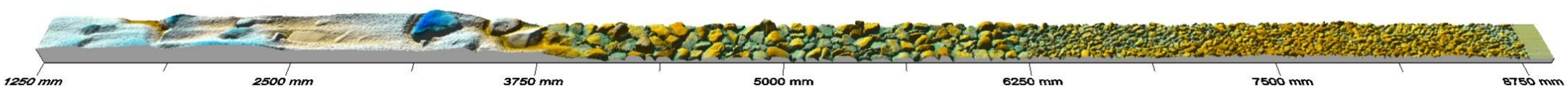


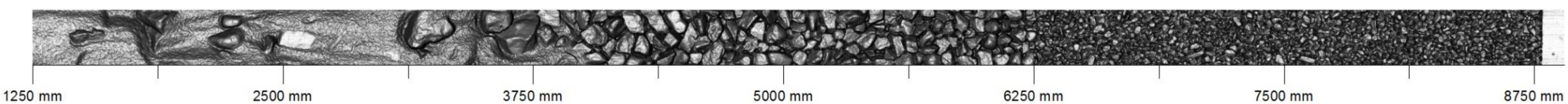


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 45 minutes

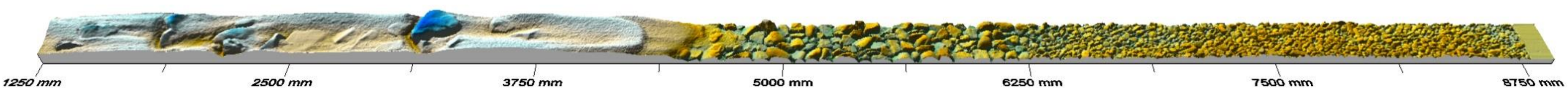


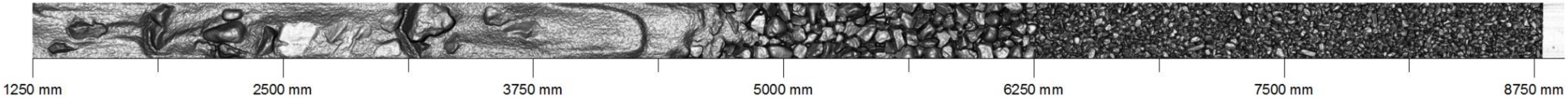


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 60 minutes

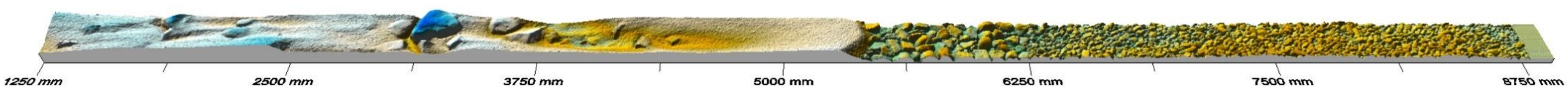


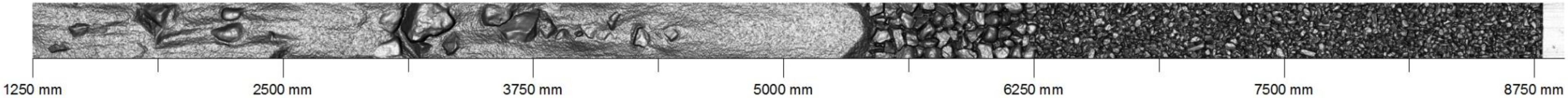


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 75 minutes

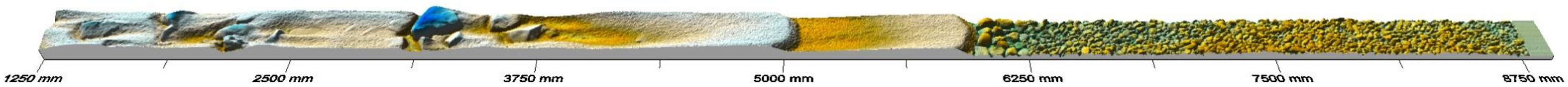


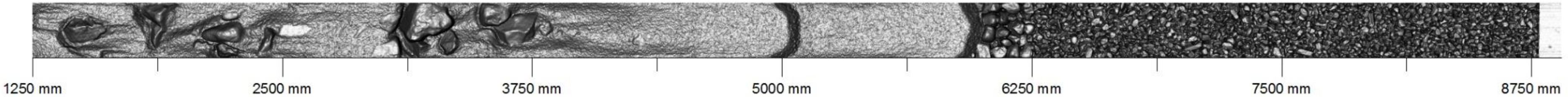


reach A	reach B	reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 90 minutes

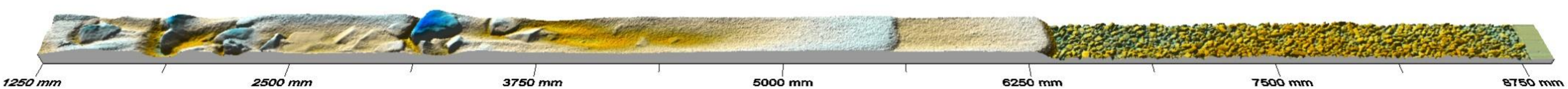


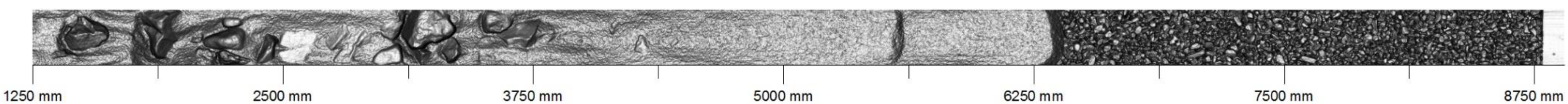


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 105 minutes

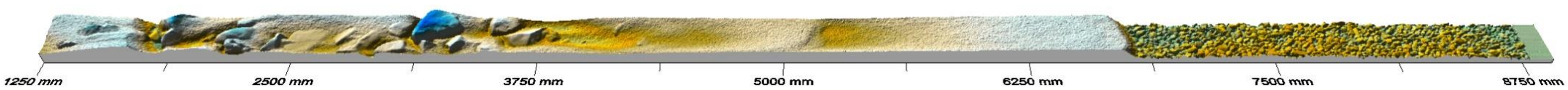


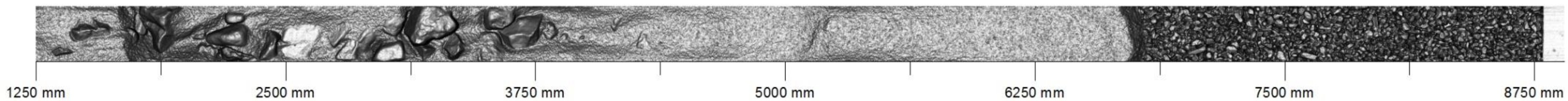


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 120 minutes

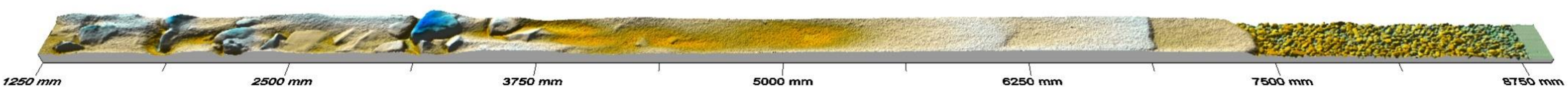


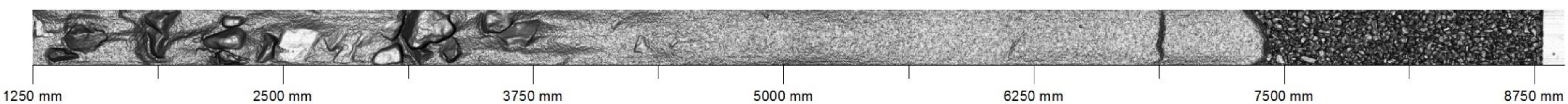


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 135 minutes

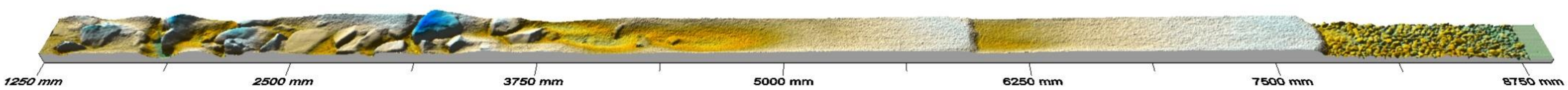


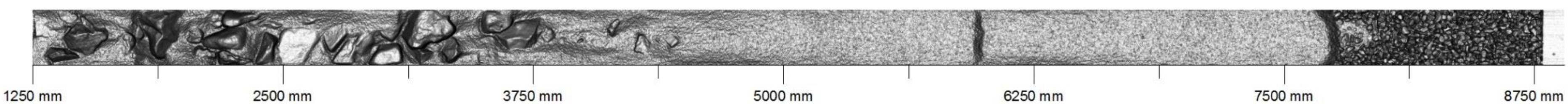


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

coarse sand infiltration 150 minutes

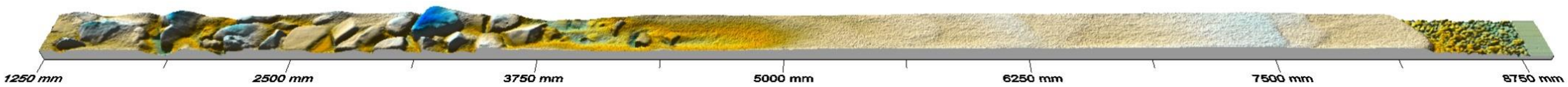


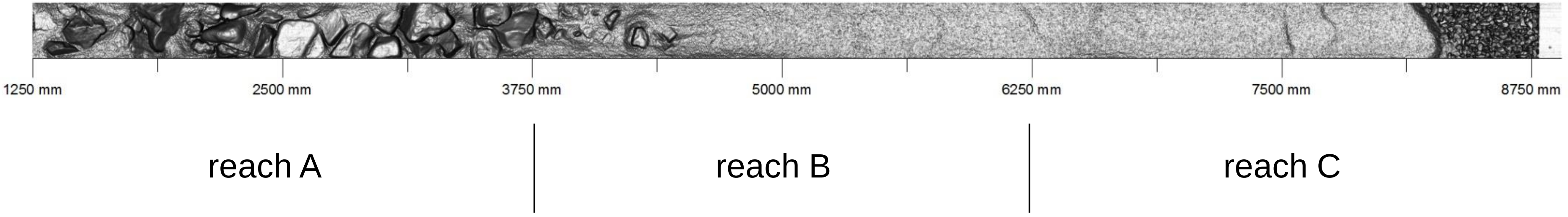


reach A | reach B | reach C

Hydraulic flume studies (IWHW)

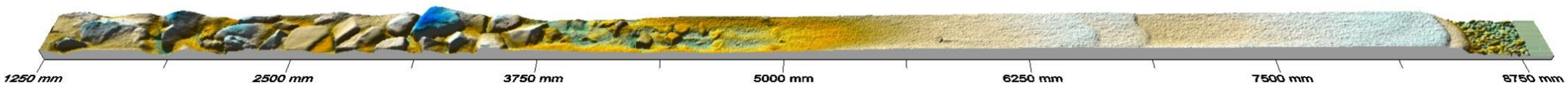
coarse sand infiltration 165 minutes

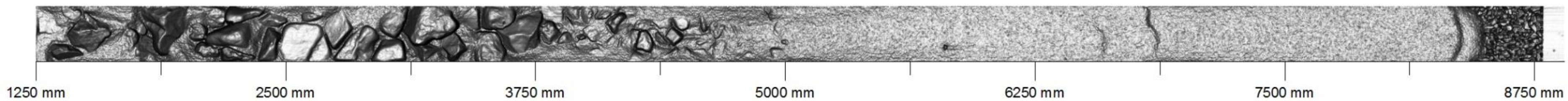




Hydraulic flume studies (IWHW)

coarse sand infiltration 180 minutes



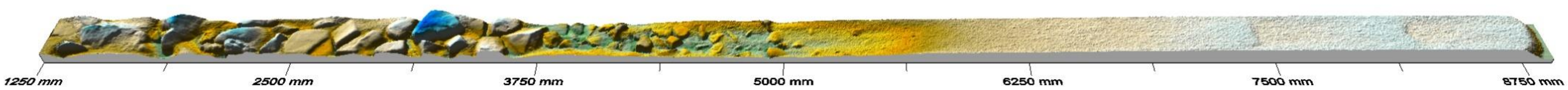


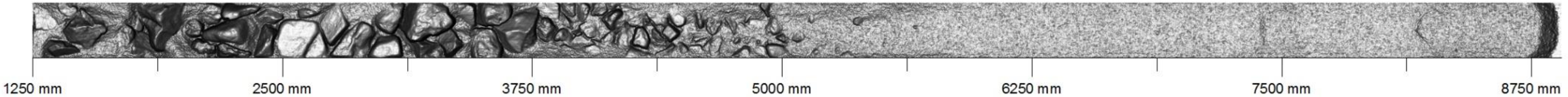
reach A	reach B	reach C

Hydraulic flume studies (IWHW)

⇨ **Determination of *transport velocity* for the *reaches A, B, C***

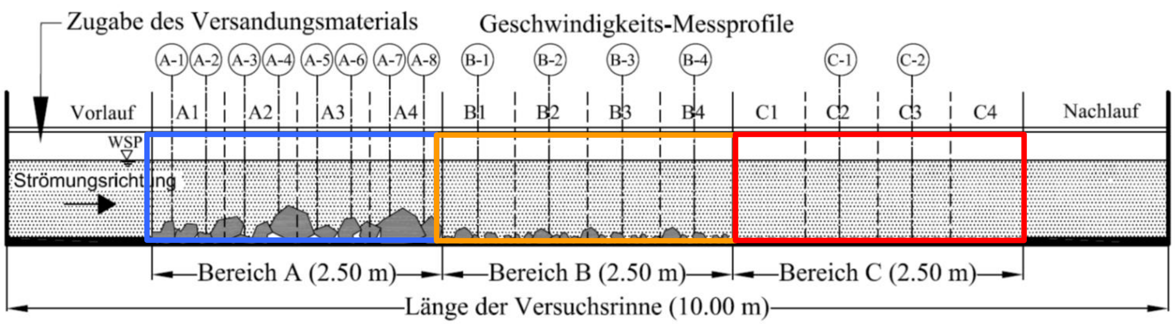
coarse sand infiltration 200 minutes





reach A	reach B	reach C

Hydraulic flume studies (IWHW)



Transport velocity of bedload in meter per hour / per day in relation to bed roughness.

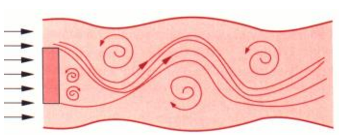
A = 3.24 m/h (78 m / day)

B = 2.27 m/h (55 m / day)

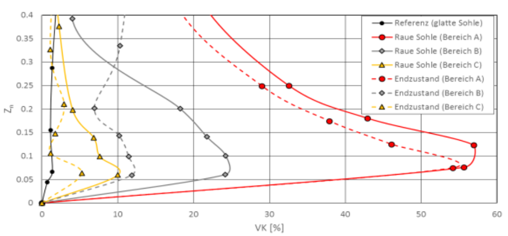
C = 1.05 m/h (25 m / day)

?

turbulence



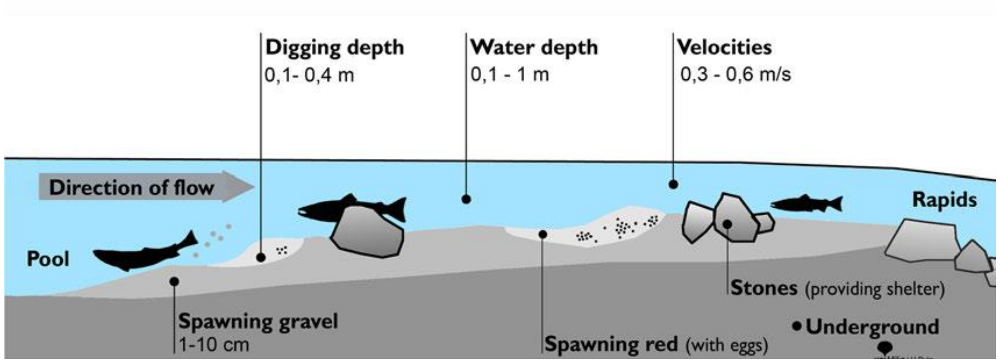
variability turbulence



Large scale turbulence impacts

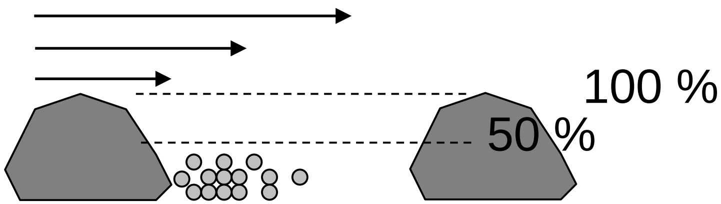
Spawning habitat mitigation in Norway: artificial deposit of spawning gravel

photos: Pulg (LFI)

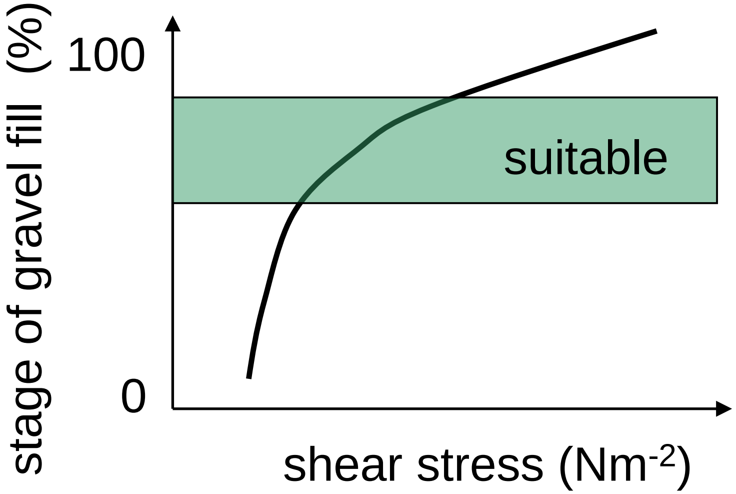


Large scale turbulence impacts

Hiding effects on spawning gravel (Aurlandselva)



or turbulence disturbances ?



Roughness: habitat forming or parts of morphological bar features?

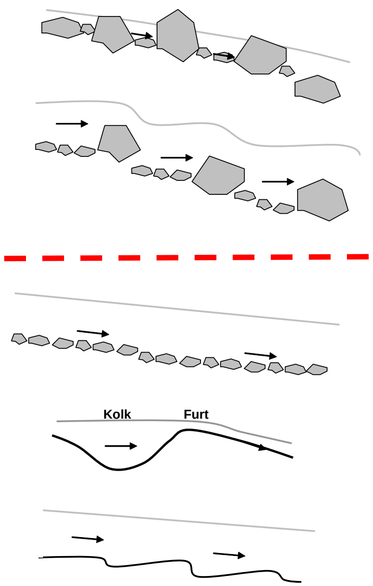
(I) Cascade

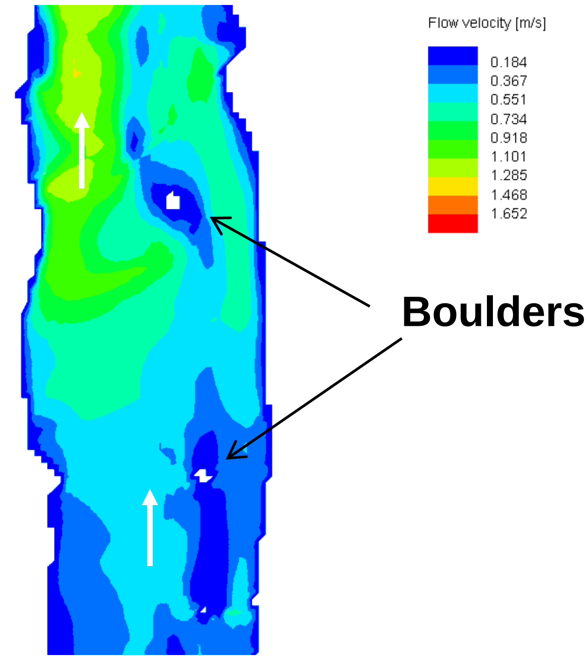
(II) Step-pool

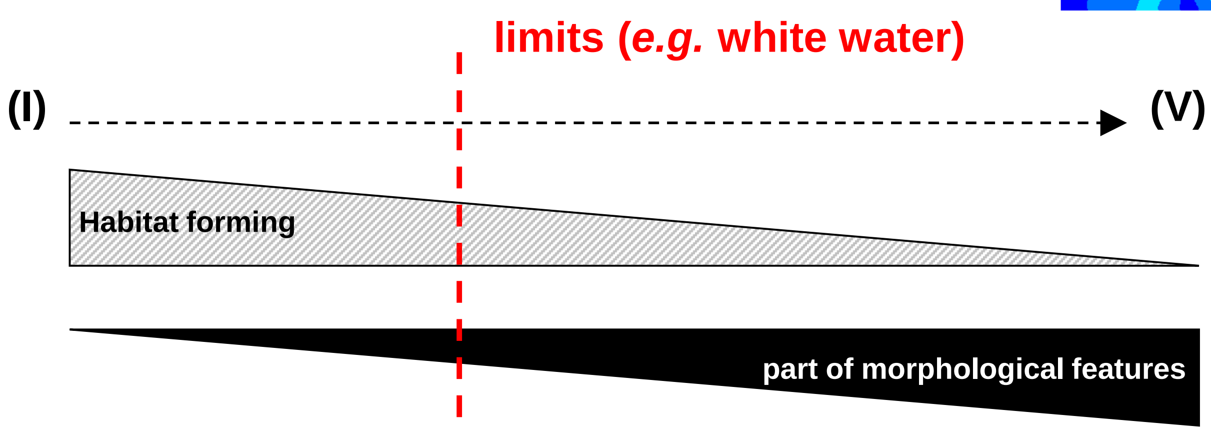
(III) Plane bed

(IV) riffle-pool

(V) Dune-ripple







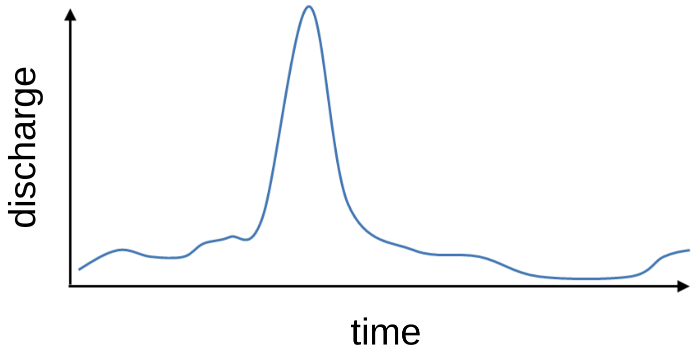
Summary / Conclusions

- ALS data provide ***high quality DTM*** data for instream habitat modelling on various scales (***flow -and flood pulse studies***)

  Important ***novel methodology*** to fulfill the ***aims*** of both the ***Floods-*** and the ***Water Framework Directive*** (e.g. wise use of resources)

- ***Small scale morphological changes*** (e.g. side erosion, gravel bar deposition) can be ***quantified*** – high quality database for river research

- ***Development*** and ***validation*** of ***numerical models*** in hydraulic engineering



Thank you for your attention!