Hydraulic Engineering and Sediment Transport

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THE FUTURE OF BORDER MURA

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8. - 9. May 2019

Content

- Introduction to sediment transport and river morphology
- Historic mophology of the Mur River
- Human impacts and consequences
- Hydraulic Engineering in the Basic Water Management Concept
- Pilot measure Gosdorf
- Monitoring of hydromorphology and verification of considerations in the Basic Water Management Concept
- Conclusions
- Outlook

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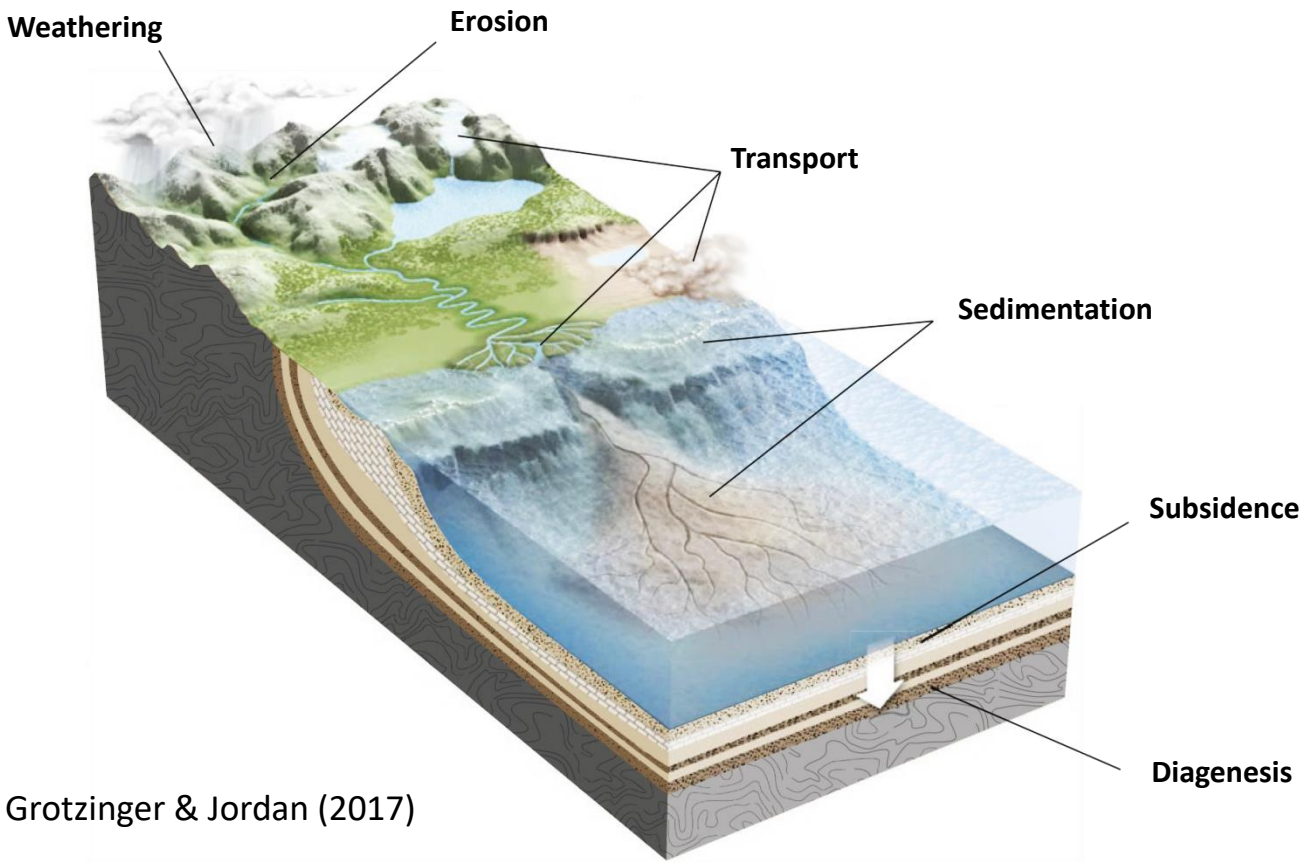
Sediment cycle



Grotzinger & Jordan (2017)

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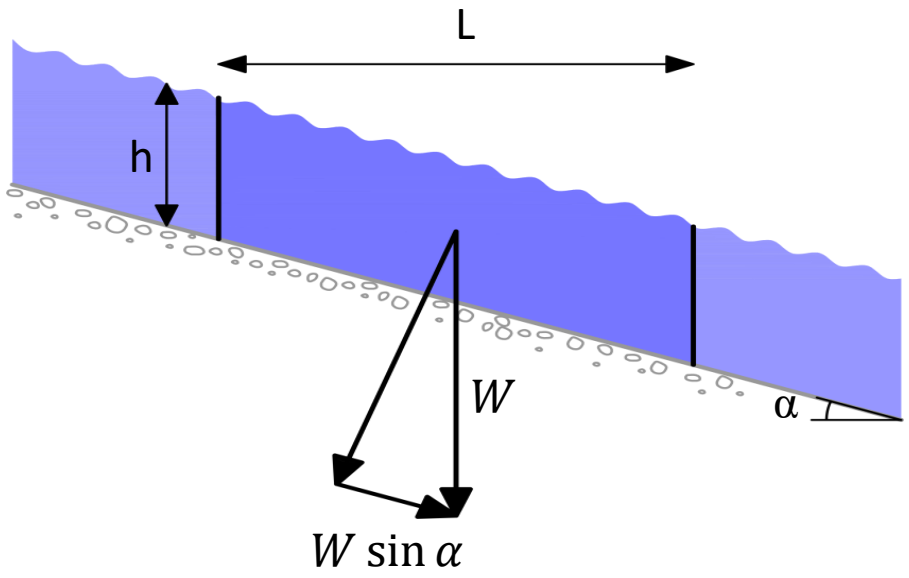
Sediment transport



Bed shear stress: $\tau = \rho g h I$

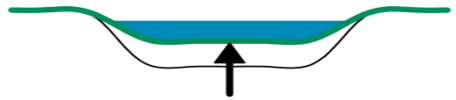
Bedload transport:
(eg. Meyer-Peter and Müller, 1948)

$$q_s = 8\sqrt{\frac{(\rho_s - \rho)}{\rho} g d^3}\left[\frac{\tau}{(\rho_s - \rho) g d} - 0.047\right]^{\frac{3}{2}}$$

Bed level change:
(Exner-equation)

$$\frac{\delta \eta}{\delta t} = \frac{1}{n-1}\frac{\delta q_s}{\delta x}$$

Degradation or **Aggradation**



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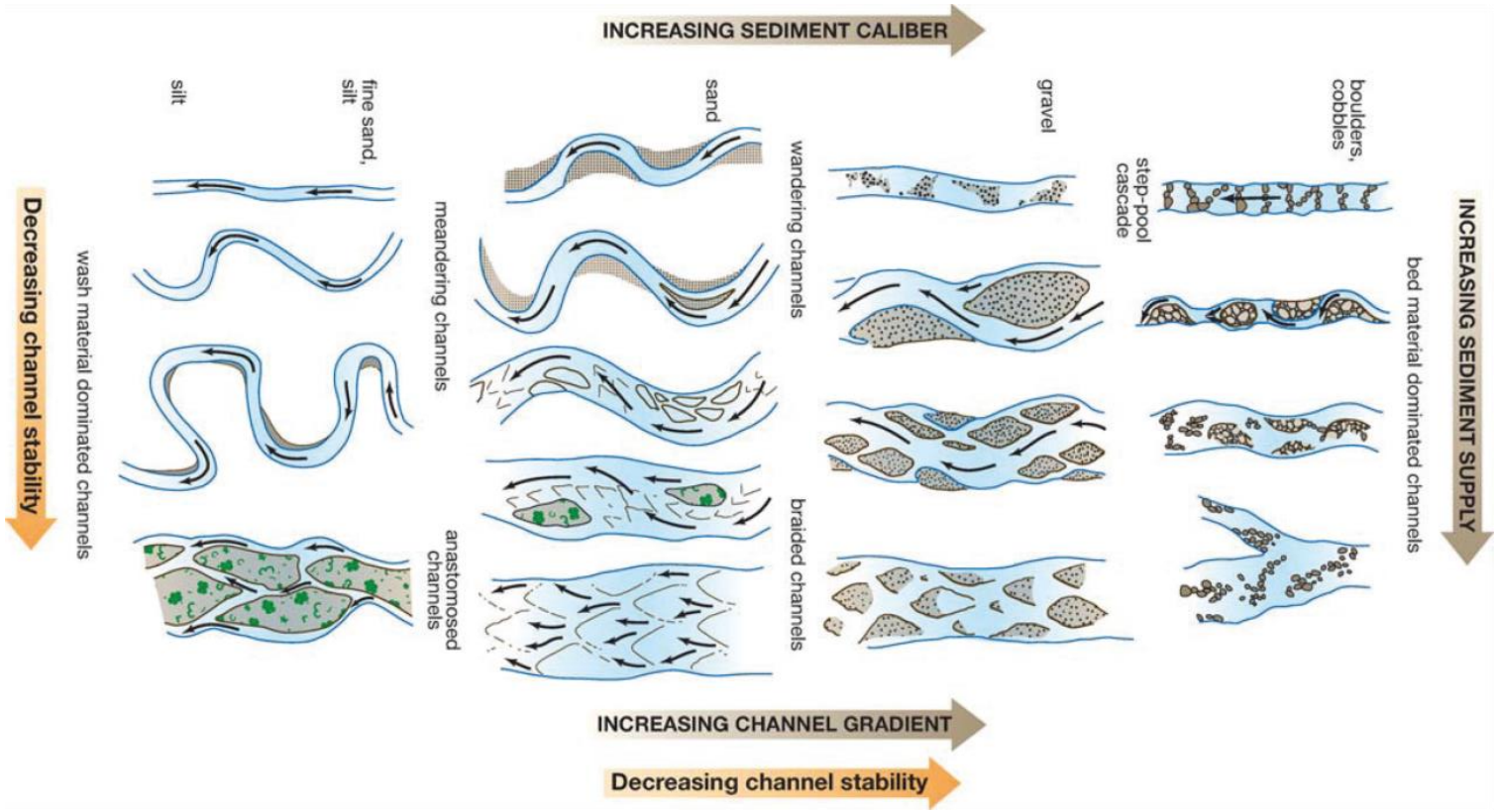
Sediment supply and river morphology

Sediment supply determines morphology



Church (2006)

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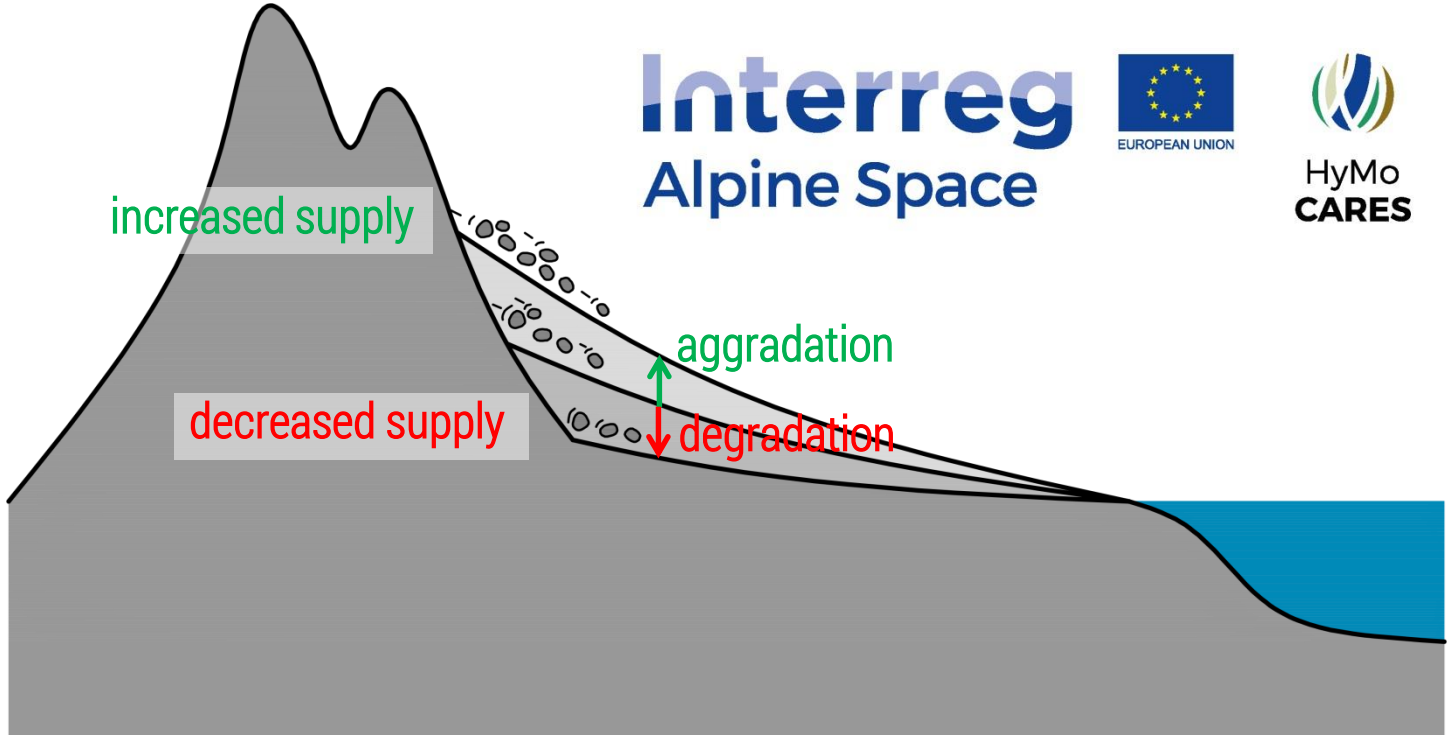
Sediment supply and river morphology

… and determines slope

Slope adjustment via aggradation/degradation



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Historic state of border Mura

1821-1836

2km

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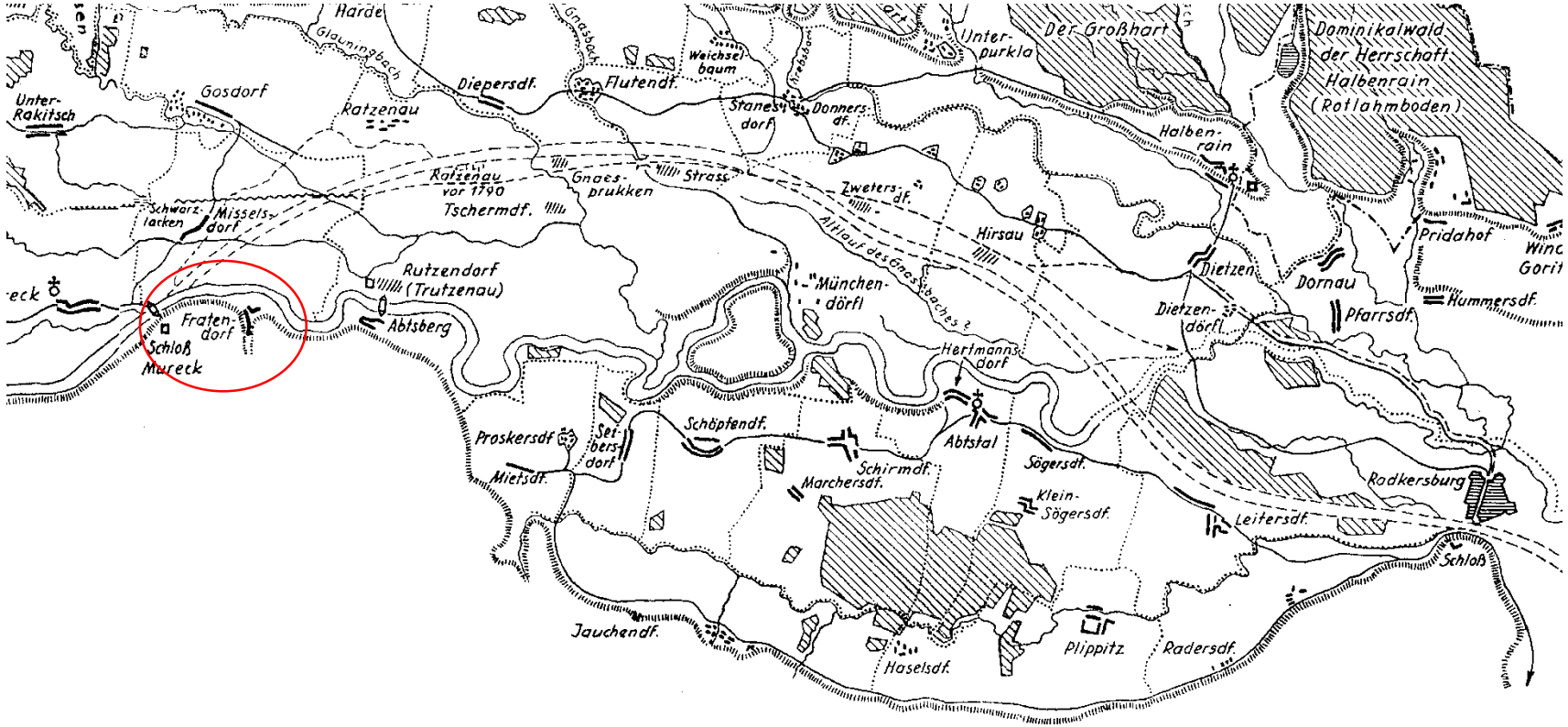
Historic state of border Mura

Before rockslide near the village of Vratja vas in 15th century



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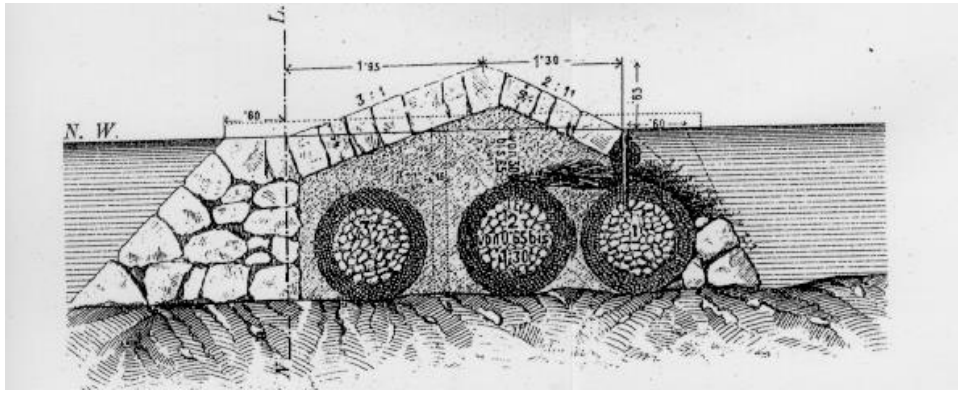
Human impacts and consequences

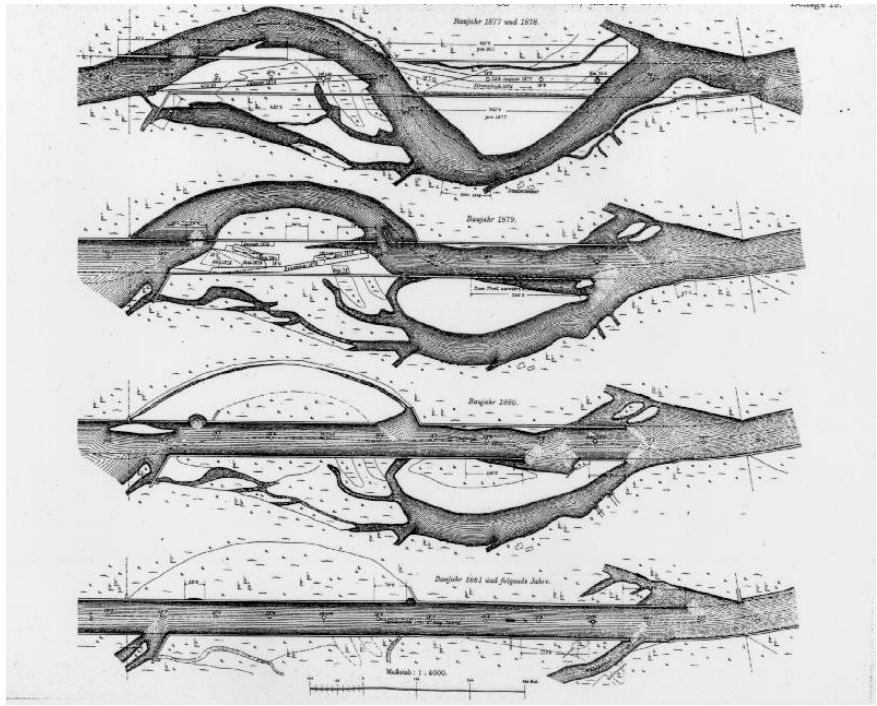
Systematic channelisation (late 19th century)

Uniform width of 76m at low flow condition

Benefits:

- Protect from damages from channel shifts
- Gain land for agricultural use
- Protect inlet structures for canals for diverse industrial uses





Hochenburger (1894)

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Human impacts and consequences

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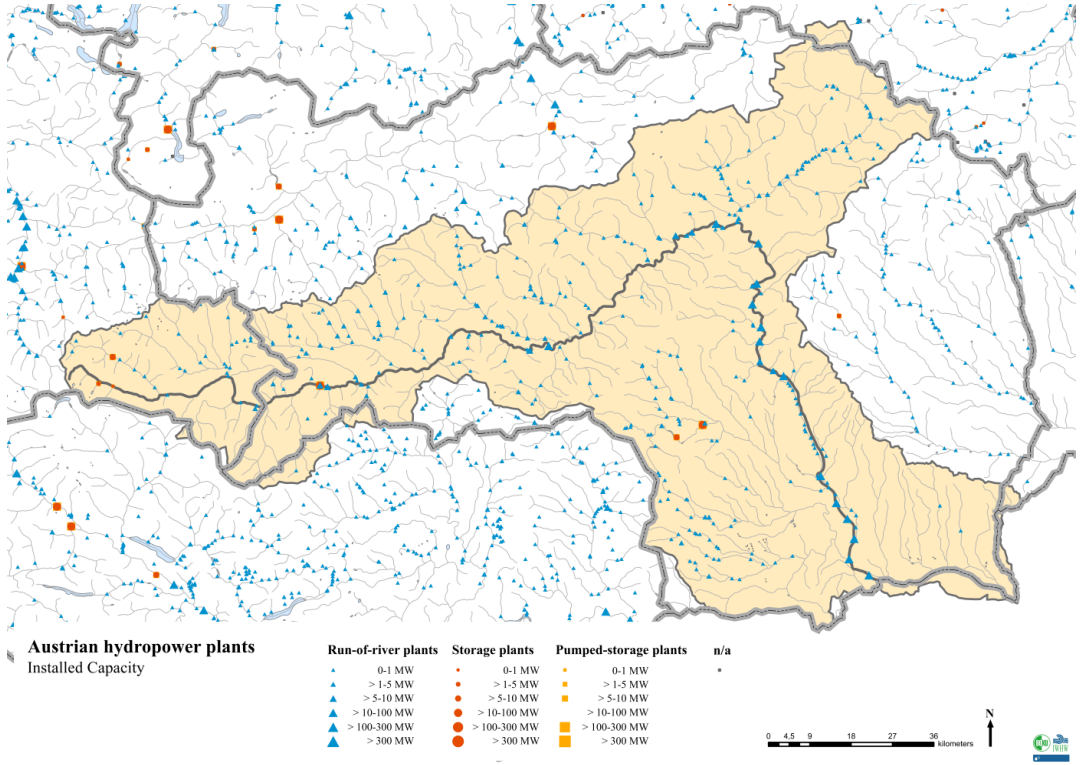
2006

2km

Human impacts and consequences

Reduction of sediment supply due to a chain of hydropower plants and torrent control



Wagner et al. (2015)

Hydropower plant Obervogau (Mur River) in a chain of hydropower plants, and plant Retznei affecting sediment supply from Sulm River catchment

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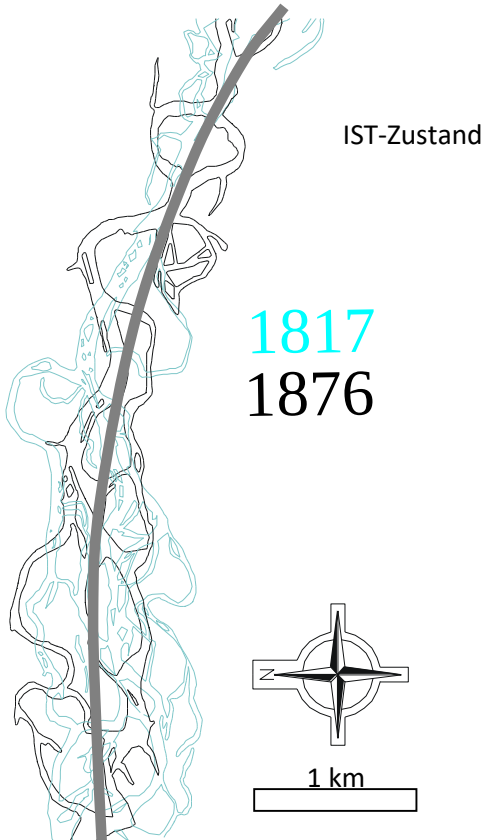
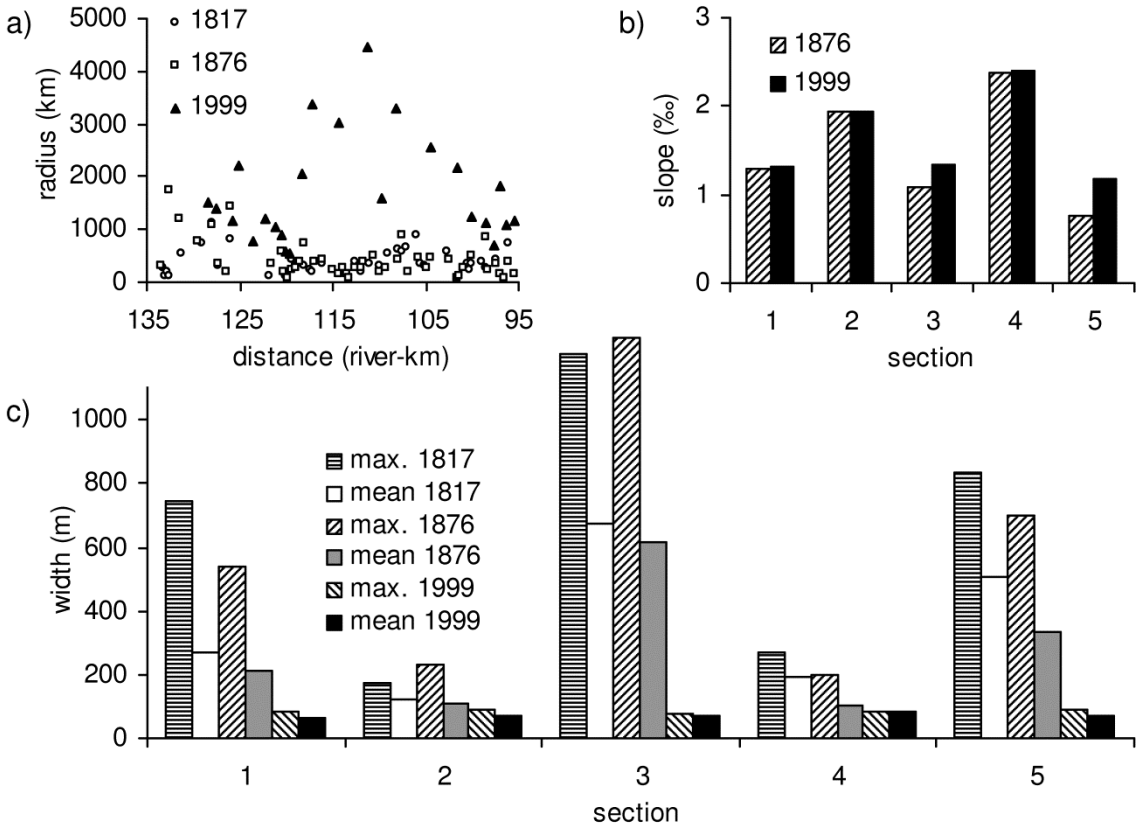
Human impacts and consequences

Channelisation:

- Increase of radius of river bends
- Increase of slope
- Decrease of width





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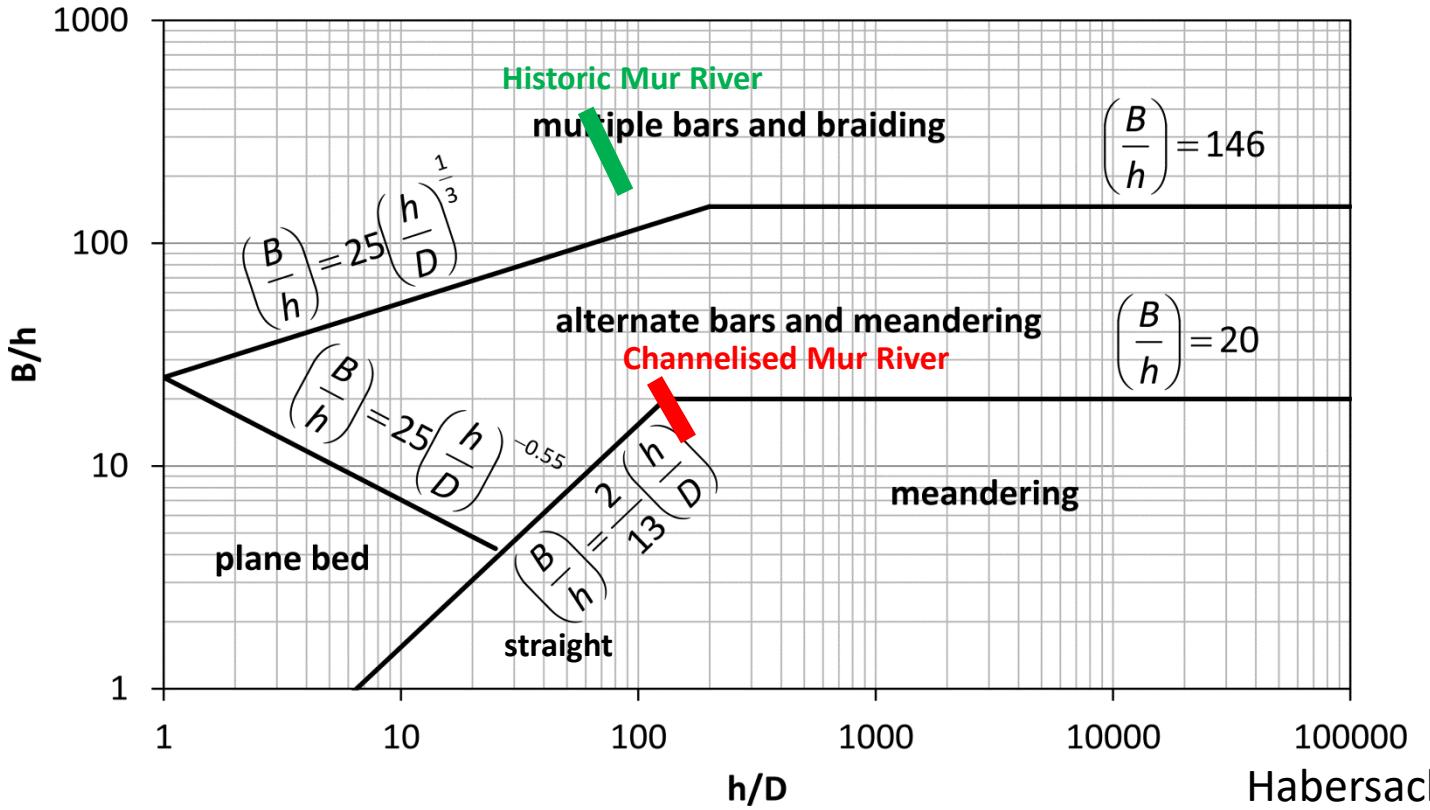
Human impacts and consequences

Change of morphological type



Habersack, 2013

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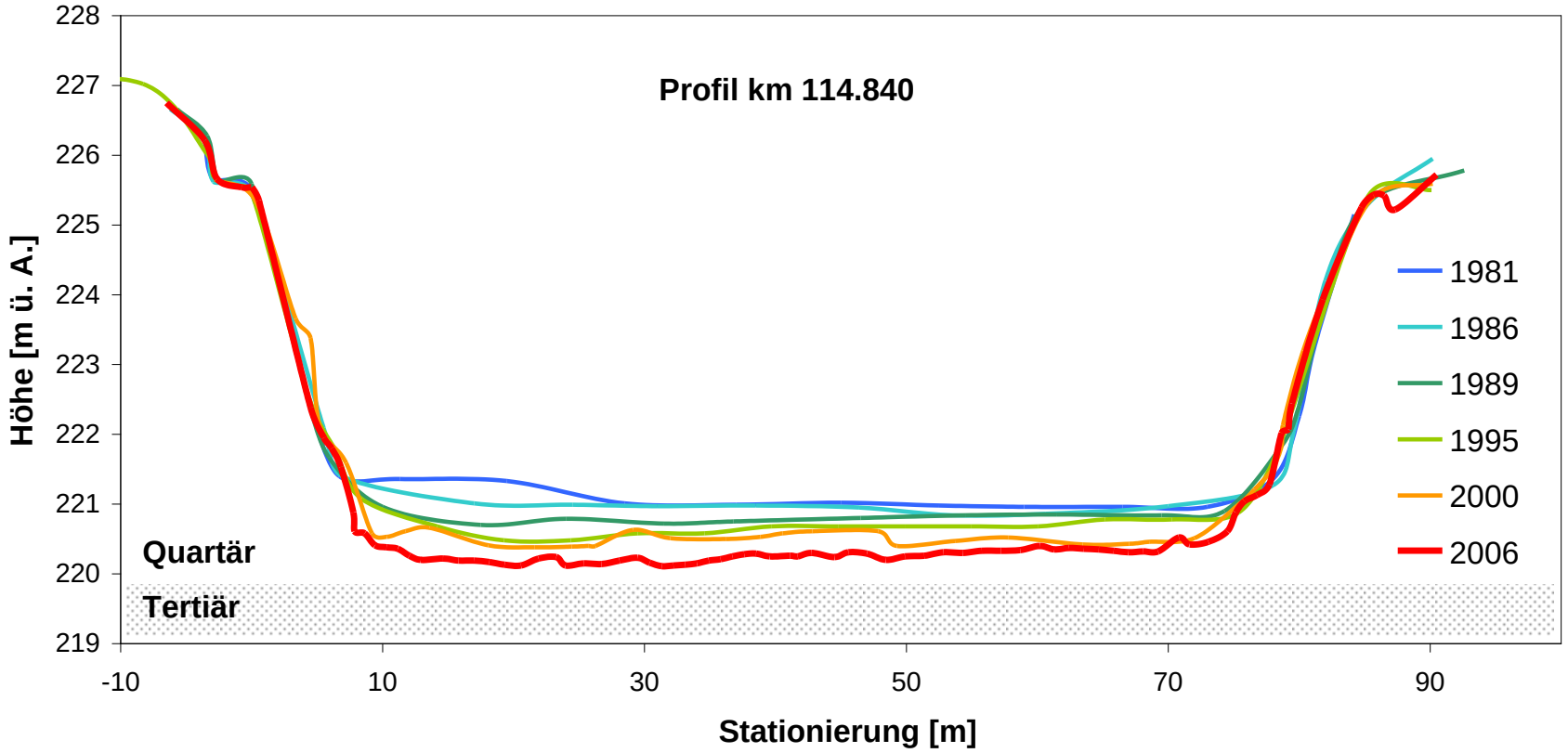
Human impacts and consequences

Limited thickness of gravel layer above finer sediment



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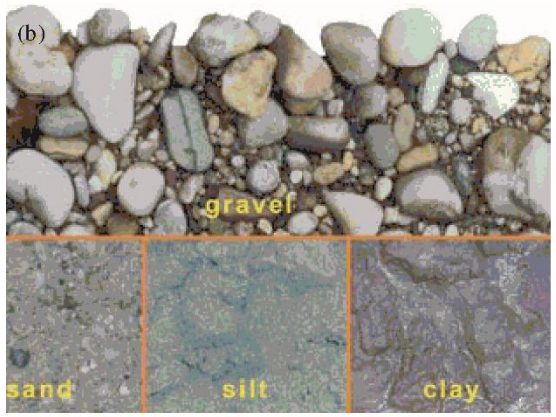
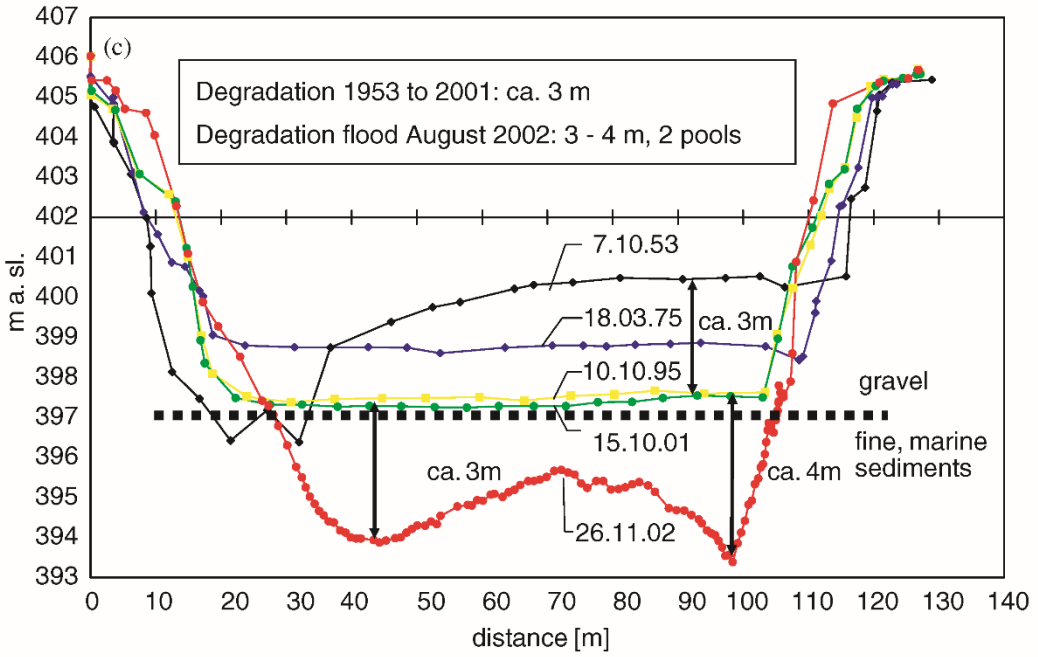
Human impacts and consequences

Riverbed breakthrough at Salzach River





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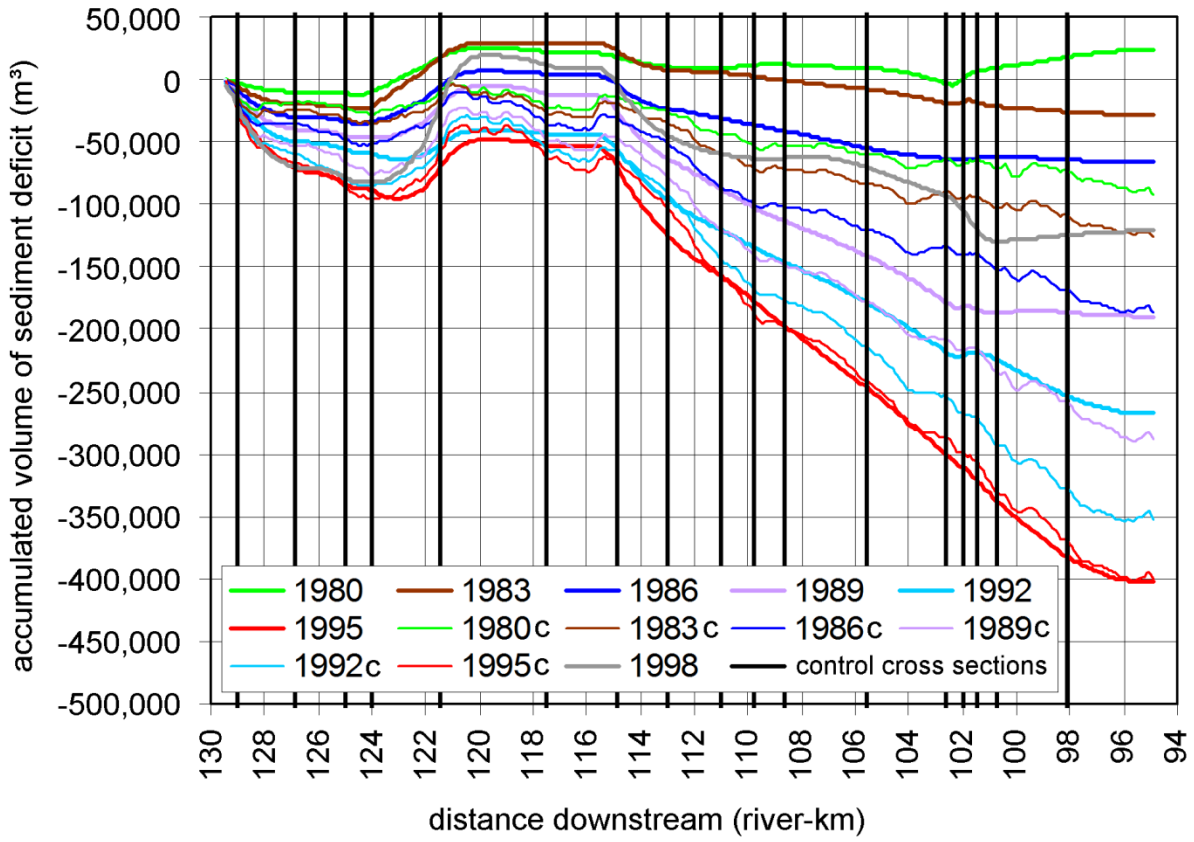
The Basic Water Management Concept

Collection and analysis of data

Cross section surveys show continuous degradation



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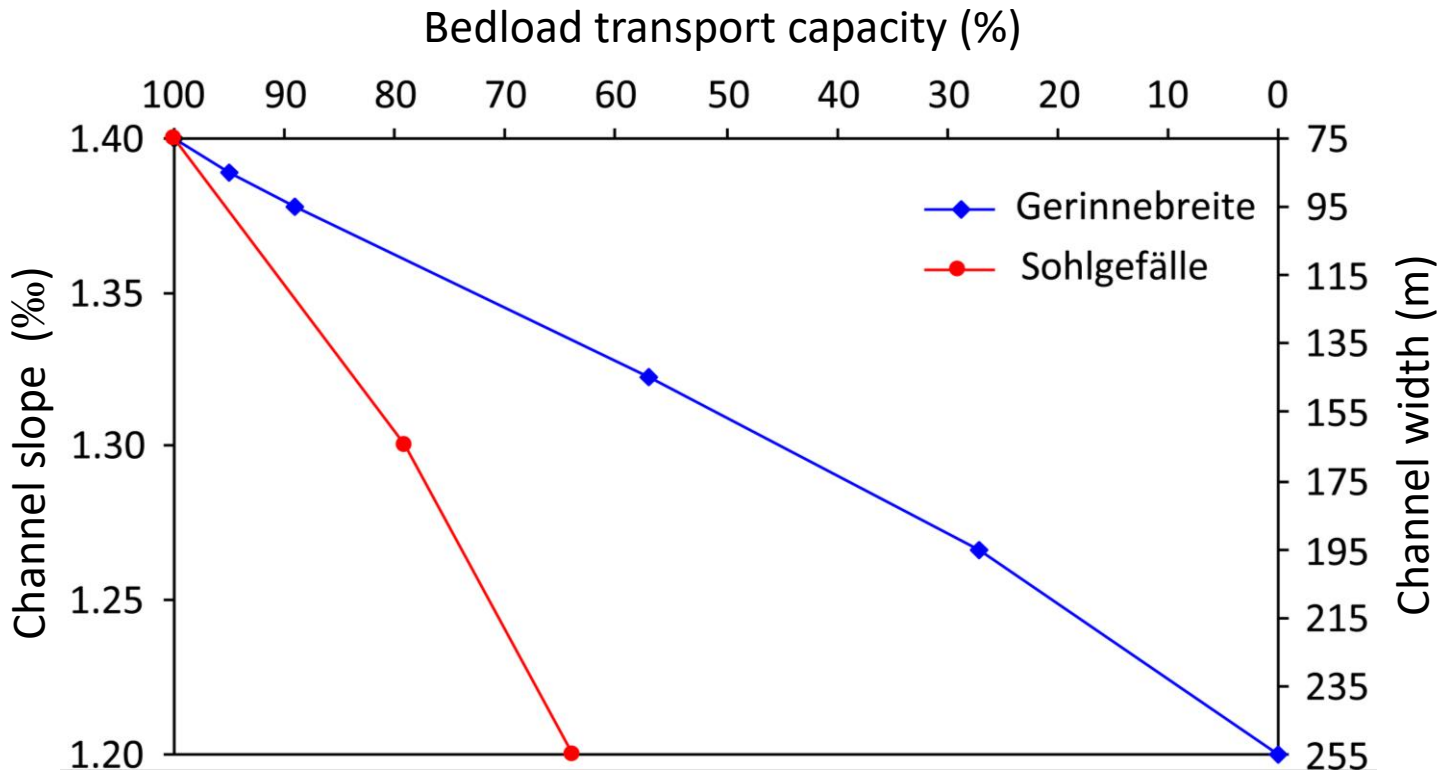
The Basic Water Management Concept

Reduction of bed shear stress: by changing slope or width?



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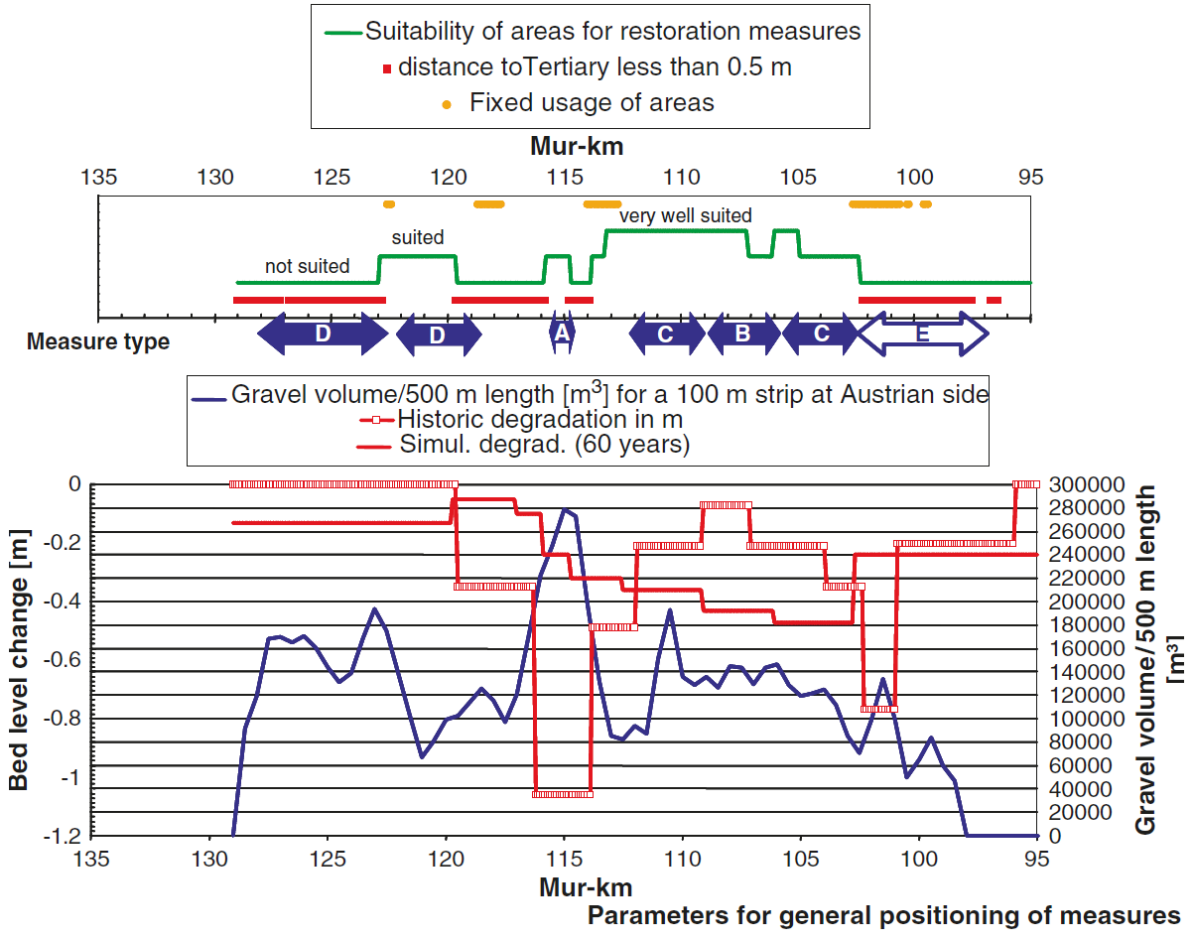
Habersack und Schneider (2000)

The Basic Water Management Concept

Measure types



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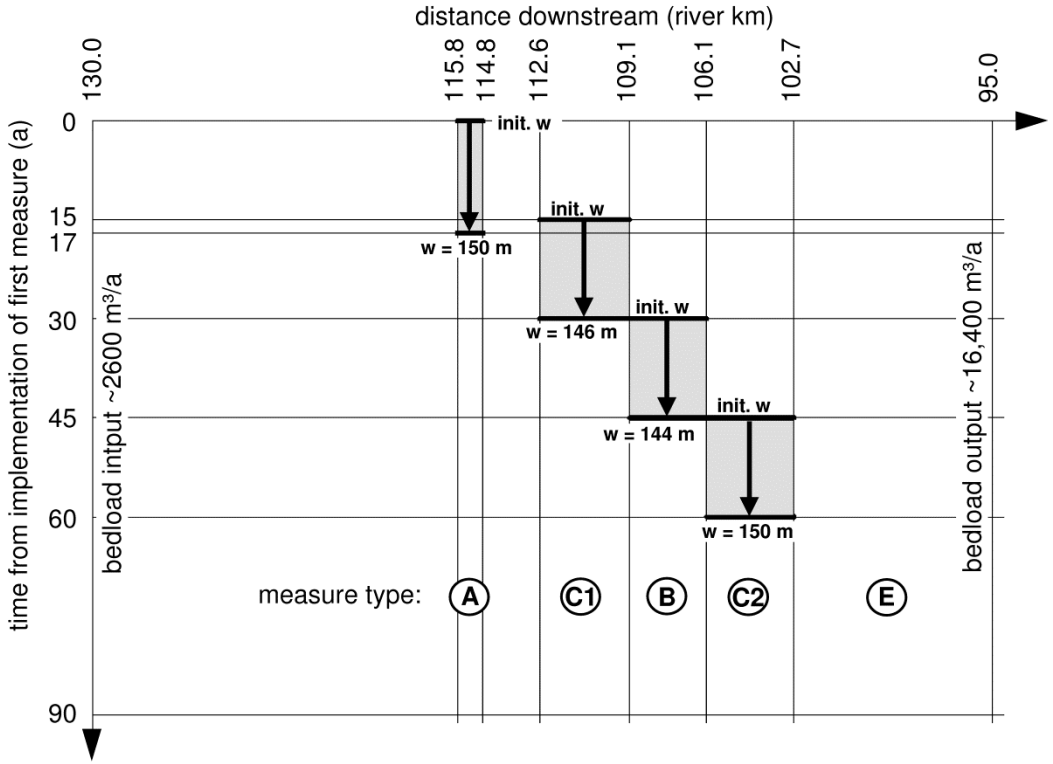
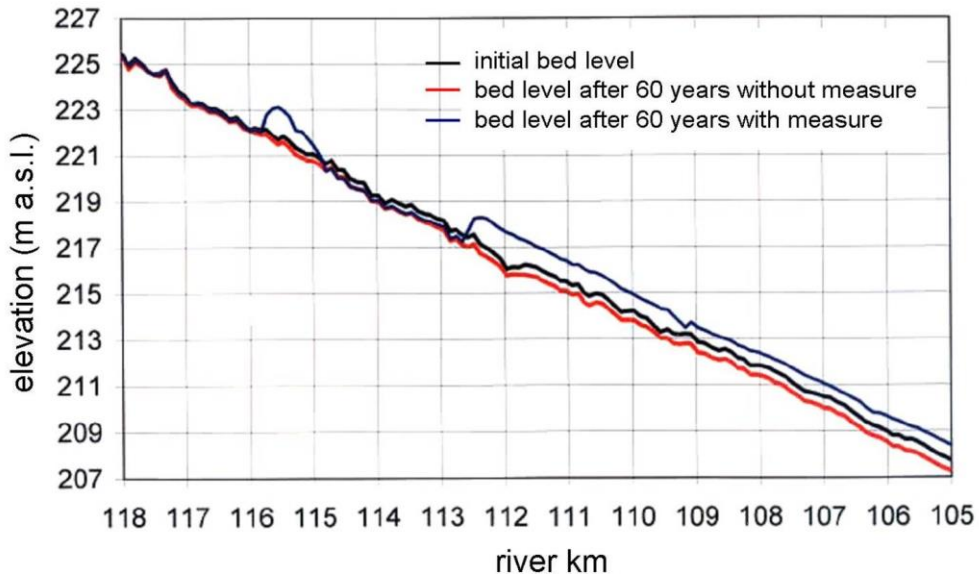
Habersack et al. (2001)

The Basic Water Management Concept

Modelling of scenarios with the sediment transport model





Hengl et al. (2001)

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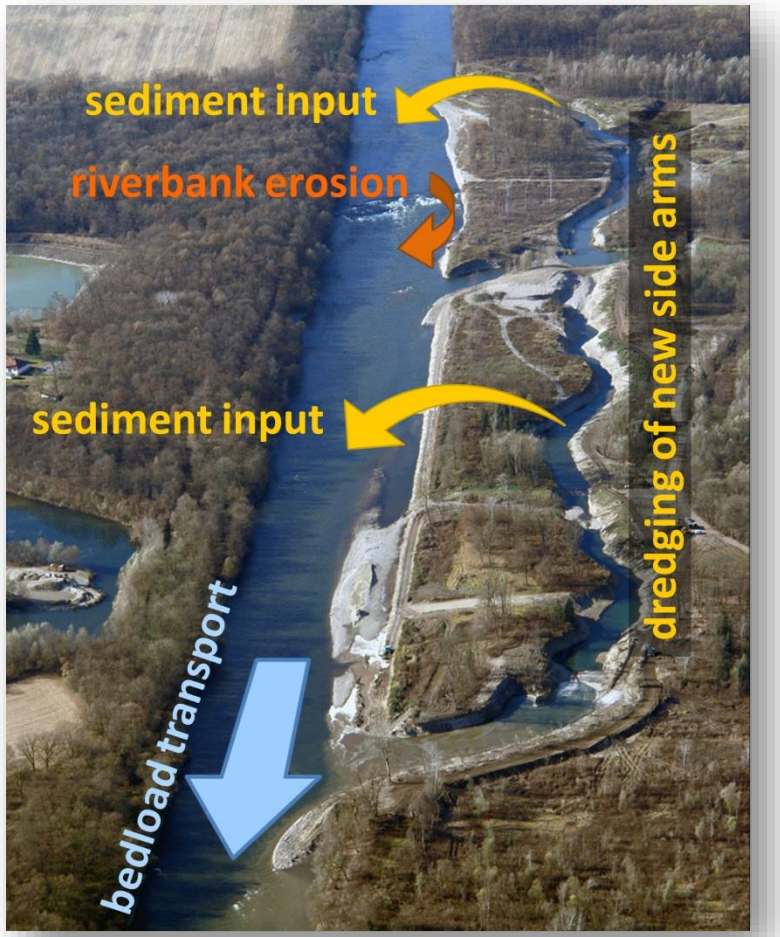
Measures

Pilot measure Gosdorf

- Removal of riprap from the left bank
- Excavation of a side-channel
- Supply of excavated sediment from side-channel into main channel



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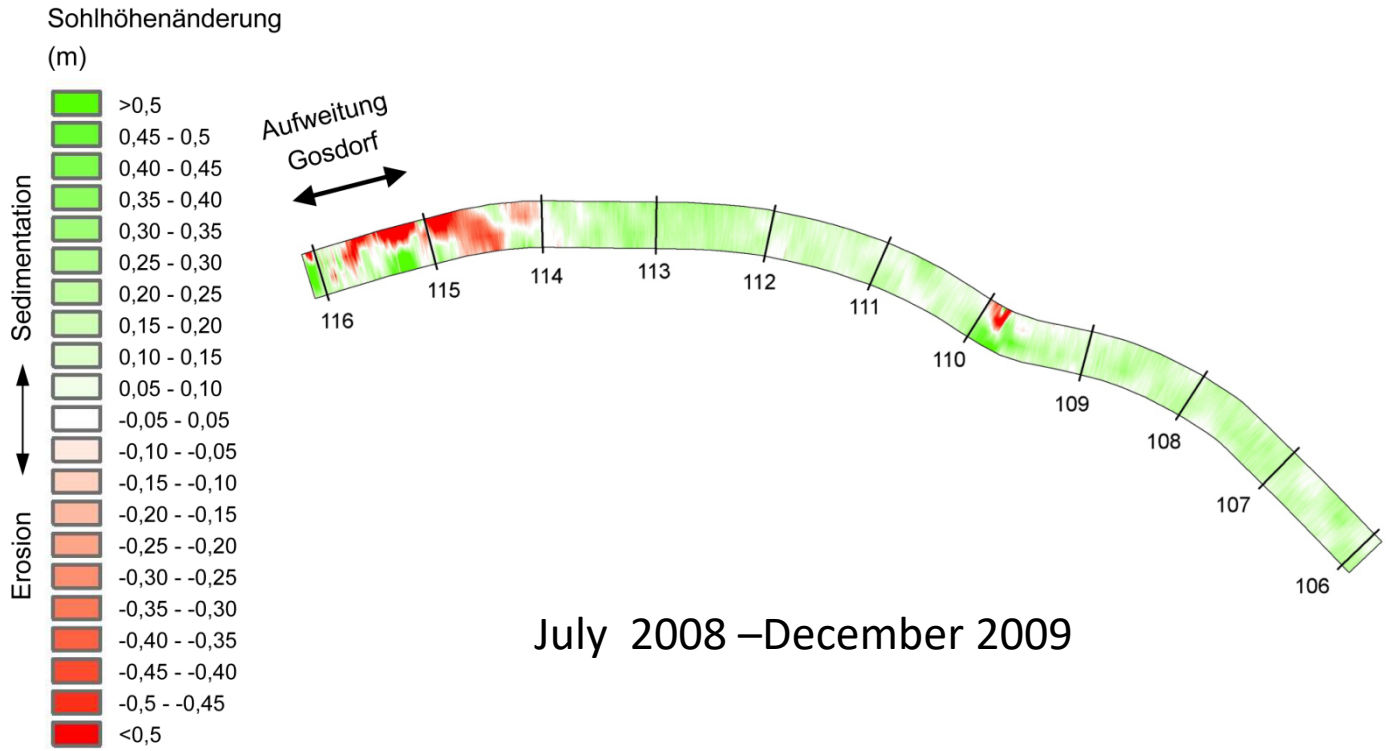
Monitoring

Bed level change

Repeated bed surveys

- Erosion of supplied sediment in Gosdorf reach
- Transport downstream
- (Temporary) stabilisation of bed levels



July 2008 –December 2009

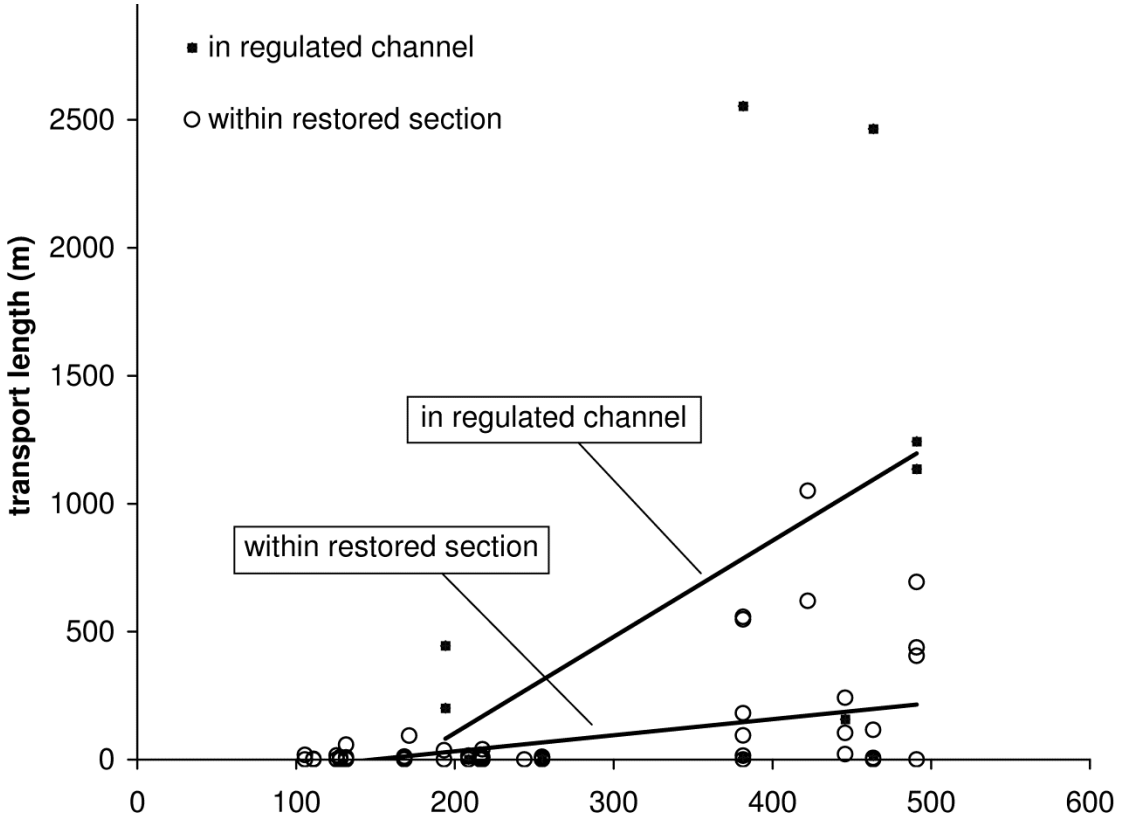
Monitoring

Bedload velocity

Mean grain size dm (b-axis 42mm): ~1 km per year

D90 (b-axis= 106mm): ~ 100m per year

- Decreased velocity in restored reach due to vertical mixing
- Increased velocity downstream
- Most sediment now already in the downstream part of the border section or transported further downstream

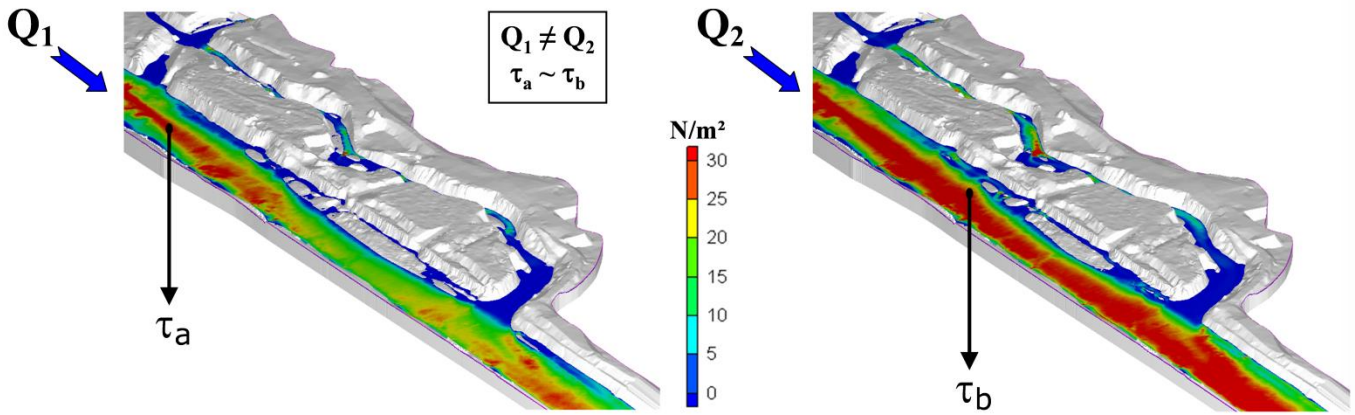


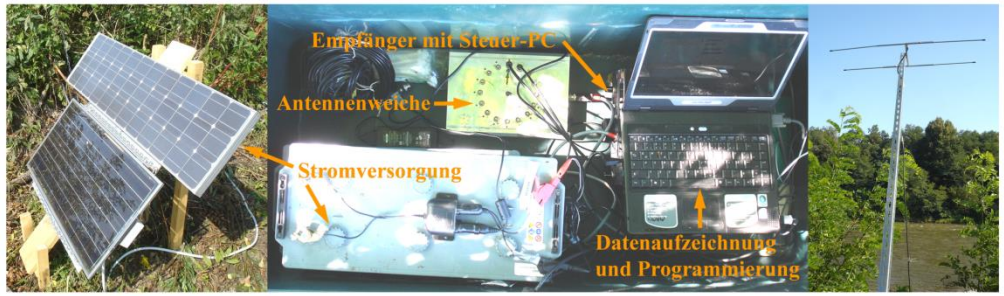
Monitoring

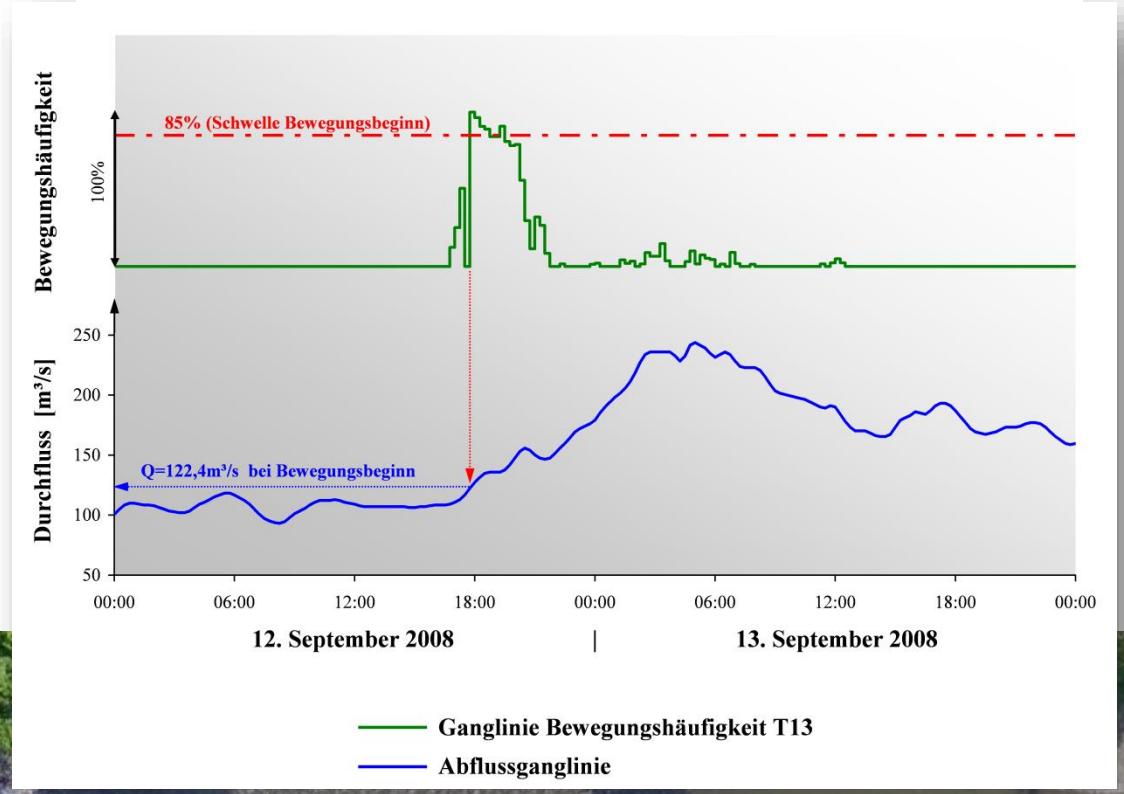
Bedload transport: Assessment of critical shear stress

- Measuring tracer mobility by continuous tracer survey
- Modelling shear stress at tracer locations with a 2D hydrodynamic-numerical model

→ Determination of critical thresholds for transport



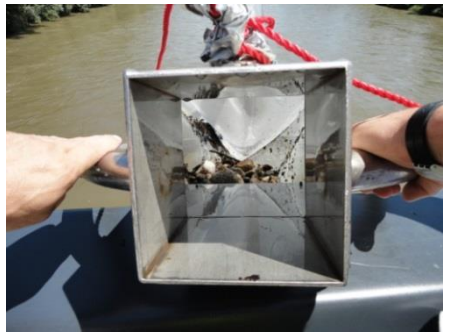


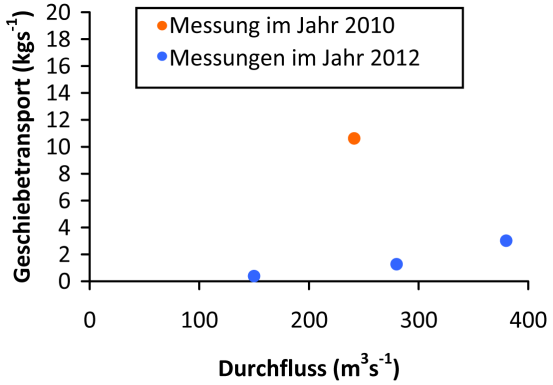


Monitoring

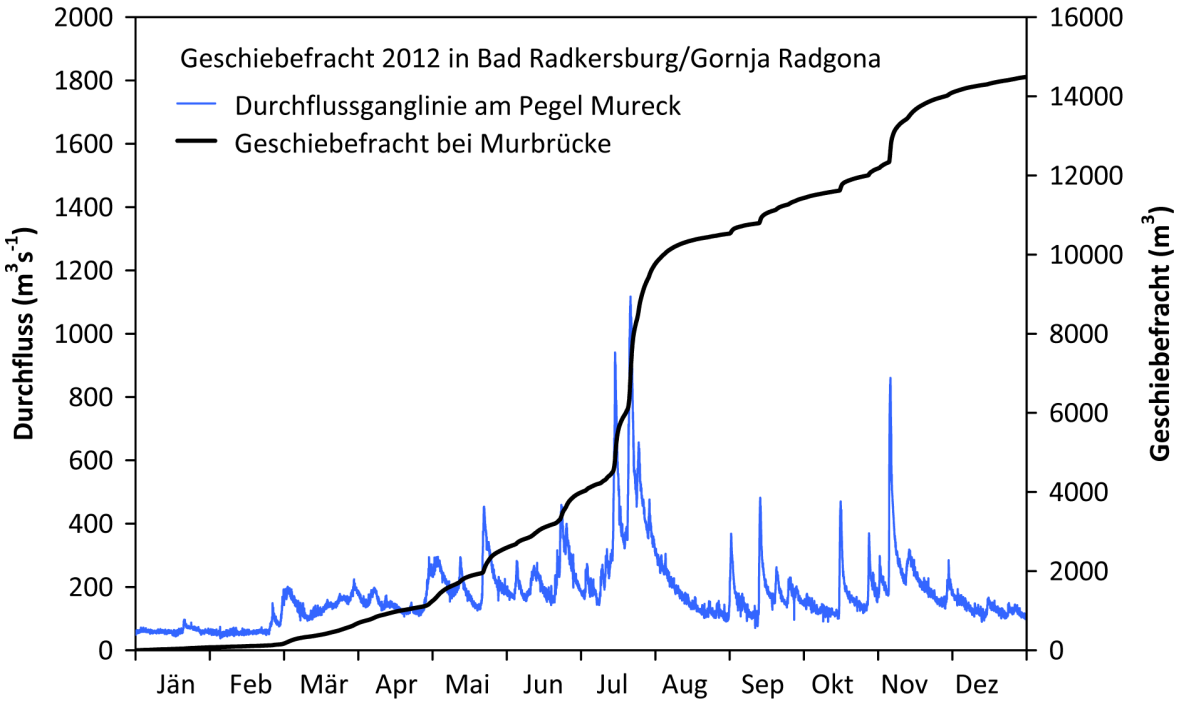
Quantification of bedload transport

Basket sampler measurements





Calculation of bedload yield

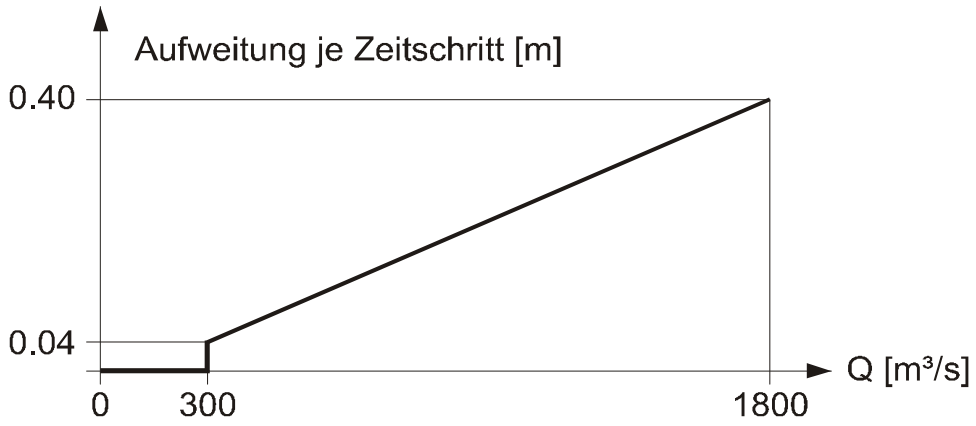


Monitoring

Measurement of riverbank erosion

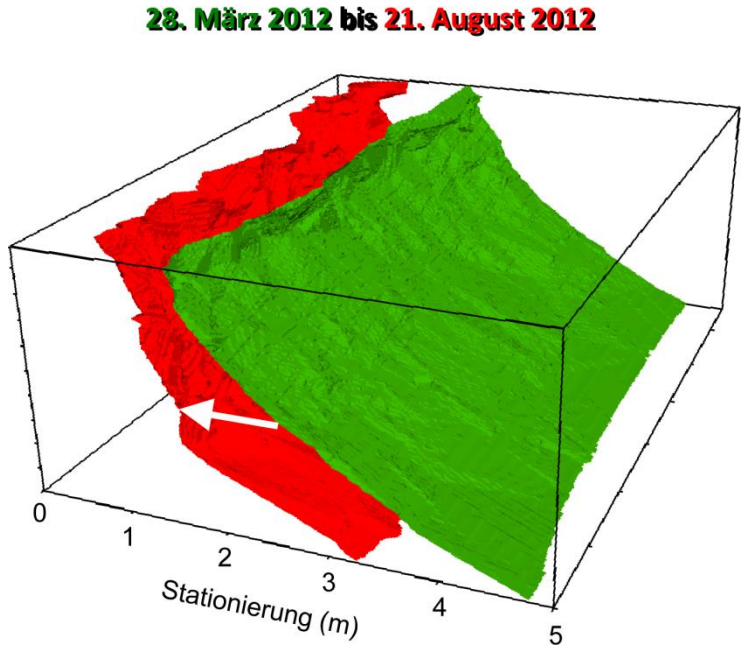
Simplified consideration in Basic Water Management Concept:

Channel widening following a simple relation, until width reached 150m (within 17 years)



Limited bank erosion

despite major flow event (> 1000 m³/s)



Monitoring

Measurement of riverbank erosion

Interreg Alpine Space

EUROPEAN UNION

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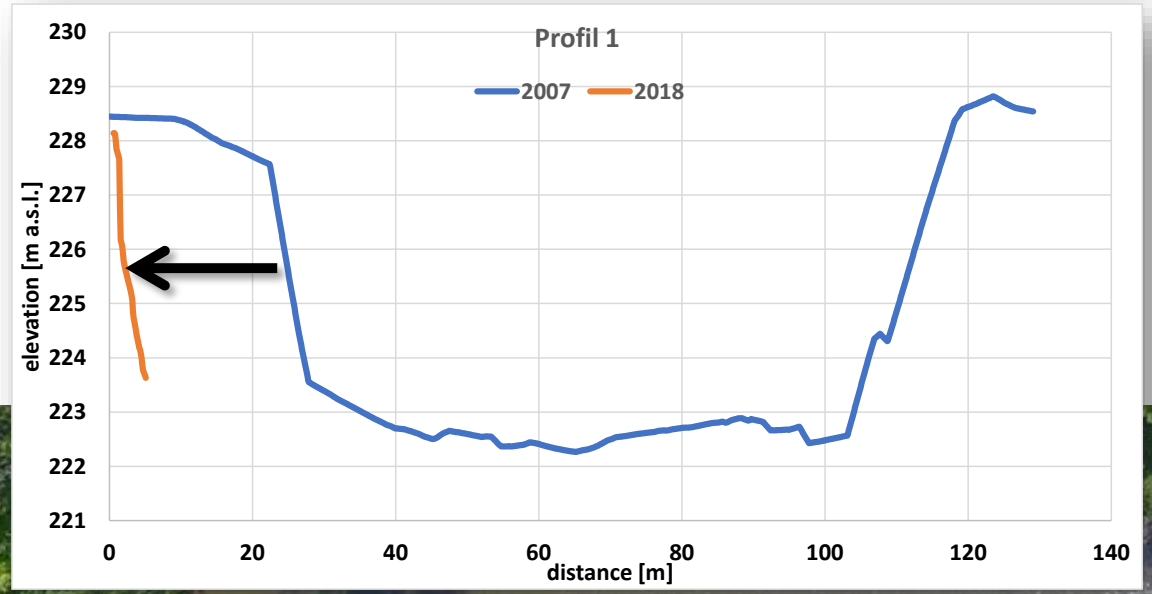
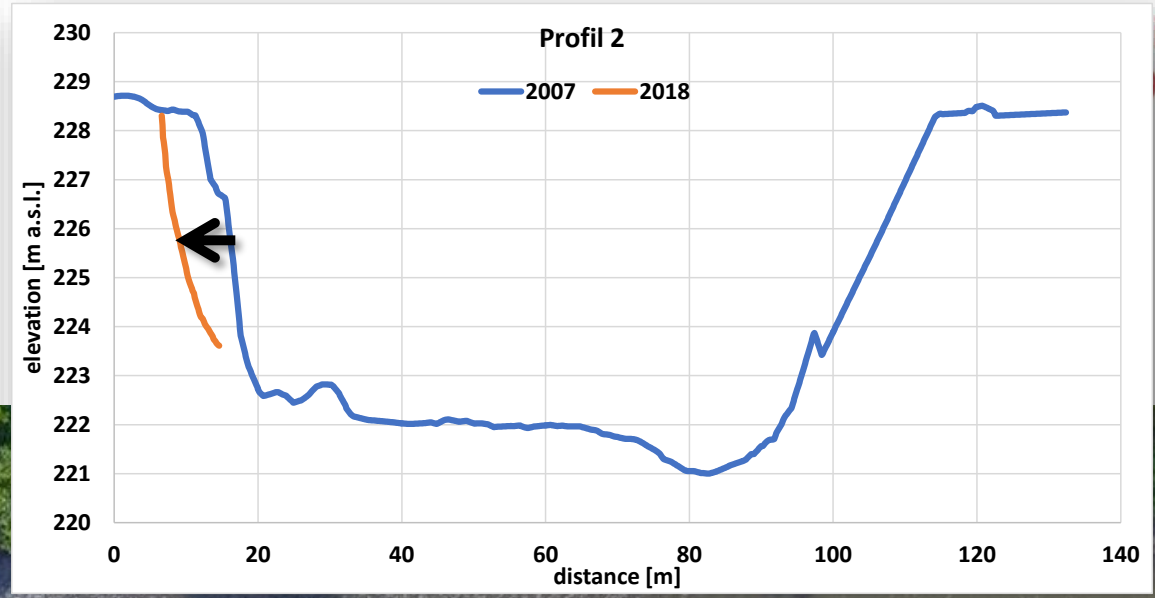
Limited bank erosion

Width increased by 10 m (uniform section) to 28 m (downstream of natural rock sill)





Monitoring

Relevance of river curvature and sediment supply

Gosdorf vs. Sicheldorf

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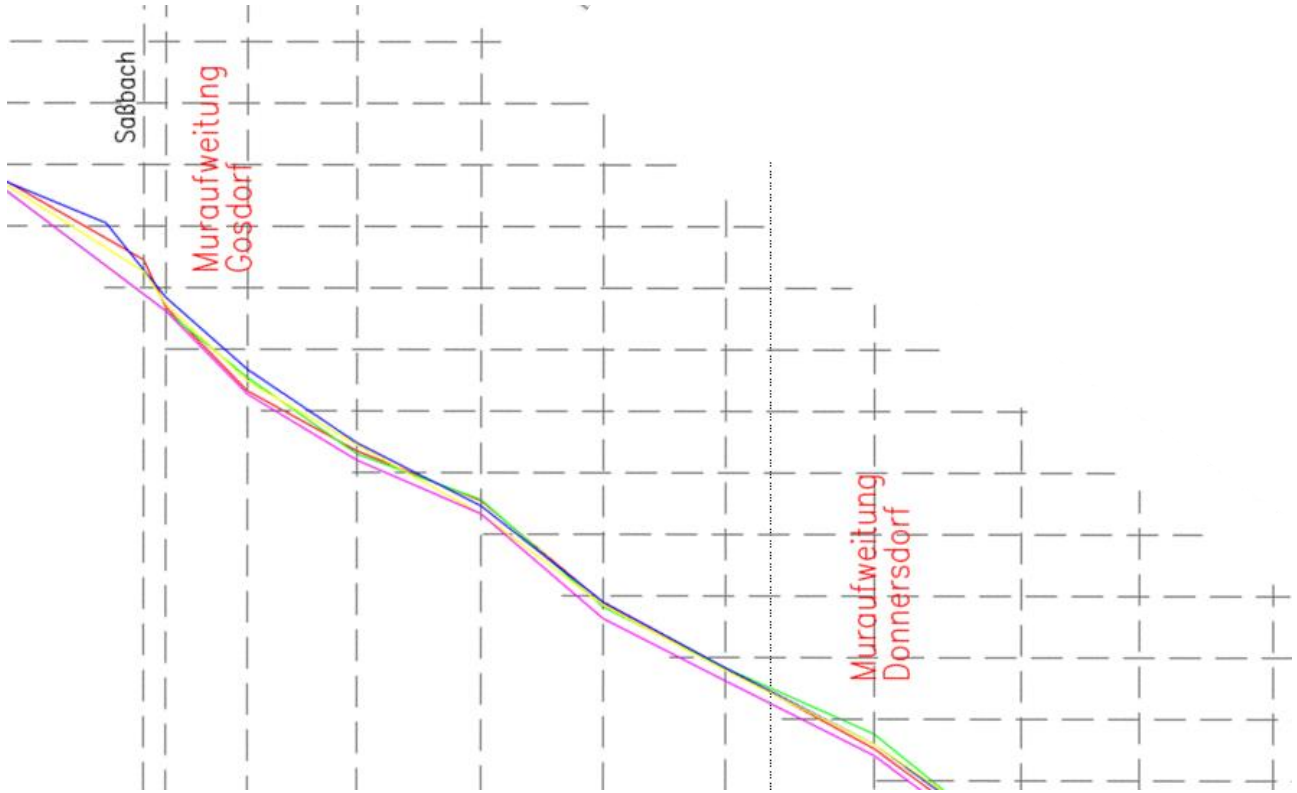
Monitoring

Consequence: restart of riverbed incison



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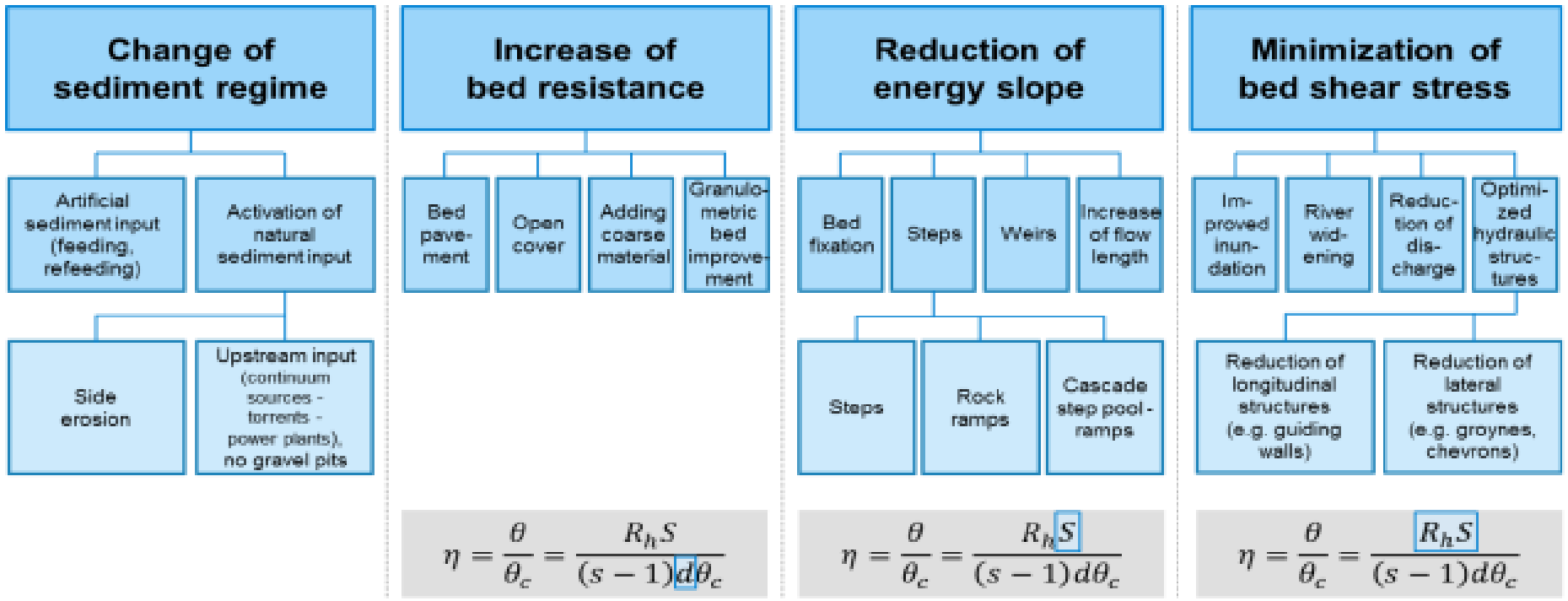
Measures



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Conclusions

- Disturbed sediment regime at Mur River, no input from upstream → sediment deficit
- Idea of Basic Water Management Concept: Stabilise bed and supply sediment via self-dynamic widenings
- Monitoring showed stabilising effect at the beginning
- According to tracer study most tracers must have been transported near the downstream end or out of the border section
- Self-dynamic increase of channel width remained below expectations (10m to 28m erosion compared to 150m after 15 years in Basic Water Managment Concept)
- No change of river course – no increased curvature
- Consequence: Initial stabilisiation of bed level turns back to incision
- Threat of loosing the gravel layer
- Need for action to maintain flood protection and to save and improve ecological condition

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Outlook (1)

- Necessity to analyse and verify the indicated effects at all restored sites of the border Mura
- Identifying the role of individual components (supply, width, river course etc.)
- Development of a Concept for future measures, focusing on the central points:
  - Sediment budget
  - Bedload supply from the banks and from upstream (goal for longterm: restoration of sediment connectivity)
  - Increase channel width to promote the development of bars and other structures
- Considering optimisation of river course (curvature) to increase secondary currents and bank erosion, including instream structures
- Find optimised mix of measures in goMURra – quantity of sediment supply, size of riverbend radius and width (and related slope change)

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Outlook (2)

- Methodology: Analysis of monitoring data (cross sections, low flow water levels, satellite images (width) etc.), Application of a 3D-hydrodynamic-numerical model coupled with a sediment transport and bank erosion model to determine the effects of scenarios of measure combination
- Implementation of pilot measure / adaptation of Gosdorf and monitoring
- Find sections with potential for corridor
- Importance of ecological evaluation of measures
- Coordination with public water supply – change of groundwater levels
- Effect for flood protection
- -> integrated river engineering approach needed

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THANK YOU!

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Das Land Steiermark
Wasserwirtschaft