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Sediment budgeting on event scale vs. long time scales

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Focus on the Rhine-Meuse delta

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Budget approaches

Sediment budget – aims

- Identify and quantify sediment sources
- Quantify sediment delivery to downstream areas
- Identify drivers for sediment delivery

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Budget approaches

Sediment budget - concept

$\Delta S = I - O$

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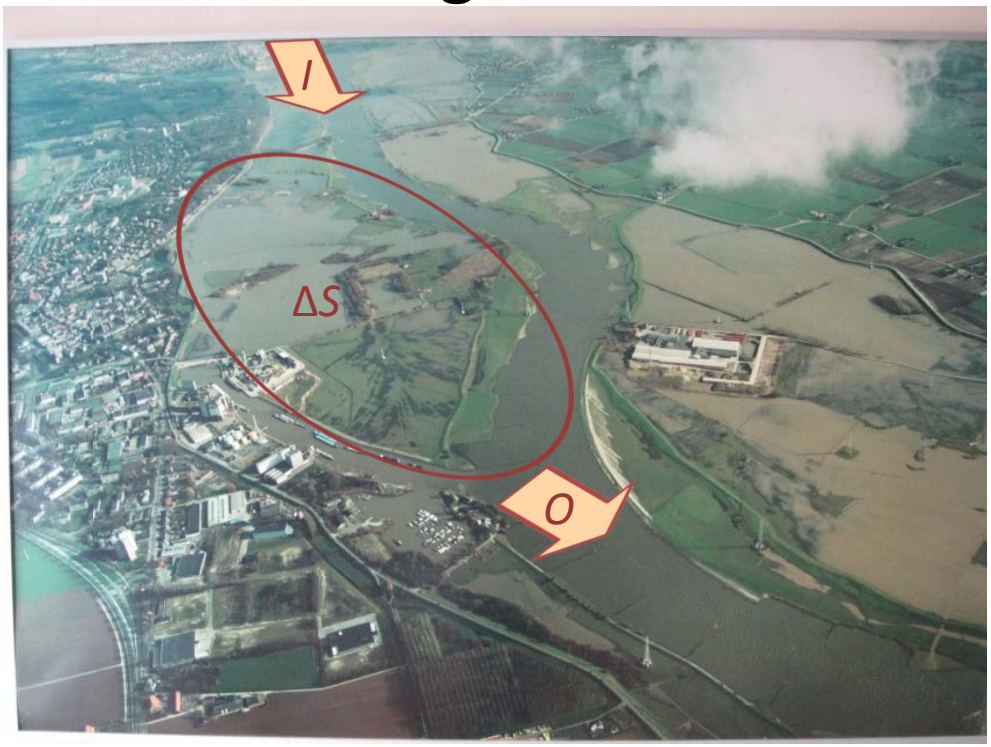
Budget approaches

Sediment budget – event scale



But:

-*I* and *O* difficult to measure / monitoring data is scarce

-*I* and *O* are large compared to Δ*S*, so large error in Δ*S*

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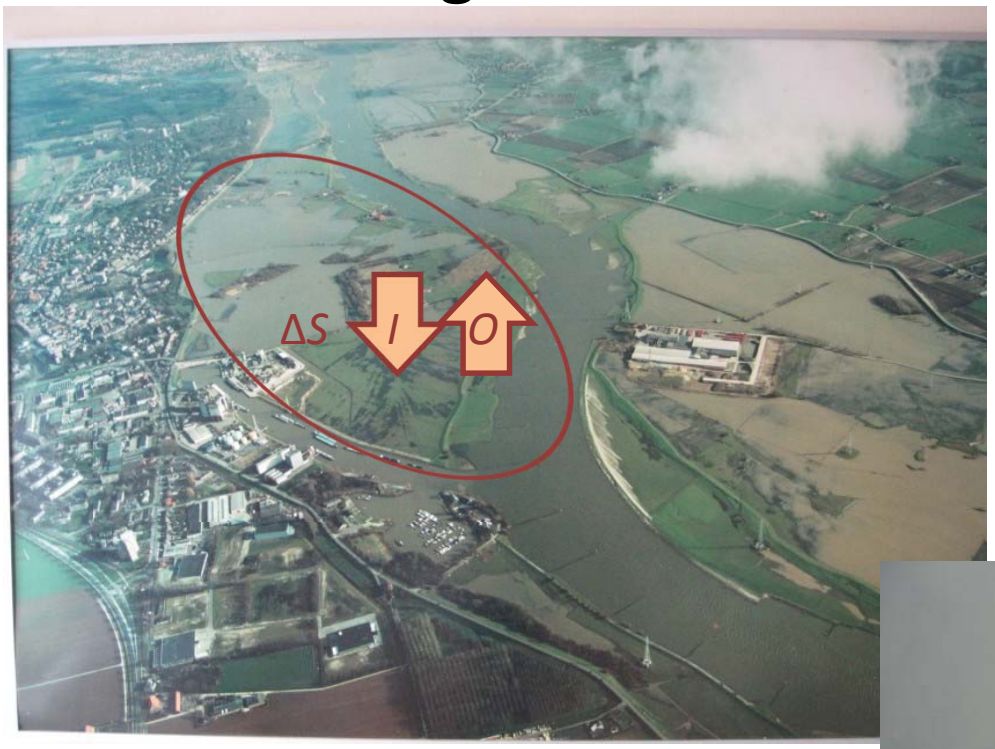
Budget approaches

Sediment budget – event scale



- *I* measured using sediment traps
- Assumption: $O \approx 0$, so $\Delta S \approx I$

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Budget approaches

Sediment budget – longer time scales

- *I* estimated from dating soil or sediment cores
- *O* ≠ 0 and need to be estimated from geological reconstructions
- Approach can also be applied for larger areas (deltas)

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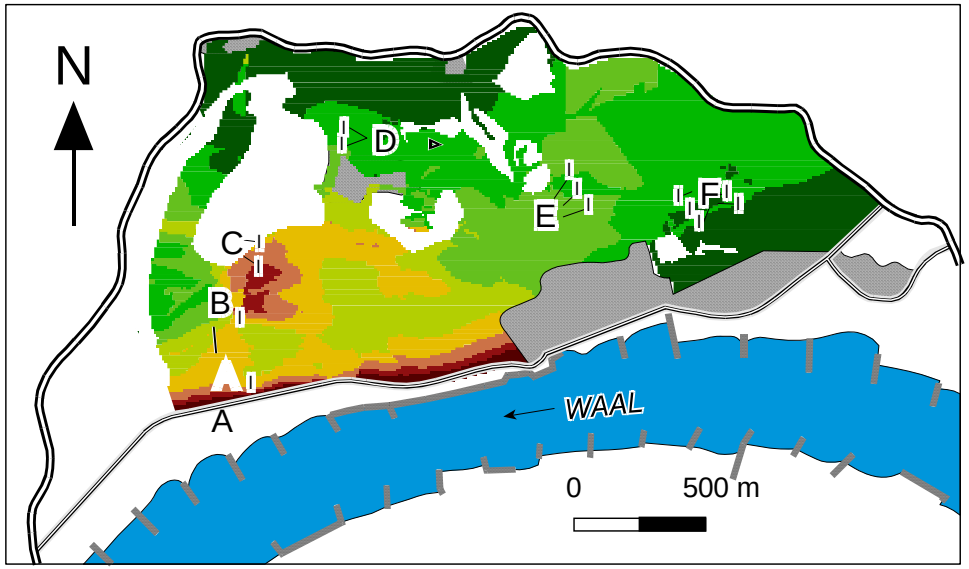
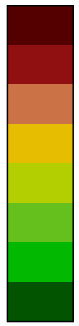
Event scale

Bemmel floodplain – measured sedimentation

Method: Measurement of contemporary overbank sedimentation after several flood events using sediment traps.

Results: During the high-magnitude 1993 flood, total deposition along the Waal (main branch) was 0.24 Mton.





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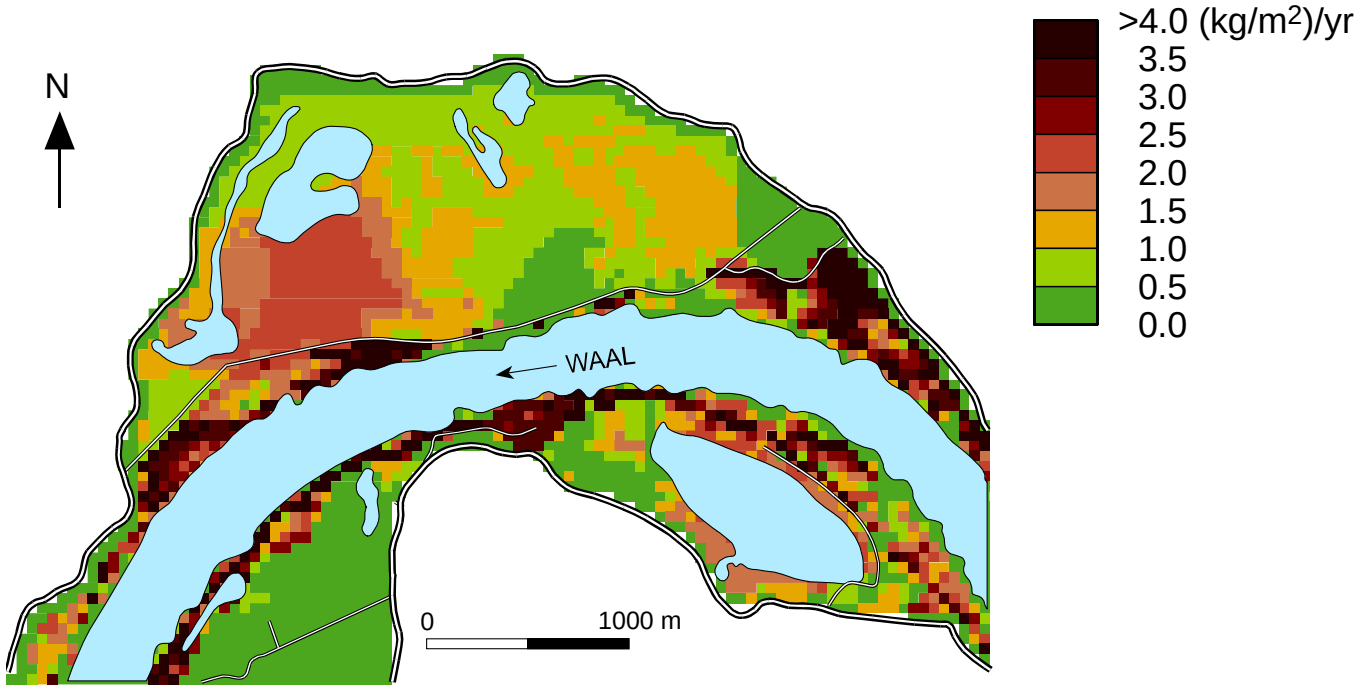
Comtemporary sedimentation rates

Bemmel floodplain – simulated sedimentation

Method: Using 2D models for overbank flow and sedimentation, we calculated average annual sedimentation.



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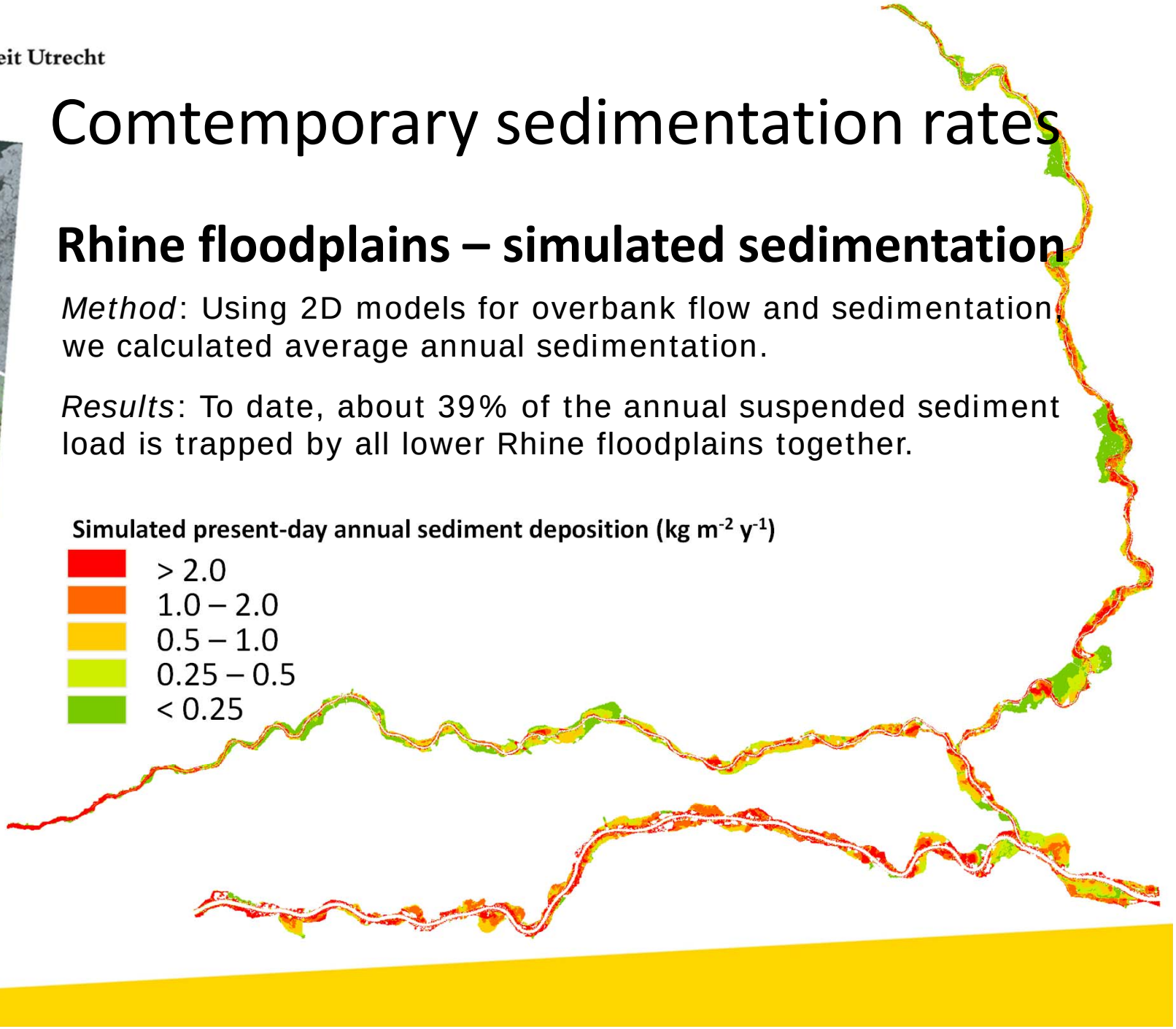
Comtemporary sedimentation rates

Rhine floodplains – simulated sedimentation

Method: Using 2D models for overbank flow and sedimentation, we calculated average annual sedimentation.

Results: To date, about 39% of the annual suspended sediment load is trapped by all lower Rhine floodplains together.



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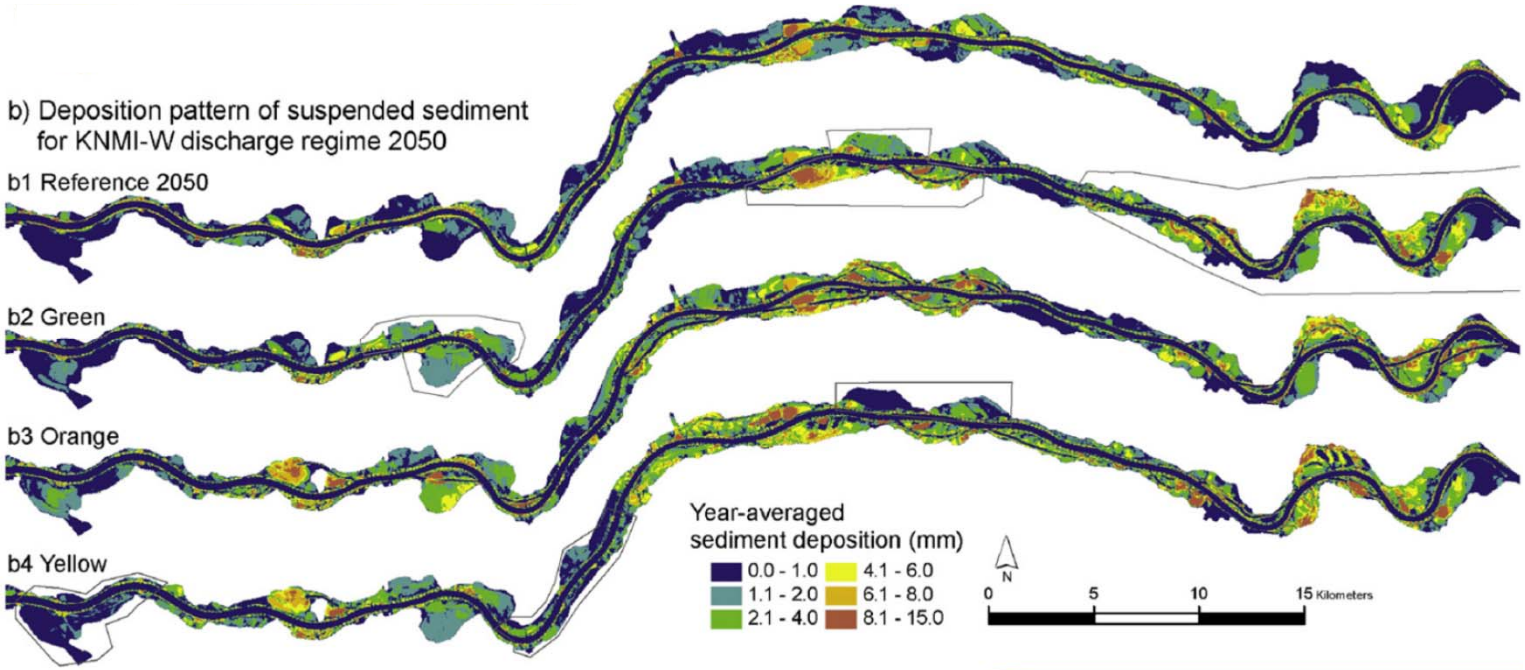
Future sediment trapping

Climate change and landscaping measures

Methods: Using the 2D models we simulated annual sediment deposition for future scenarios of climate and landscaping measures (lowering floodplain surface, removal of minor embankments, digging side channels).



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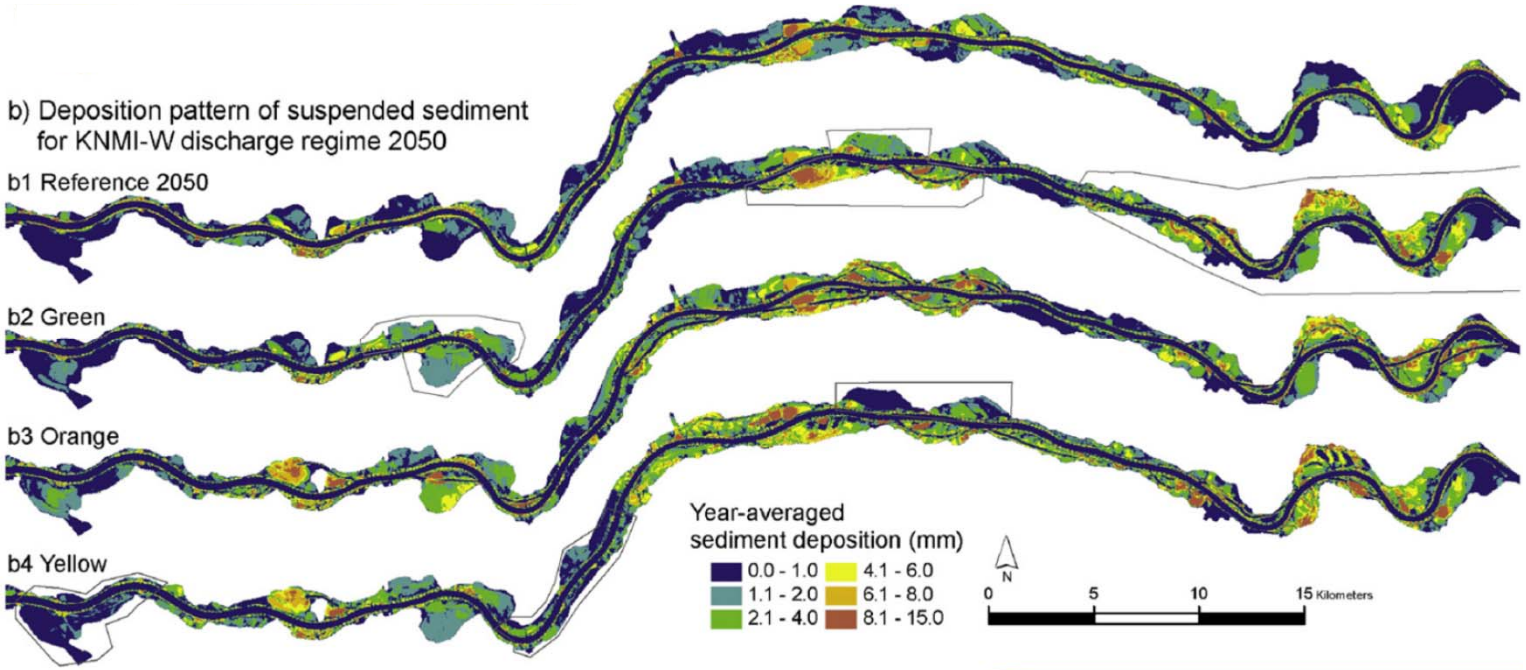
Future sediment trapping

Climate change and landscaping measures

Results: Climate change enhances deposition by + 60%; landscaping measures increase trapping efficiency: deposition doubles



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Decennial time scale

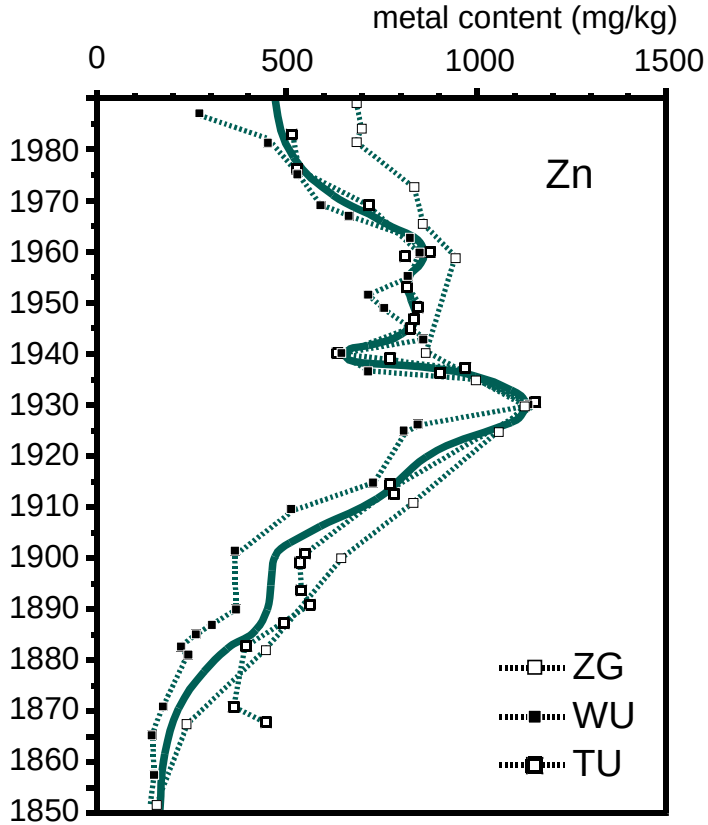
Normalized Rhine river after 1850

After 1850 the channels were normalized by groynes, preventing lateral bank erosion. Due to the channel fixation, re-mobilisation of older sediments has not occurred.

Method:

Post-1850 sediments were traced by enhanced heavy metal concentrations.

The pollution history was reconstructed from floodplain lake sediments.



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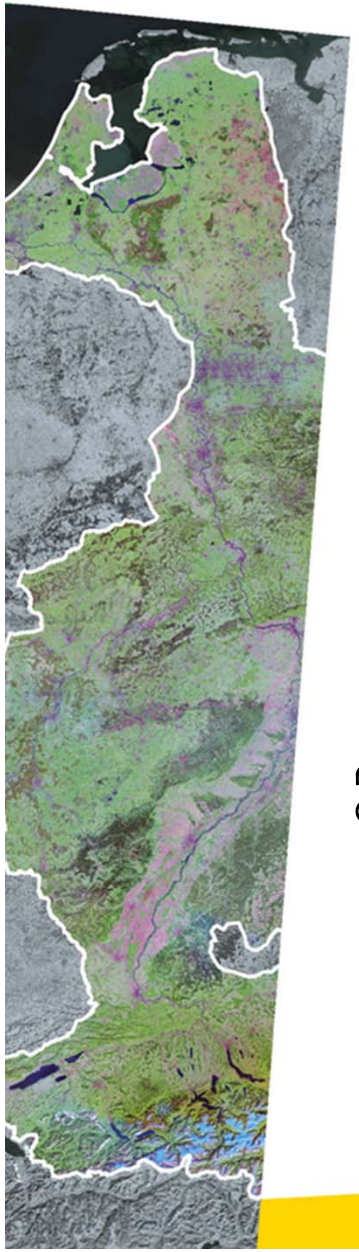
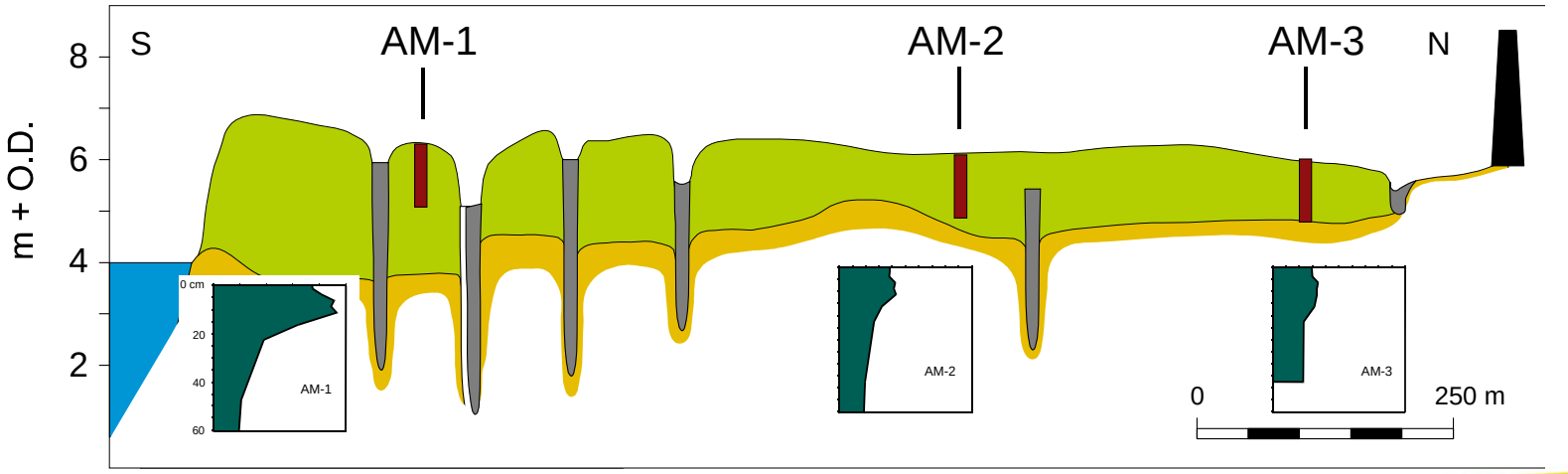
Decennial time scale



Normalized Rhine river after 1850

Results:

The total sediment deposition after 1850 AD amounts to 173 Mton (10^9 kg).



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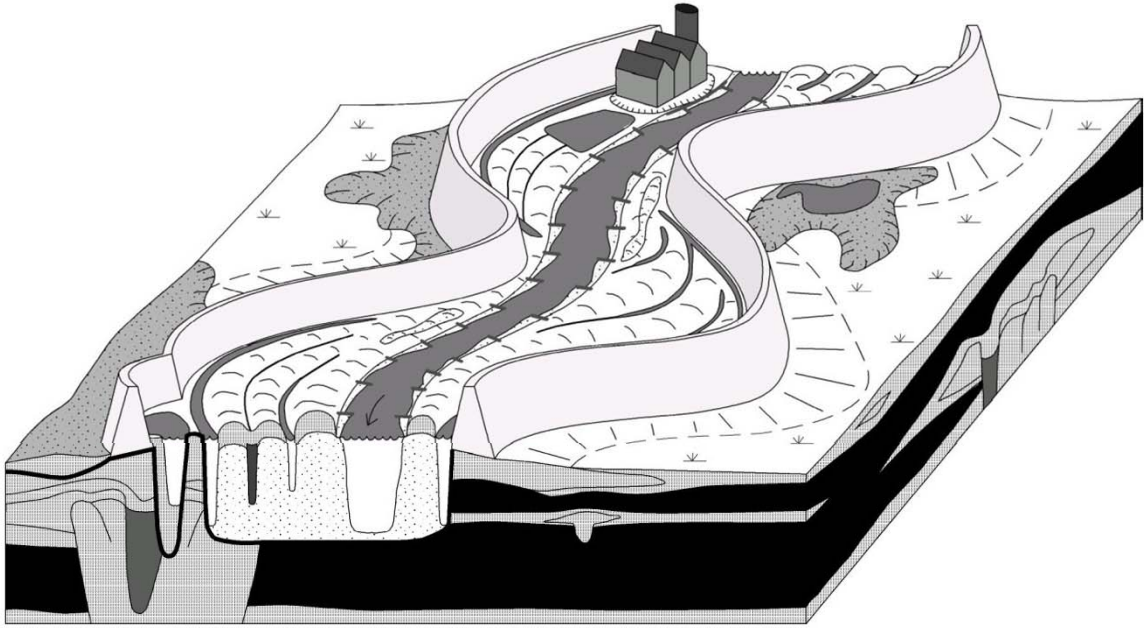
Century time scale

Embanked Rhine river after 1200

After embankment (1200 and 1350 AD), sediment deposition was limited to narrow zones along the main channels.



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Century time scale

Embanked Rhine river after 1200

Method:

Using coring data the amount of overbank deposits was estimated. OSL dating and historic river maps were used to reconstruct lateral accretion and post-depositional erosion of floodplains.

Results:

After embankment, the floodplains have trapped 640 Mton overbank fines. About 70-80% of the floodplain deposits were re-eroded by lateral channel migration.

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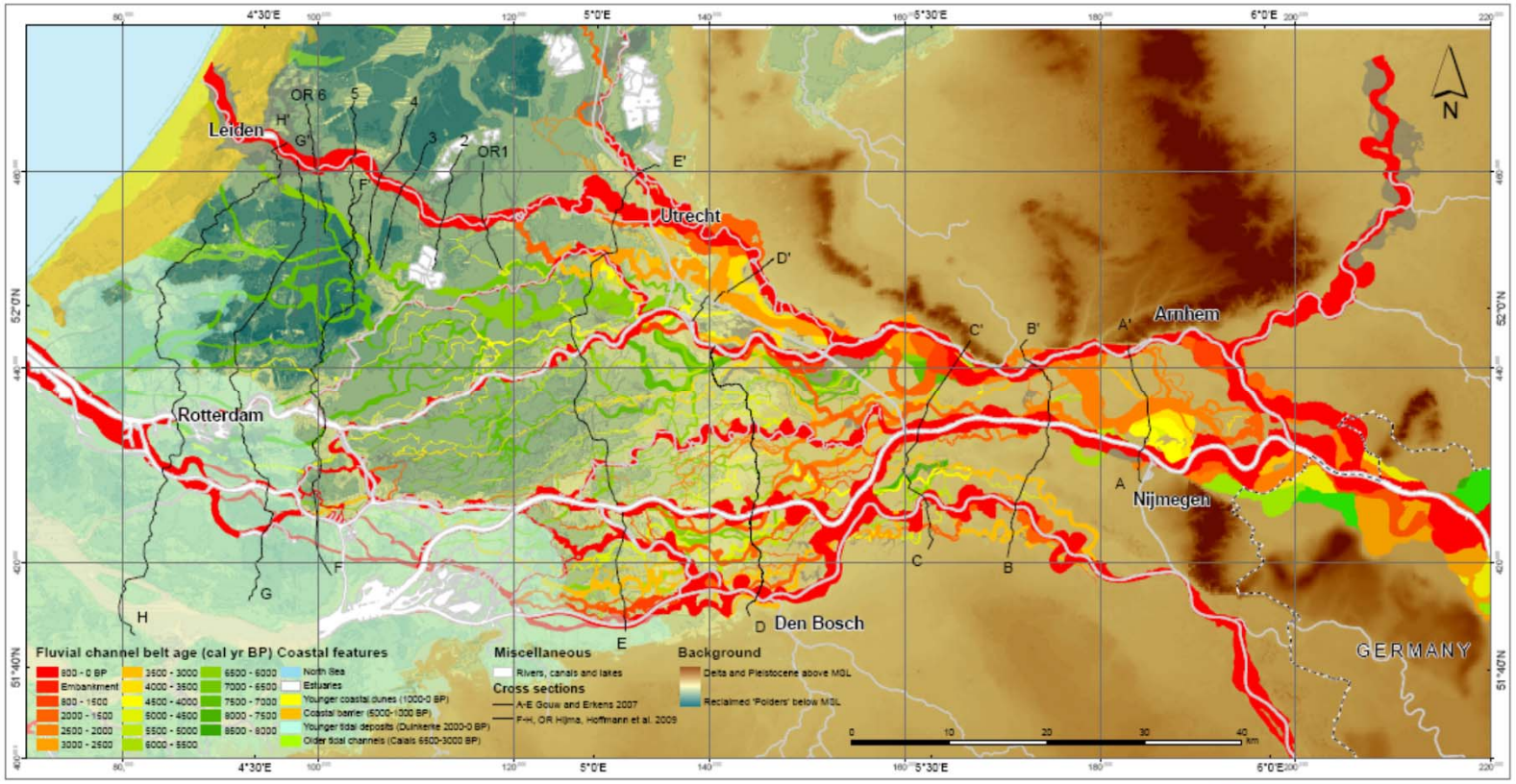
Millennial time scale

Holocene natural delta



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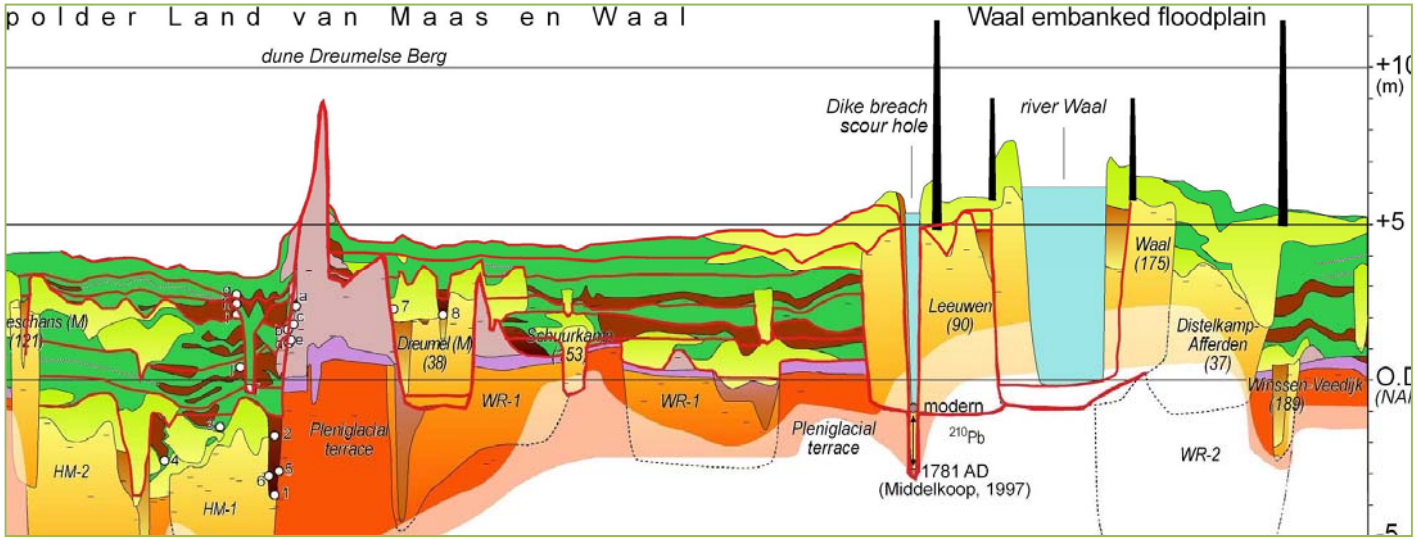
Millennial time scale

Holocene natural delta

Method: Using a large coring database the amounts of sediment trapped over the past millennia were determined using 8 detailed cross sections. Age control was based on >200 ^{14}C-datings.



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Millennial time scale

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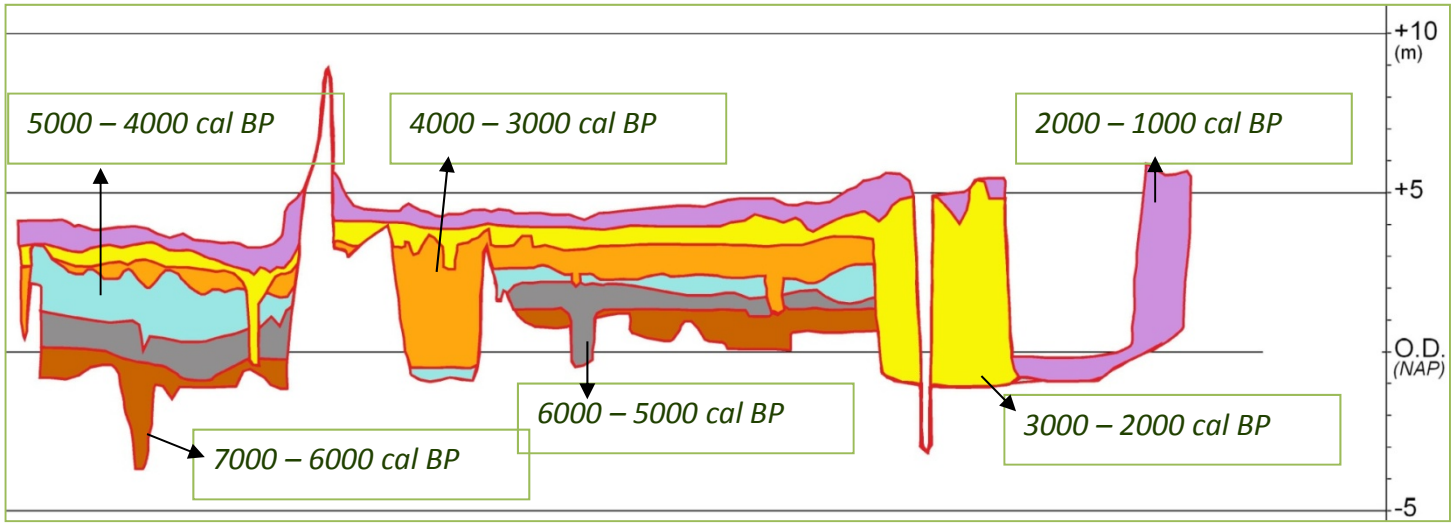

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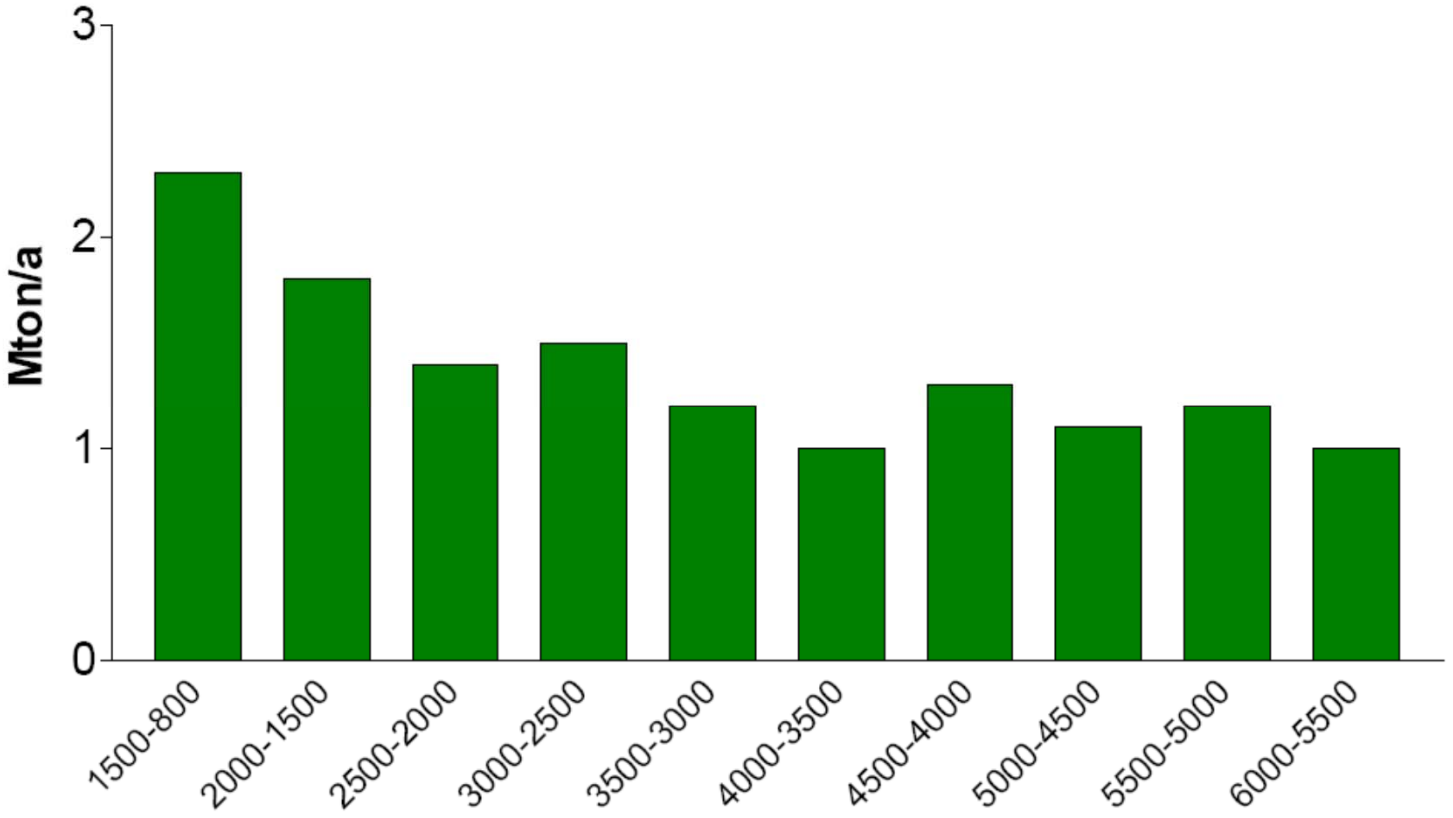
Millennial time scale

Holocene natural delta

Results: Sediment accumulation increased after 2000 BP.



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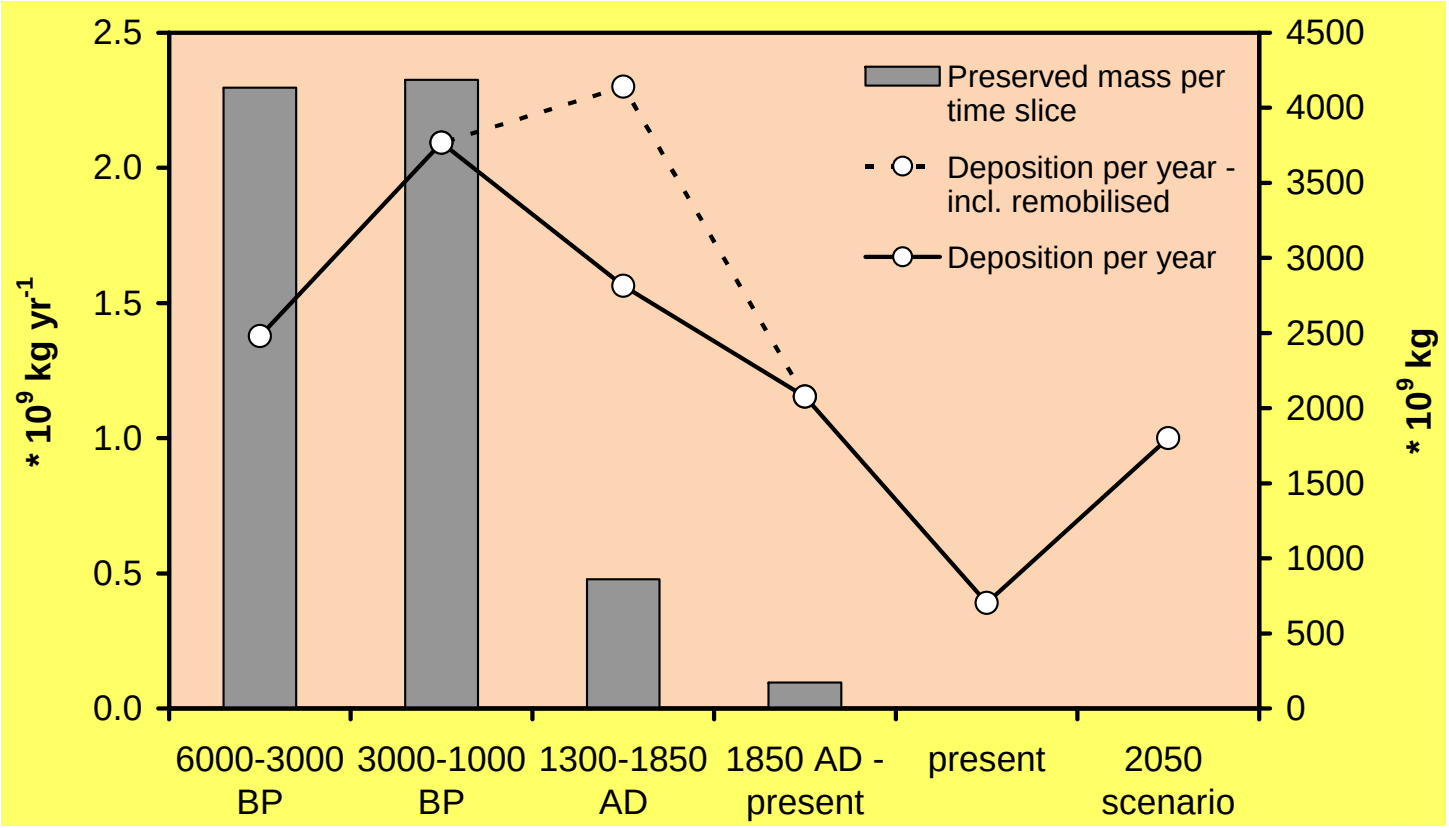
Synthesis

Sediment accumulation in the Rhine delta



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Synthesis

Sedimentation in the Rhine delta

- Deforestation in the river basin increased deposition in the delta after 2000 BP. The bulk of these deposits have been well preserved.
- Embankment of the river channels enhanced deposition, but preservation of deposits was low.
- Channel fixation resulted in aggraded floodplains, which reduced the trapping efficiency, but preserved sediment.
- Present-day floodplain sedimentation is mainly controlled by distance from inlet. Sediment remobilisation can be neglected.
- Landscaping measures will enhance floodplain deposition in the future.

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Conclusions

Short vs. long time scale

	Short time scales	Long time scales
Budget items	Remobilisation/ erosion can be neglected	- Remobilisation must be reconstructed - Supply and remobilisation have changed over time
Identification of drivers for sediment supply	n/a	Land use change in upstream areas
Identification of drivers for sediment trapping	Distance from inlet	- Preservation - Embankment - Channel fixation - Landscaping measures