Bundesanstalt für Wasserbau
Federal Waterways Engineering and Research Institute

# Evaluation of Surface-Subsurface Interactions Following an Embankment Opening for the Enhancement of Stream-Floodplain Connectivity

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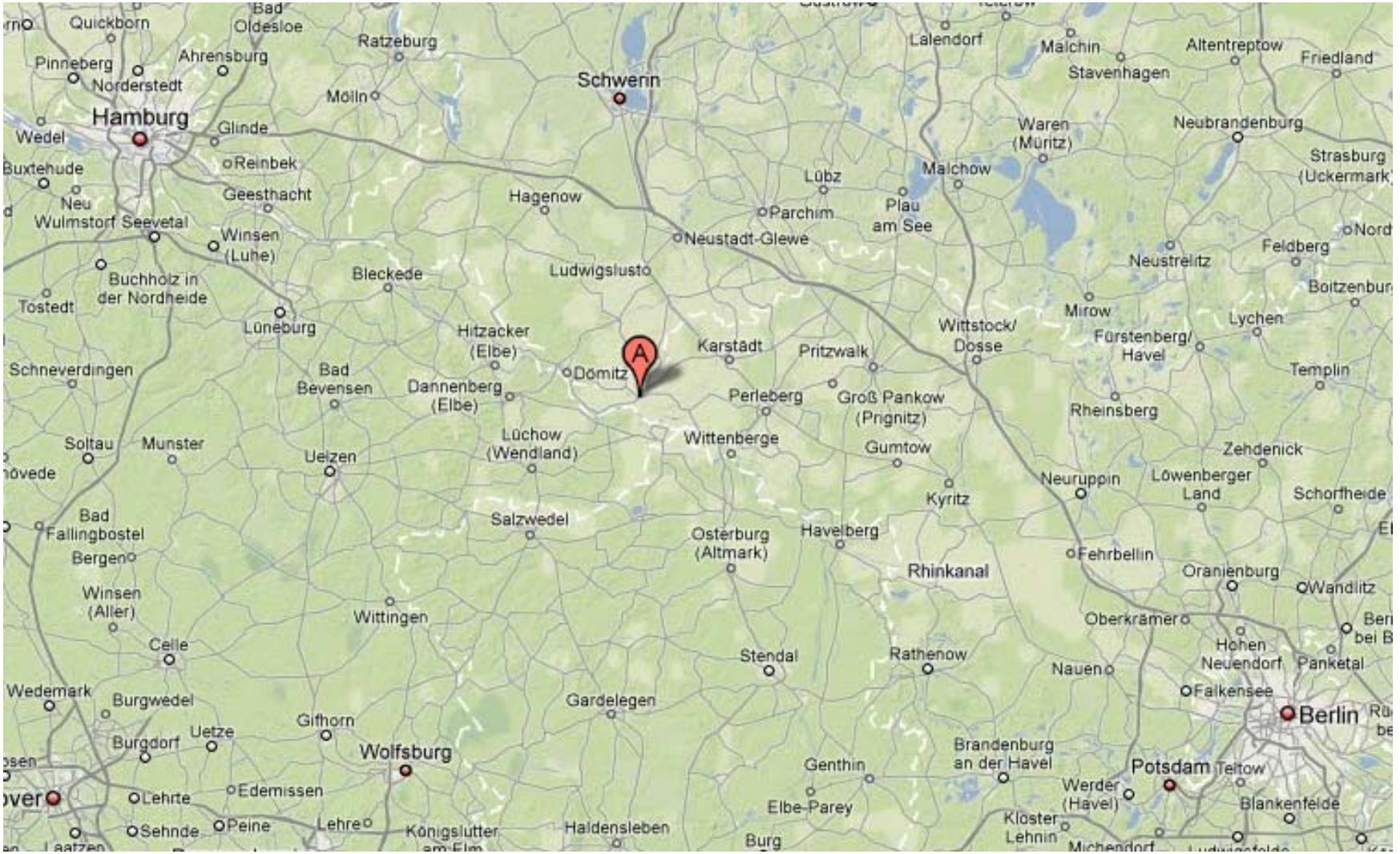
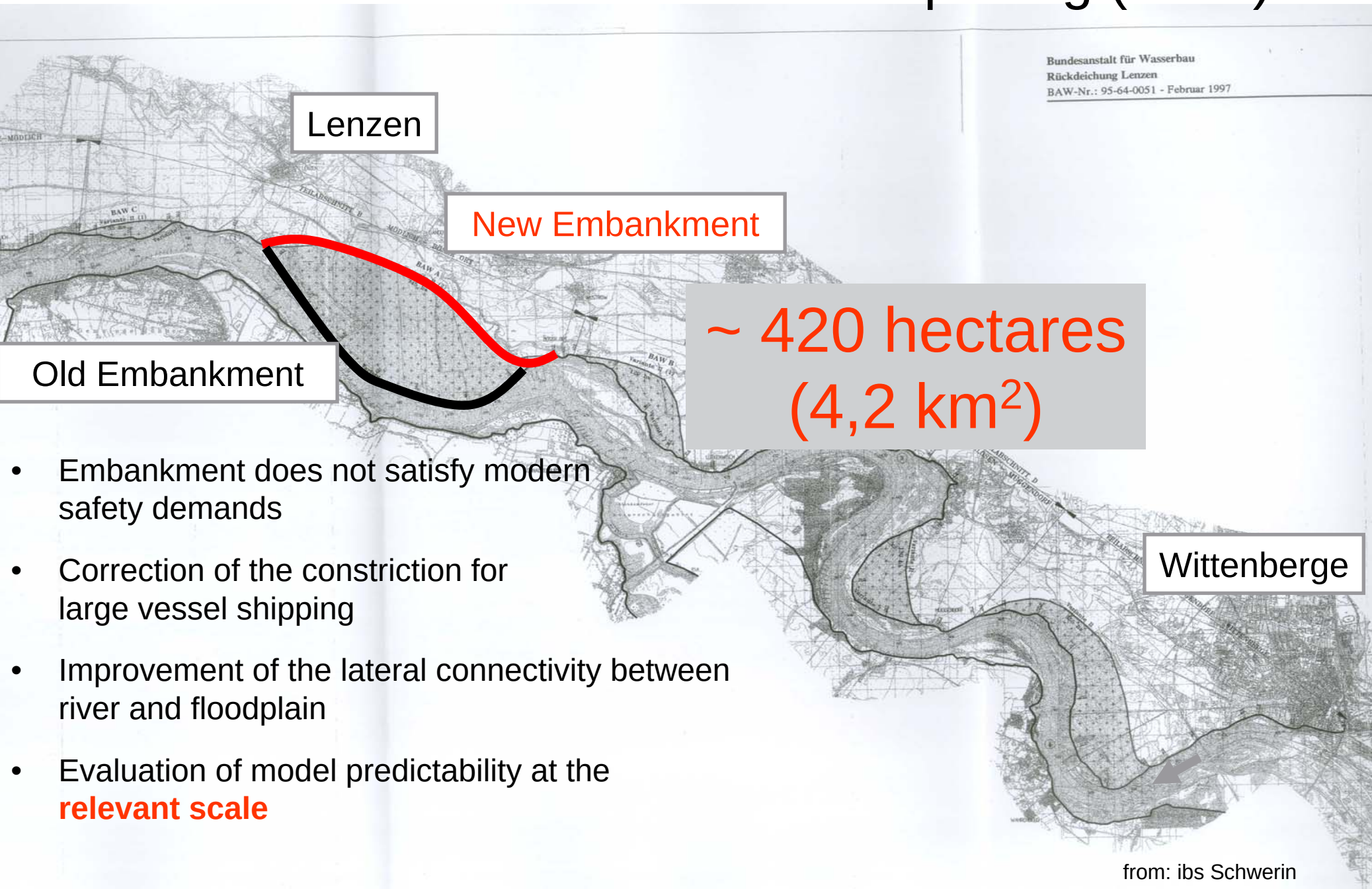
# Outline

- Motivation for embankment opening
- Model conceptualization
- Groundwater model set up
- Surface water
- Conclusions

# Embankment Opening Near Lenzen Elbe

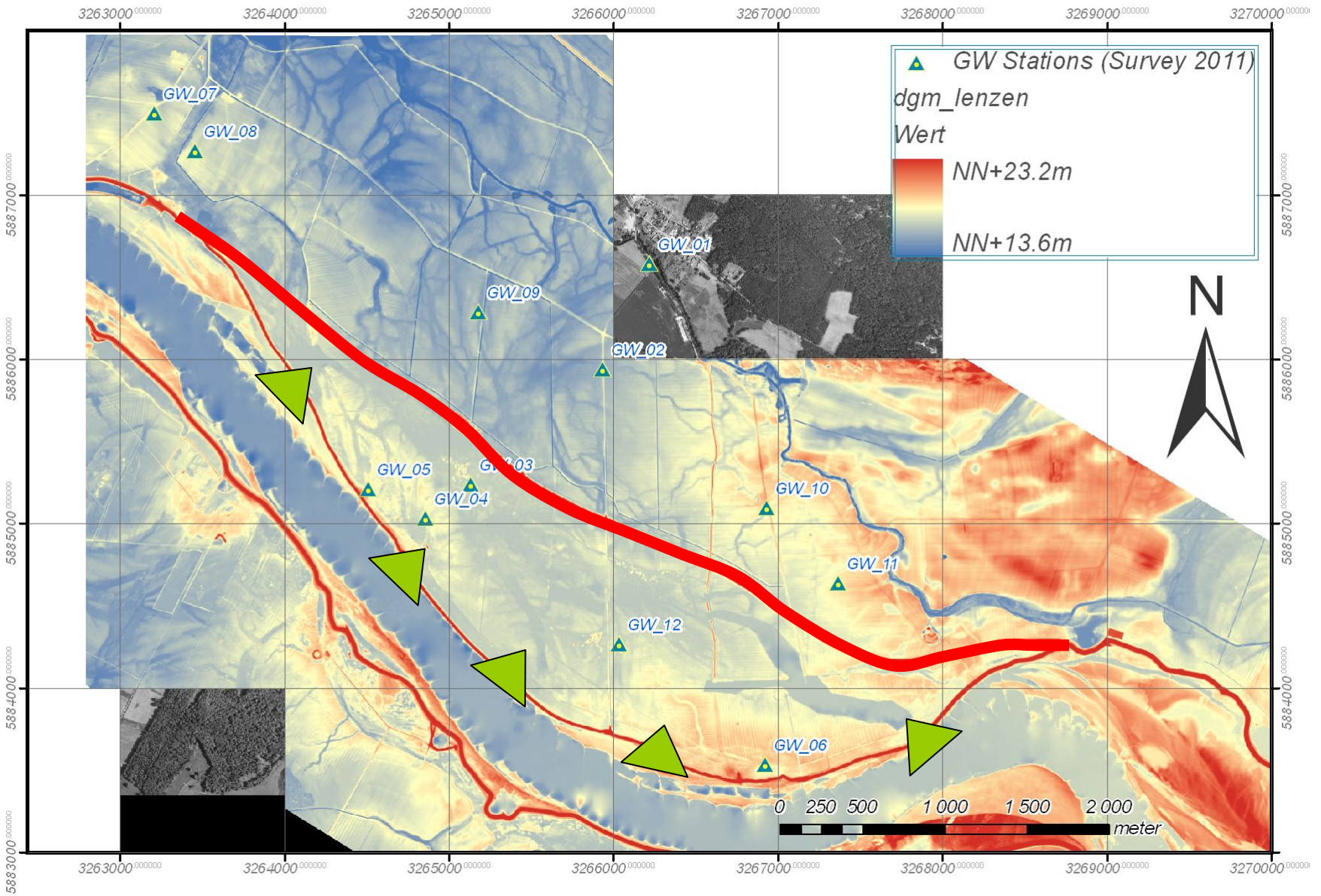


# Motivation for an Embankment Opening (1995)

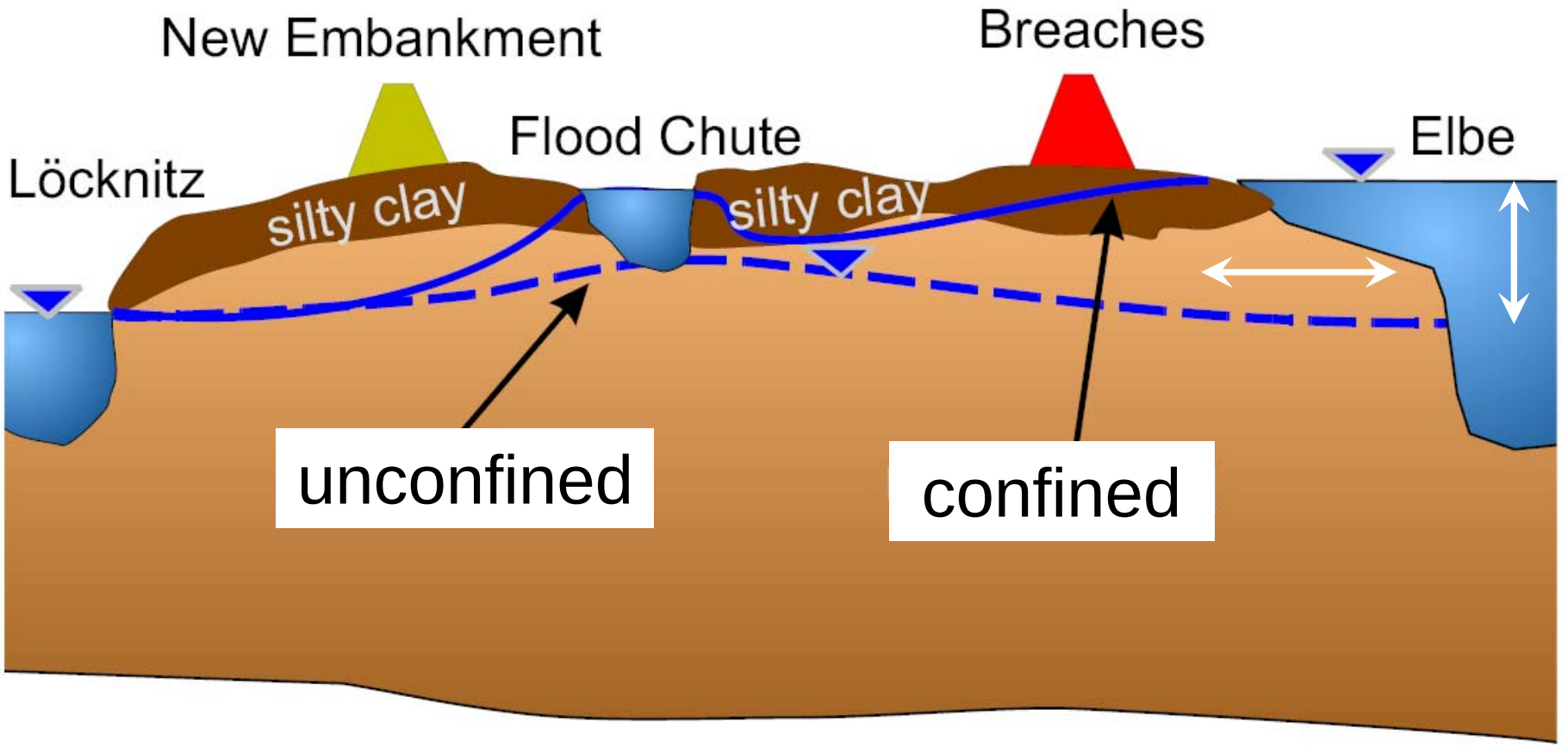



- Embankment does not satisfy modern safety demands
- Correction of the constriction for large vessel shipping
- Improvement of the lateral connectivity between river and floodplain
- Evaluation of model predictability at the **relevant scale**

from: ibs Schwerin


GW Stations (Survey 2011)
dgm_lenzen
Wert
NN+23.2m
NN+13.6m
N
GW_01
GW_02
GW_03
GW_04
GW_05
GW_06
GW_07
GW_08
GW_09
GW_10
GW_11
GW_12
0 250 500 1 000 1 500 2 000
meter
3263000.000000
3264000.000000
3265000.000000
3266000.000000
3267000.000000
3268000.000000
3269000.000000
3270000.000000
5887000.000000
5886000.000000
5885000.000000
5884000.000000
5883000.000000

# Confined-Unconfined Transitions




Gaining / Losing Transitions

# Depth, Duration and Frequency of Flooding

REQUIRES TRANSIENT SIMULATIONS OF LARGE PERIODS

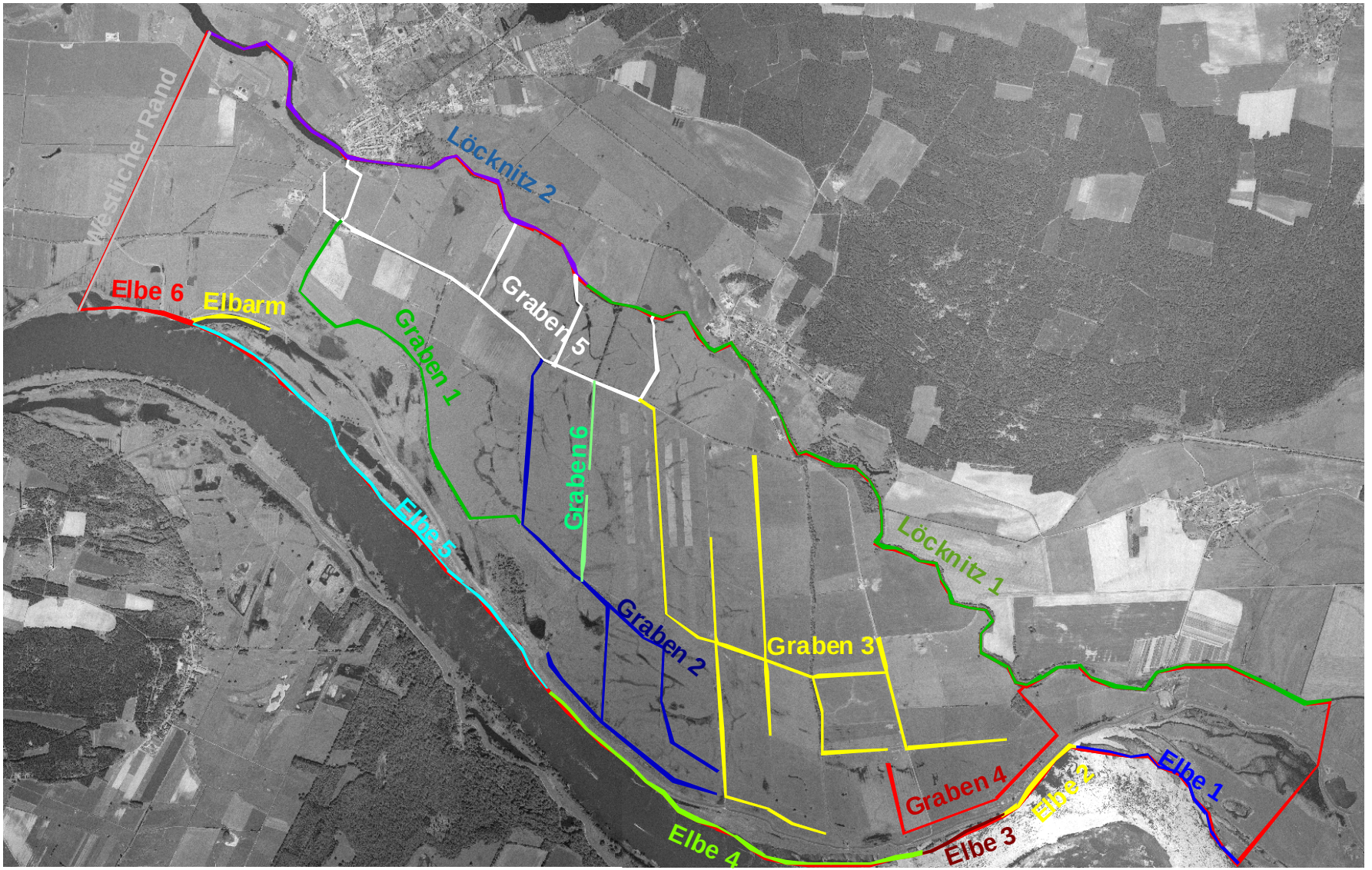
What are the relevant processes to consider?

- Surface flow 2D
- Subsurface flow
  - Vadose Zone (Recharge < 150 mm/year)
  - Groundwater 2D

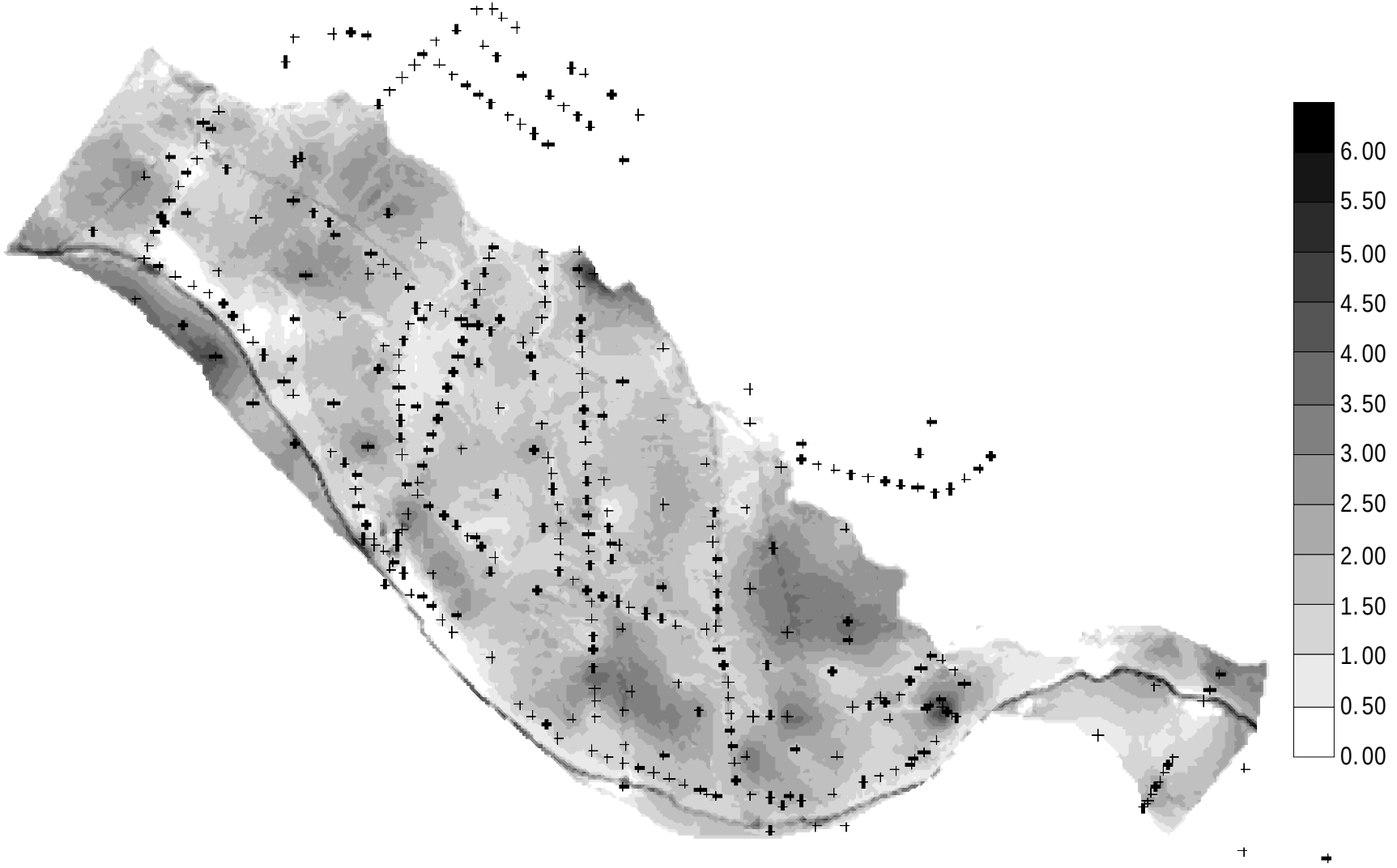
Uncoupled Surface-Subsurface Interaction

No unsaturated flow storage approach

# Drainage Trench System Before Opening

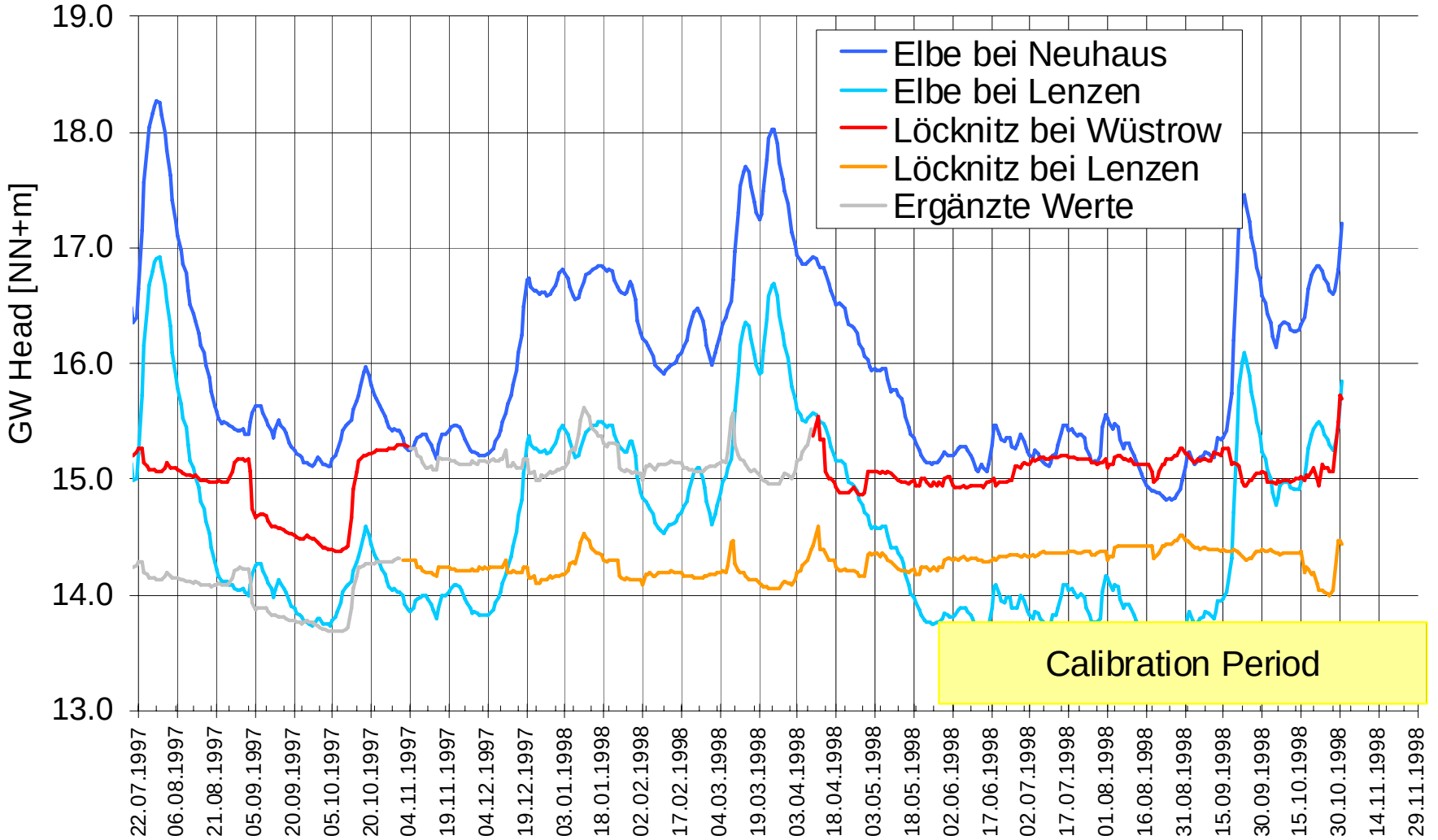


# Distribution of Clay Layer Thickness

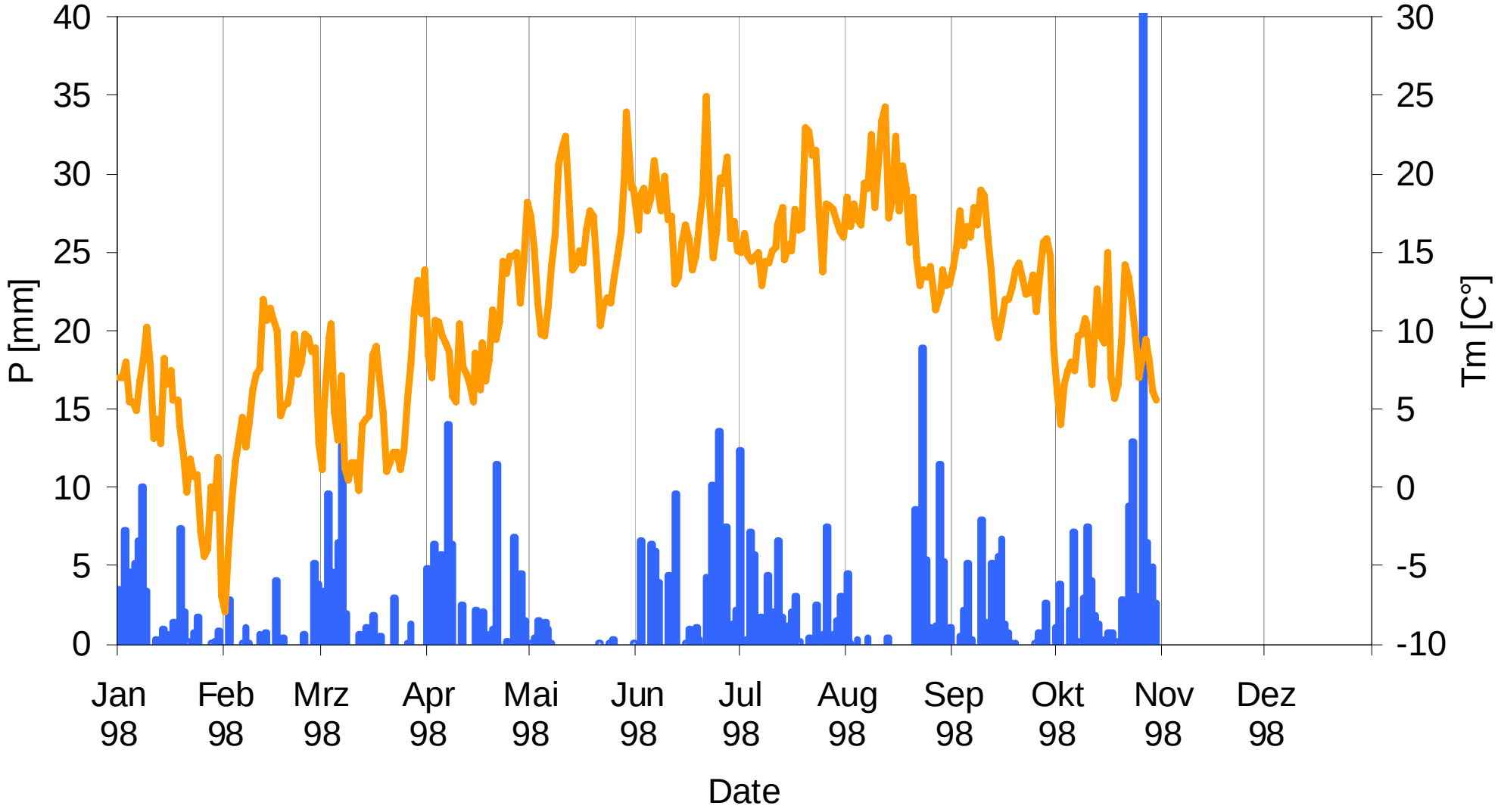


# Domain and FE-Mesh of the GW-Model

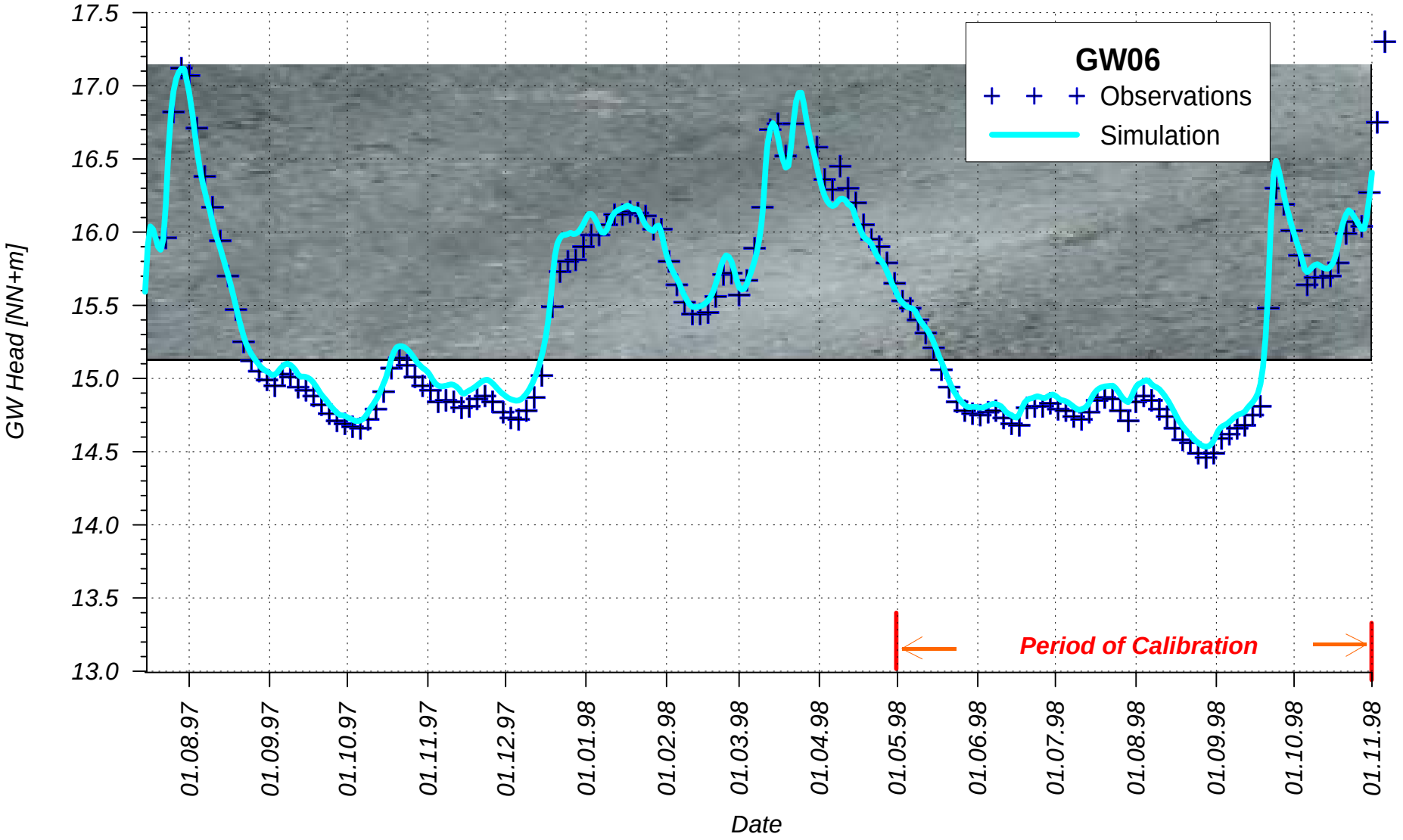
# Upstream Downstream Boundary Conditions



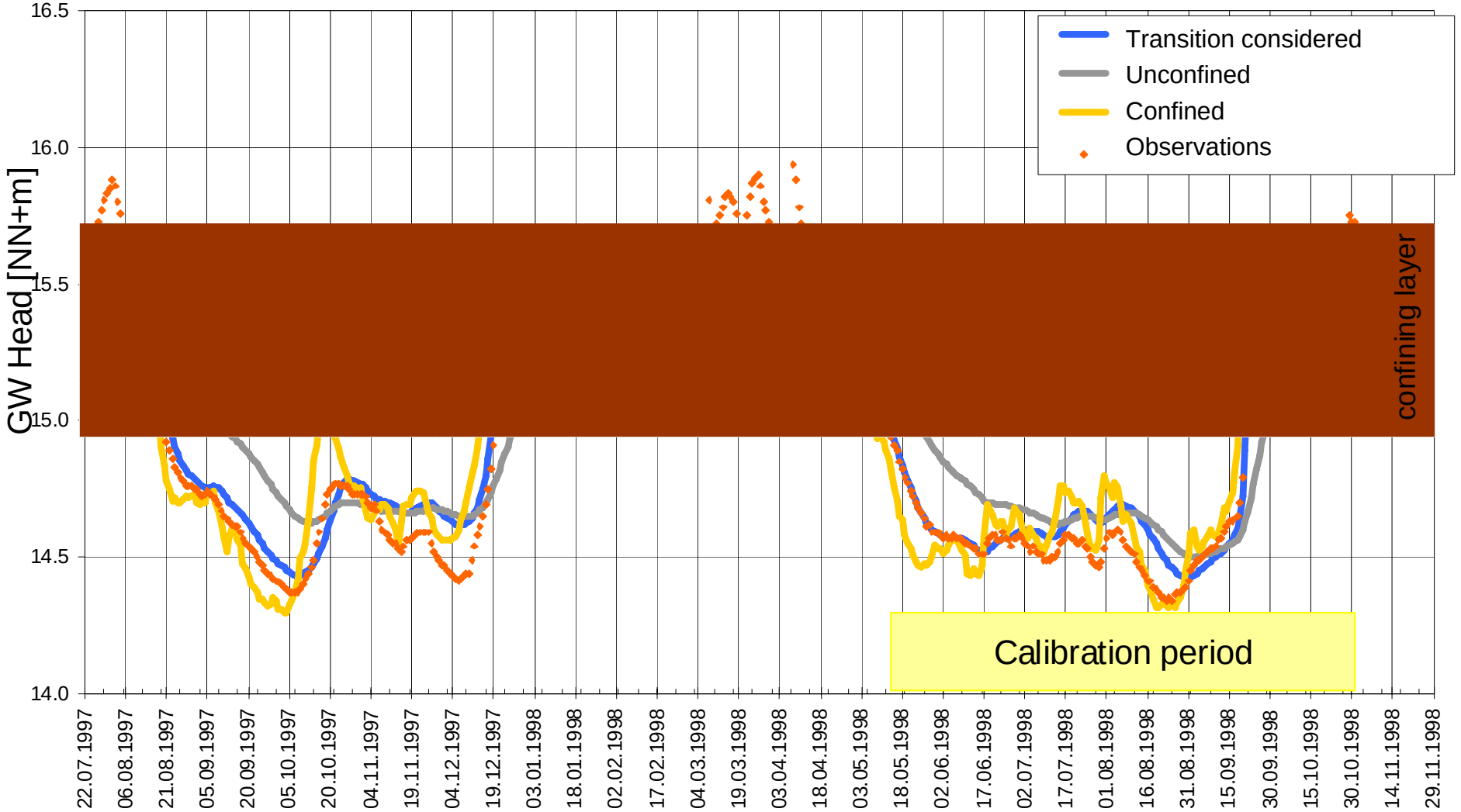
# Daily Precipitation and Mean Temperature



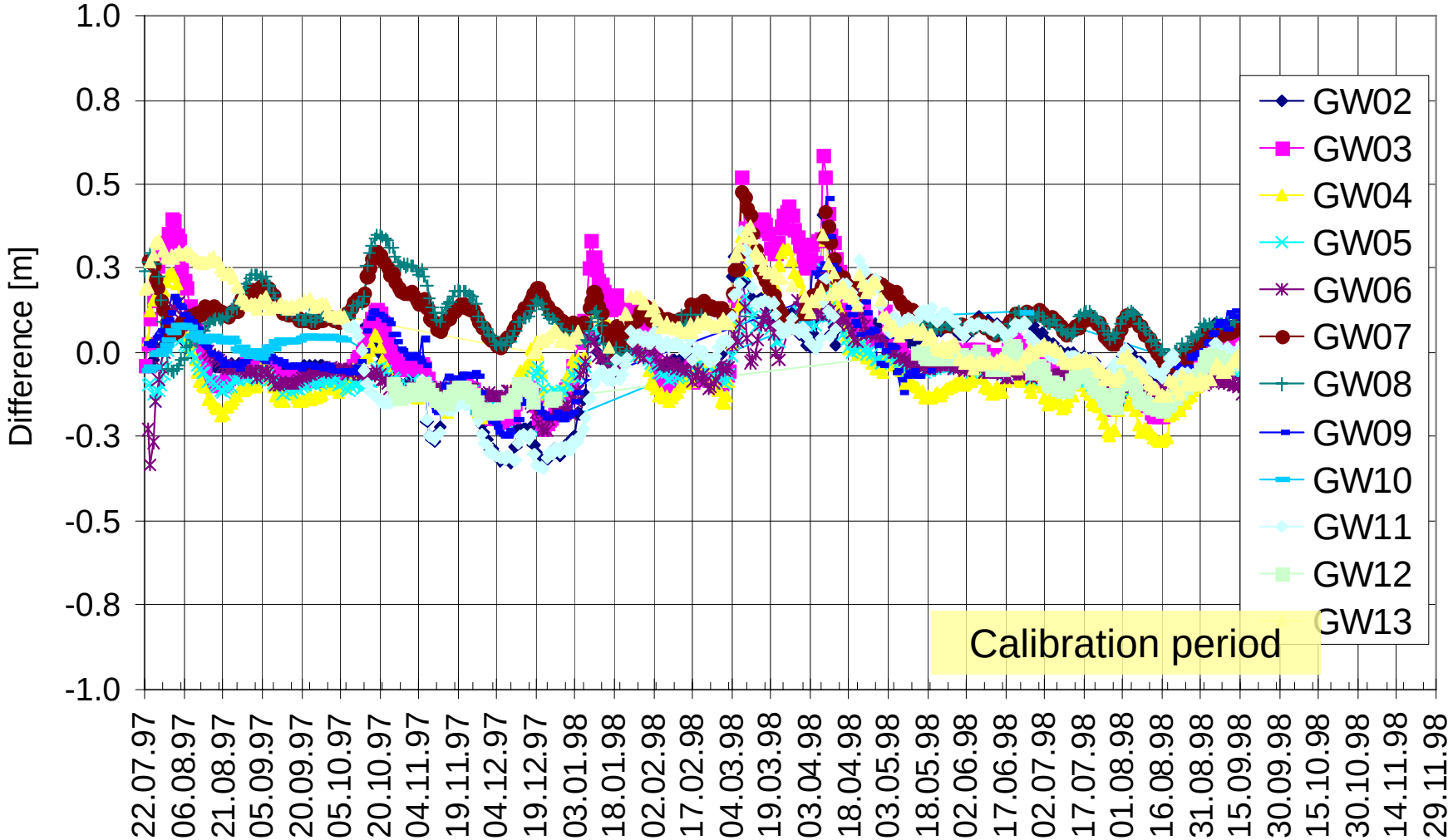
# Confined-Unconfined Transitions



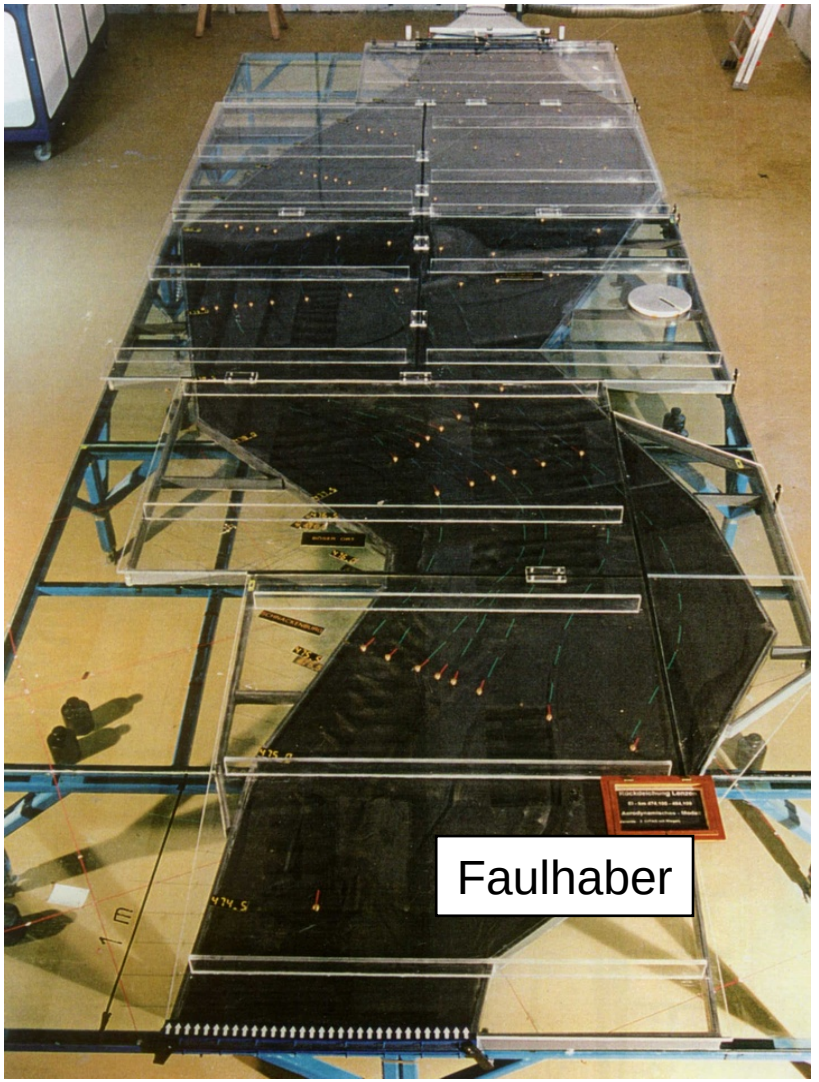
# Consideration of Confined-Unconfined Transition



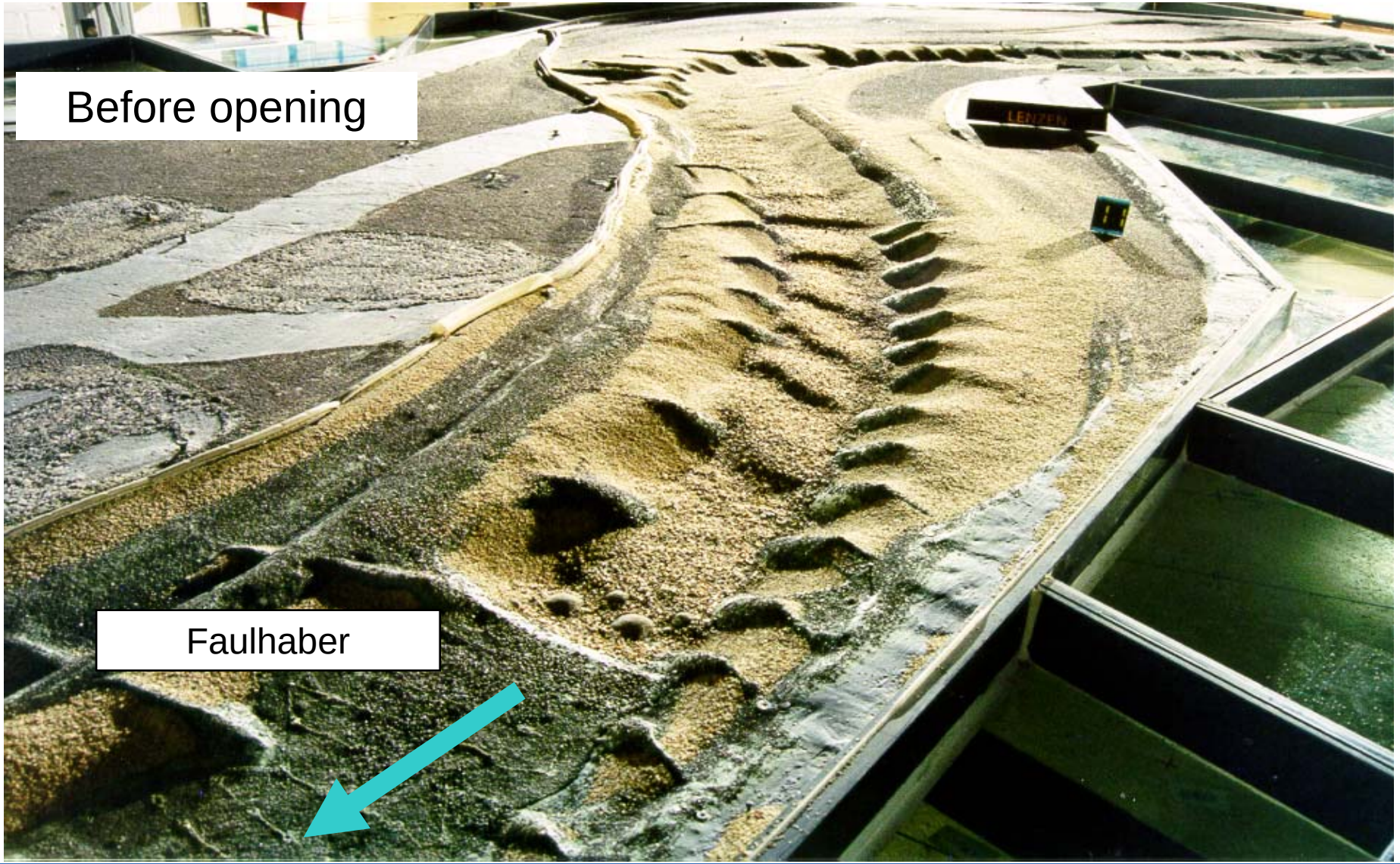
# Performance of GW 2D-Model



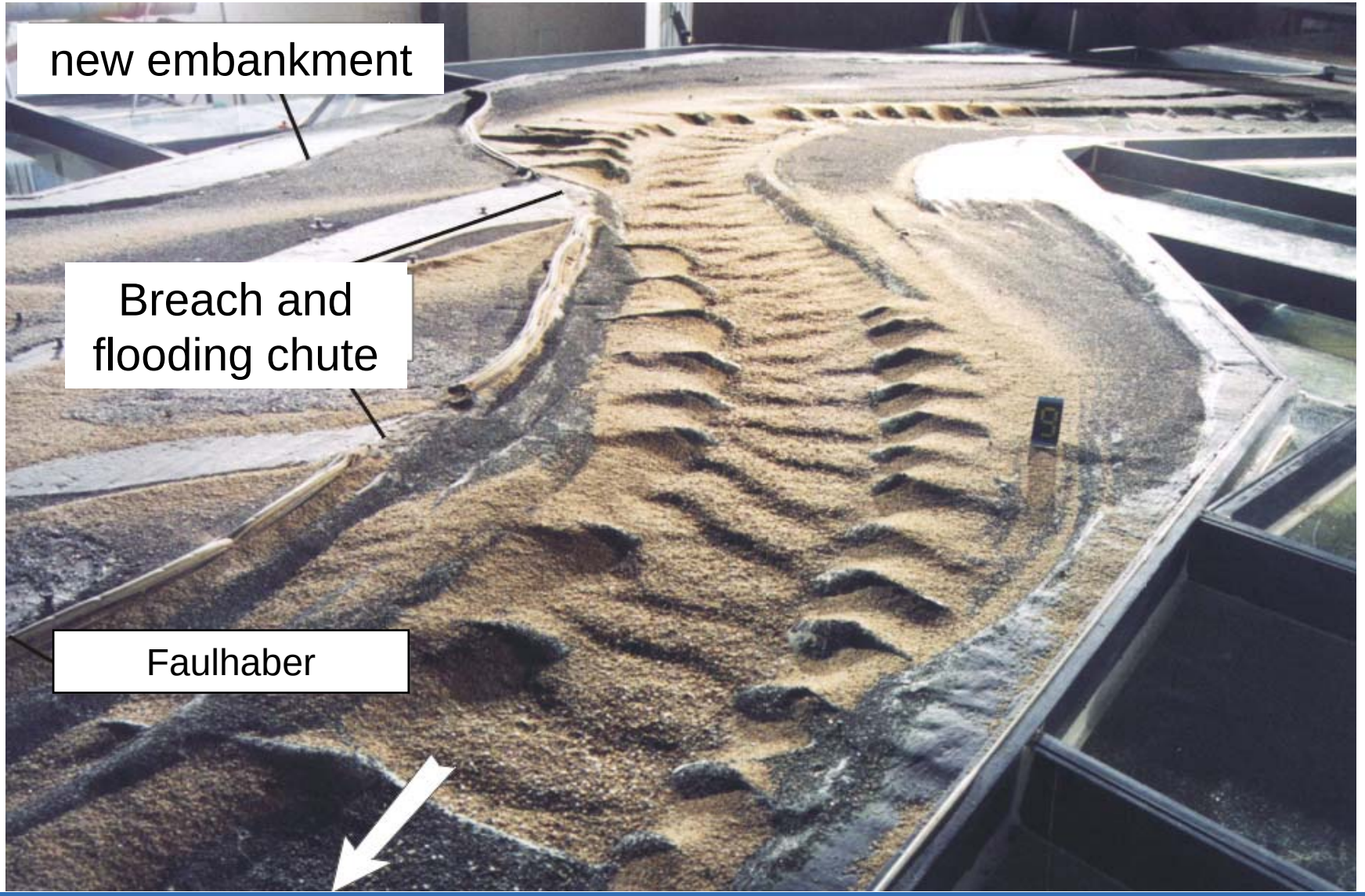
# Aerodynamic Model; solid bed



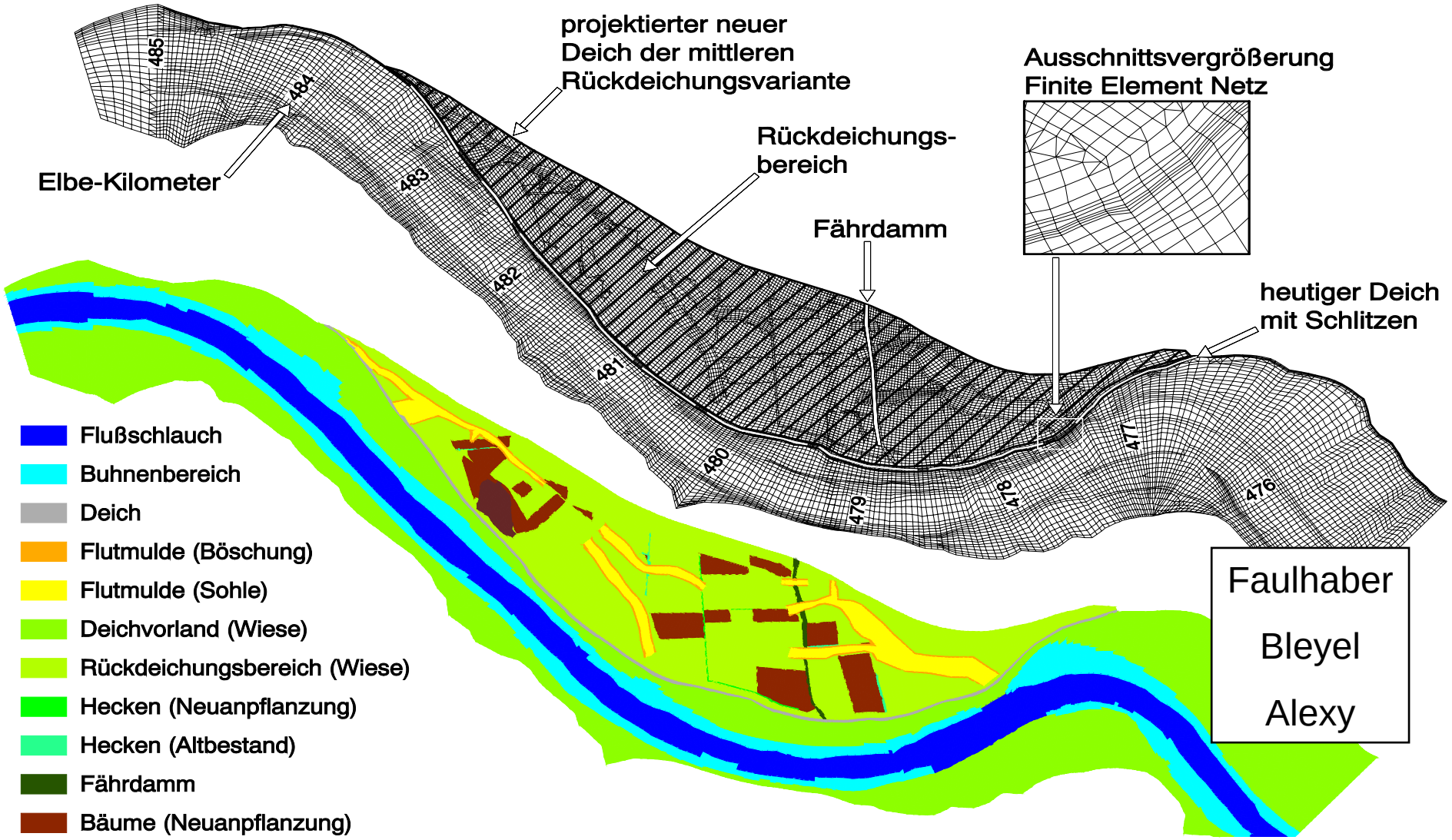
# Aerodynamic Model; deformable bed



# Aerodynamic Model; deformable bed



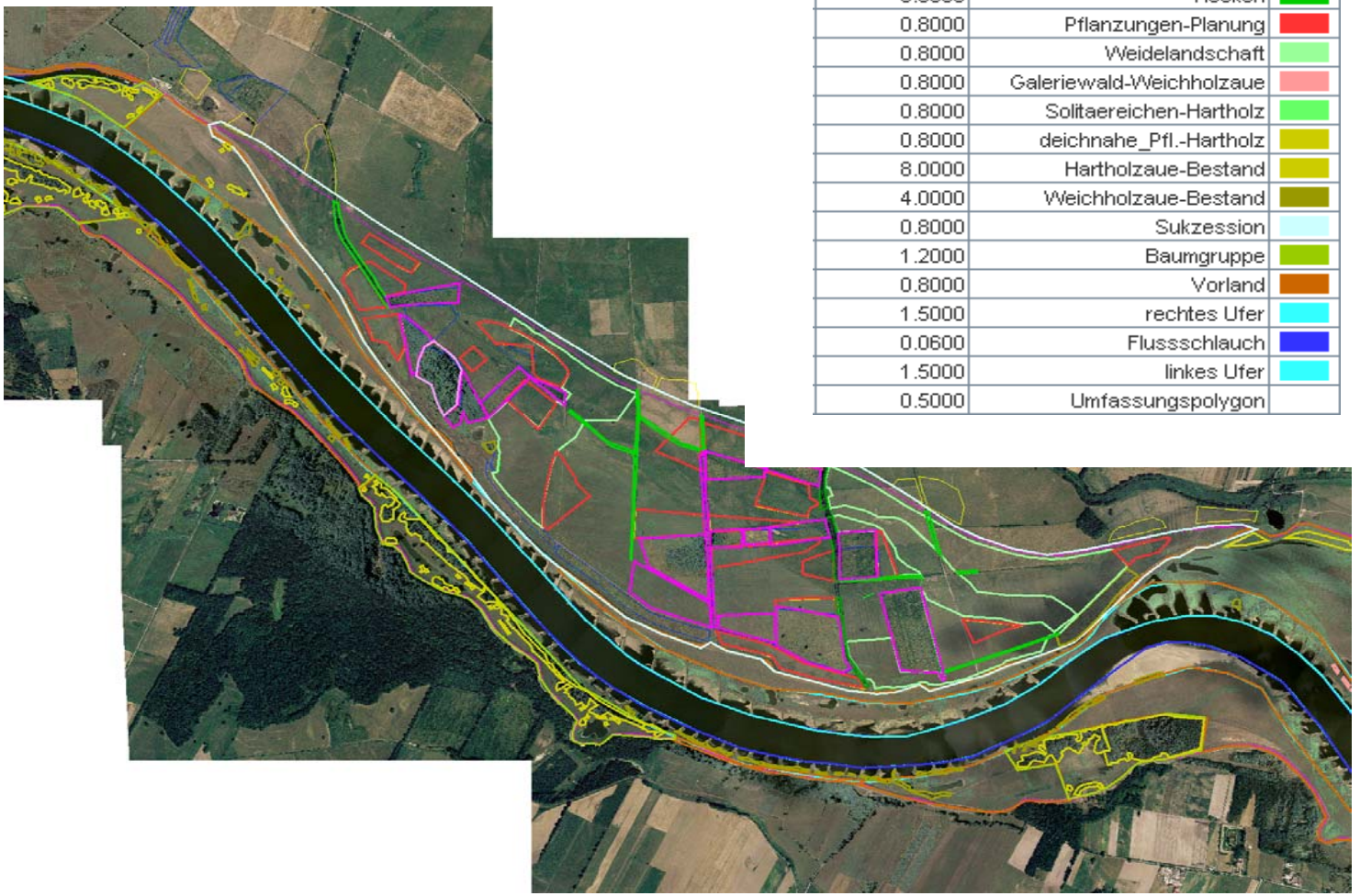
# 2D-Numerical Modelling of Surface Water Flow



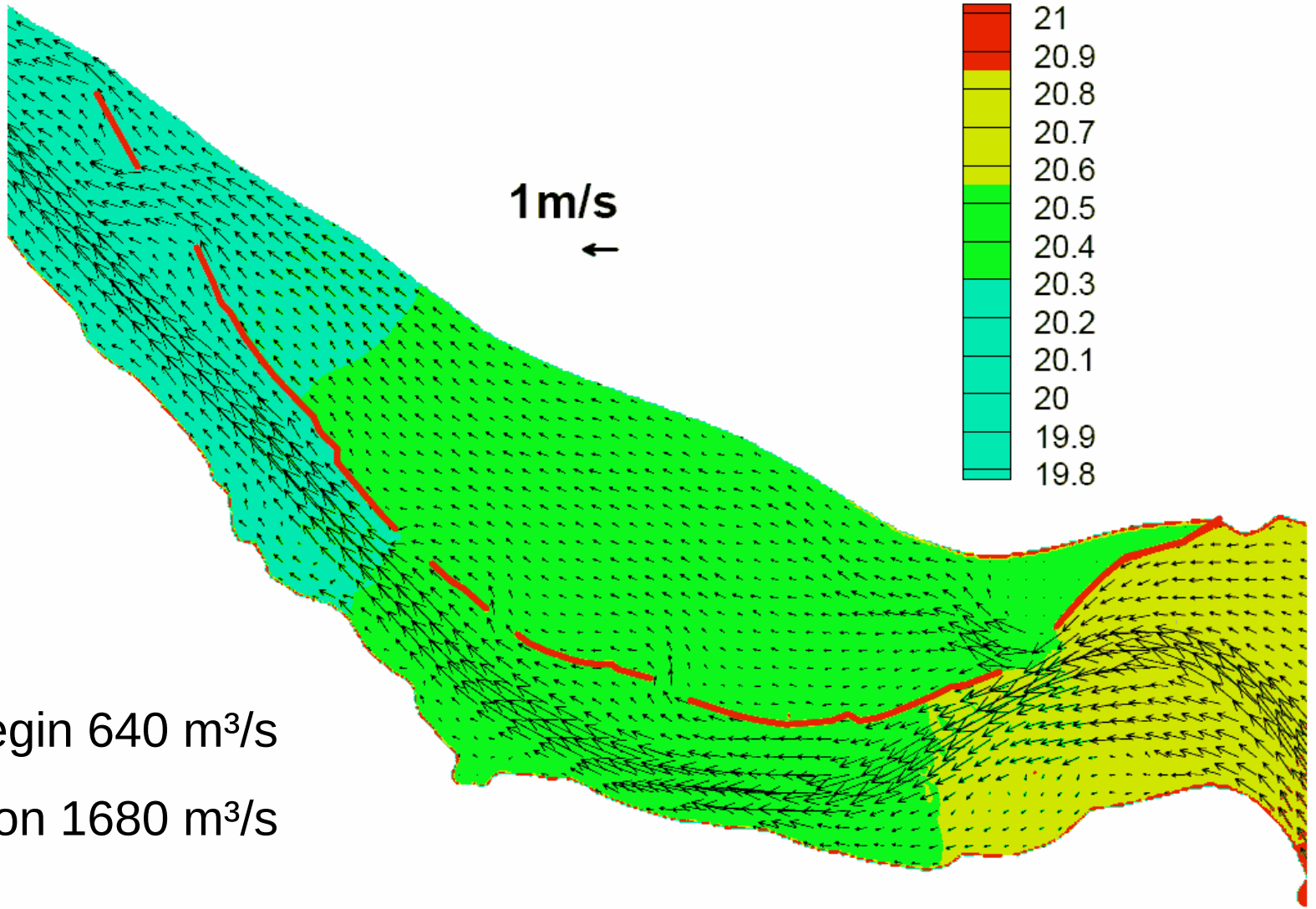

*1999*

# Distribution of Roughness Coefficients

| Rauheitswert | Beschreibung | Farbe |
|---|---|---|
| 8.0000 | Eichholz | |
| 3.5000 | Pflanzungen_vor_2002 | |
| 9.0000 | Faehrdamm | |
| 9.0000 | Hecken | |
| 0.8000 | Pflanzungen-Planung | |
| 0.8000 | Weidelandschaft | |
| 0.8000 | Galeriewald-Weichholzaue | |
| 0.8000 | Solitaereichen-Hartholz | |
| 0.8000 | deichnahe_Pfl.-Hartholz | |
| 8.0000 | Hartholzaue-Bestand | |
| 4.0000 | Weichholzaue-Bestand | |
| 0.8000 | Sukzession | |
| 1.2000 | Baumgruppe | |
| 0.8000 | Vorland | |
| 1.5000 | rechtes Ufer | |
| 0.0600 | Flussschlauch | |
| 1.5000 | linkes Ufer | |
| 0.5000 | Umfassungspolygon | |



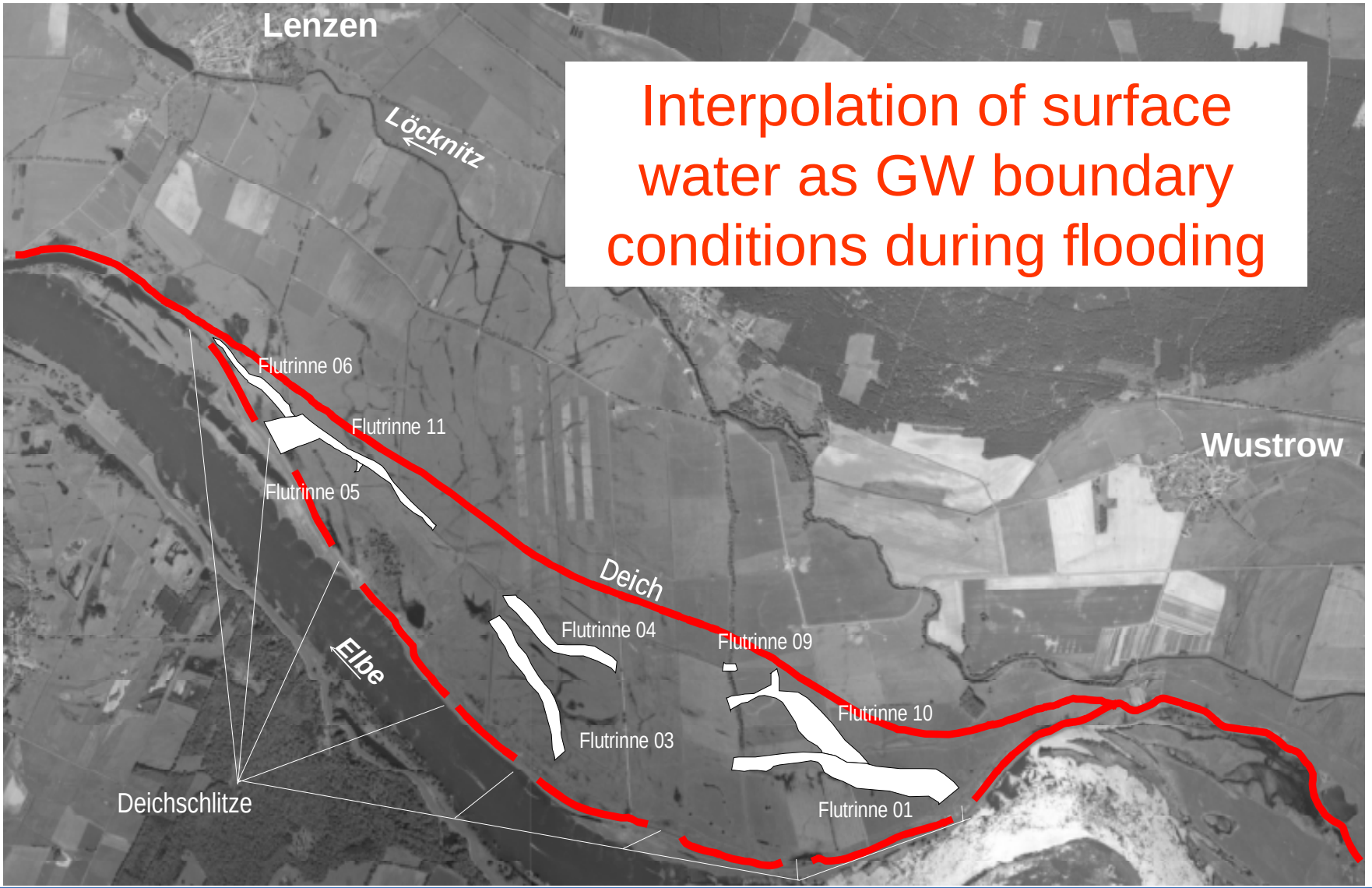
# Computed Head and Velocity Distribution at Q=3750 m³/s



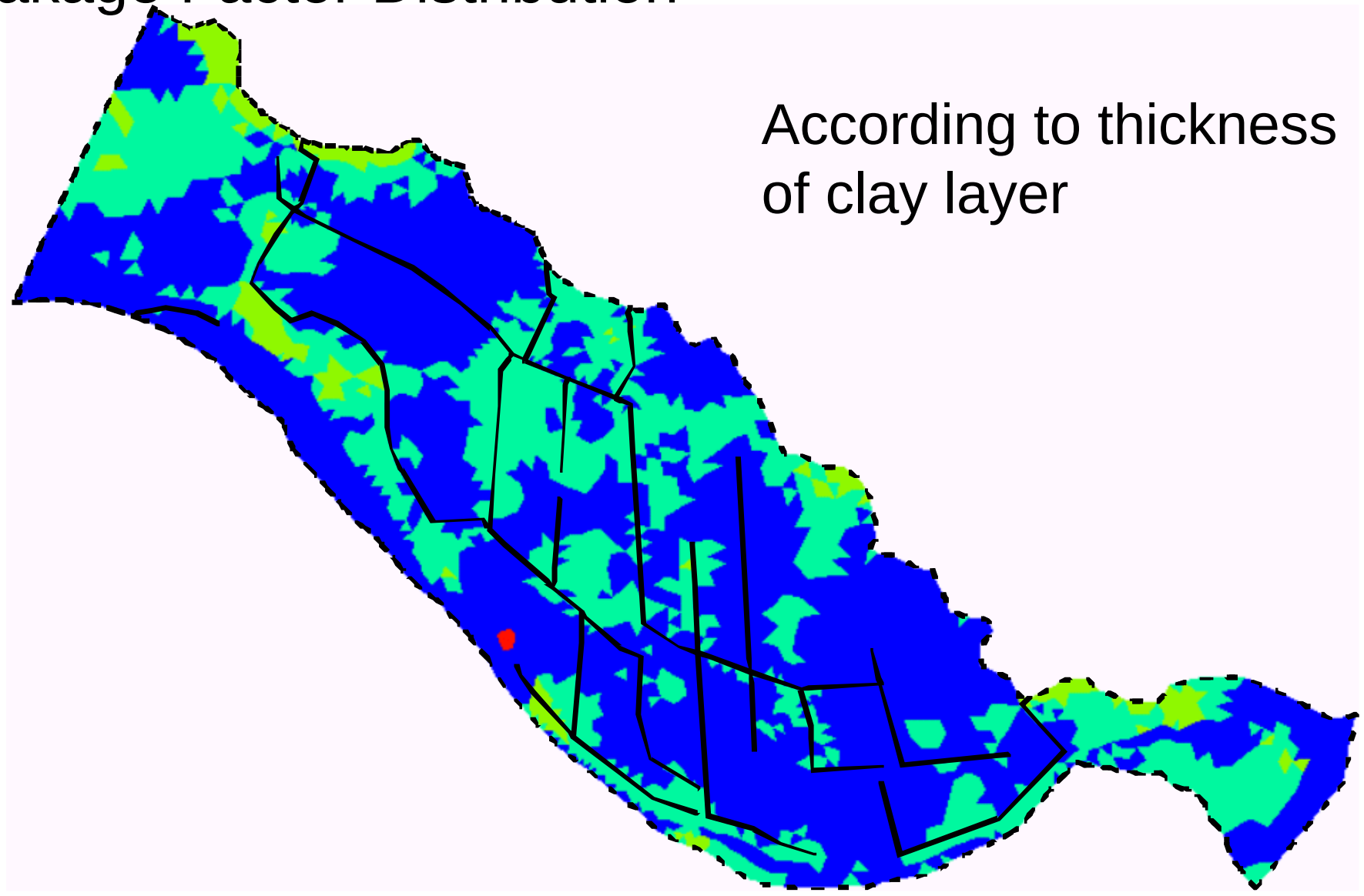

Begin 640 m³/s

Inundation 1680 m³/s

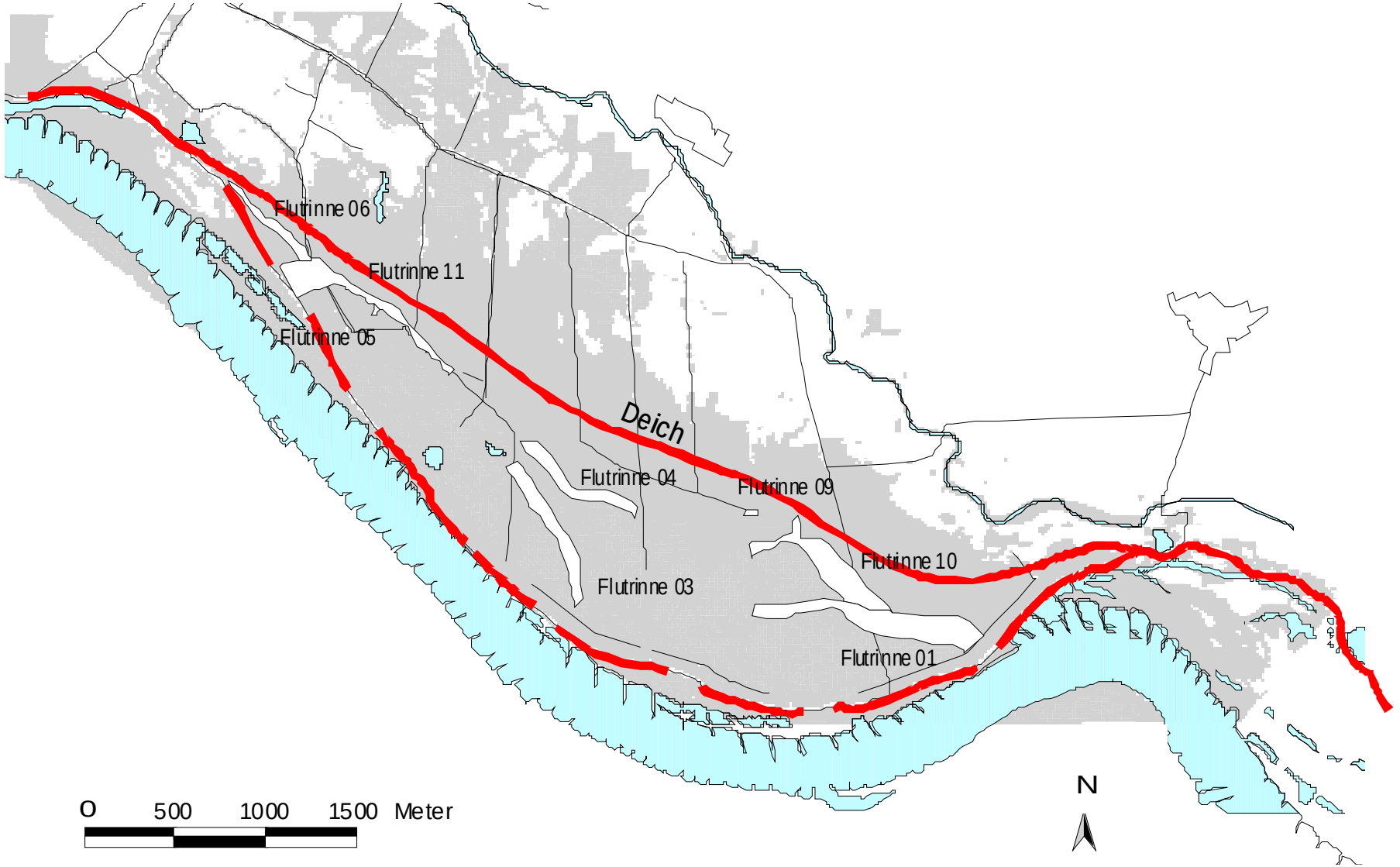
# Surface Water Head Distribution as BC for GW-Model



# Leakage Factor Distribution



# Prediction of GW Seepage During Flooding



# Final report was presented 1998

2010

# Inflow Through Breach #1

# Aerial View on the New Floodplain

# Aerial View on the New Embankment

# Field Observations

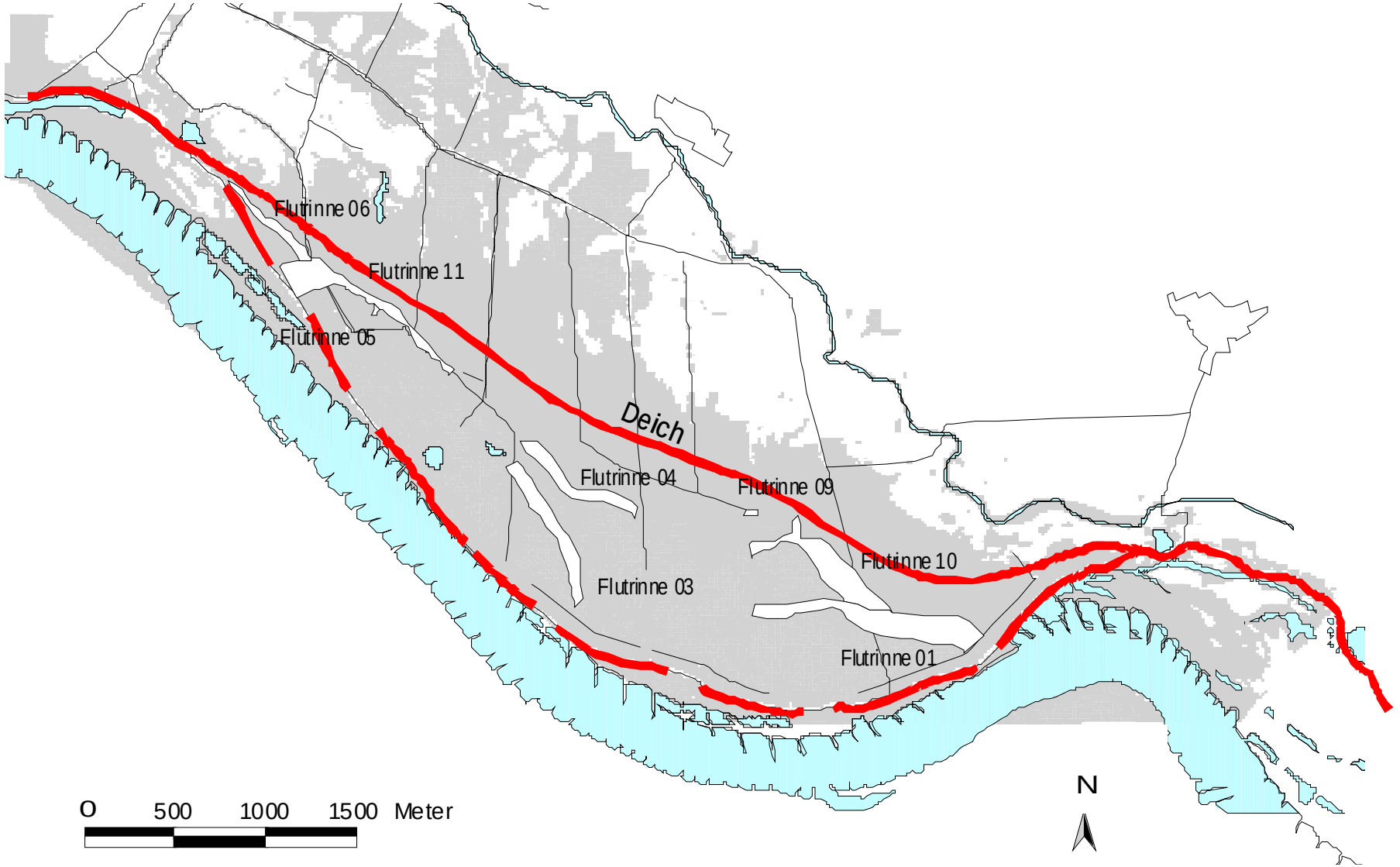
Continuously

- Groundwater 12 piezometers

Event orientated

- River discharge
- Partial discharges in floodplain and breaches
- Water velocities in the floodplain
- Surface water level 6 piezometers (from summer 2011 on)
- Water level datum along the river axis

# Prediction of GW Seepage During Flooding (1998)



Validation of the GW modelling approach

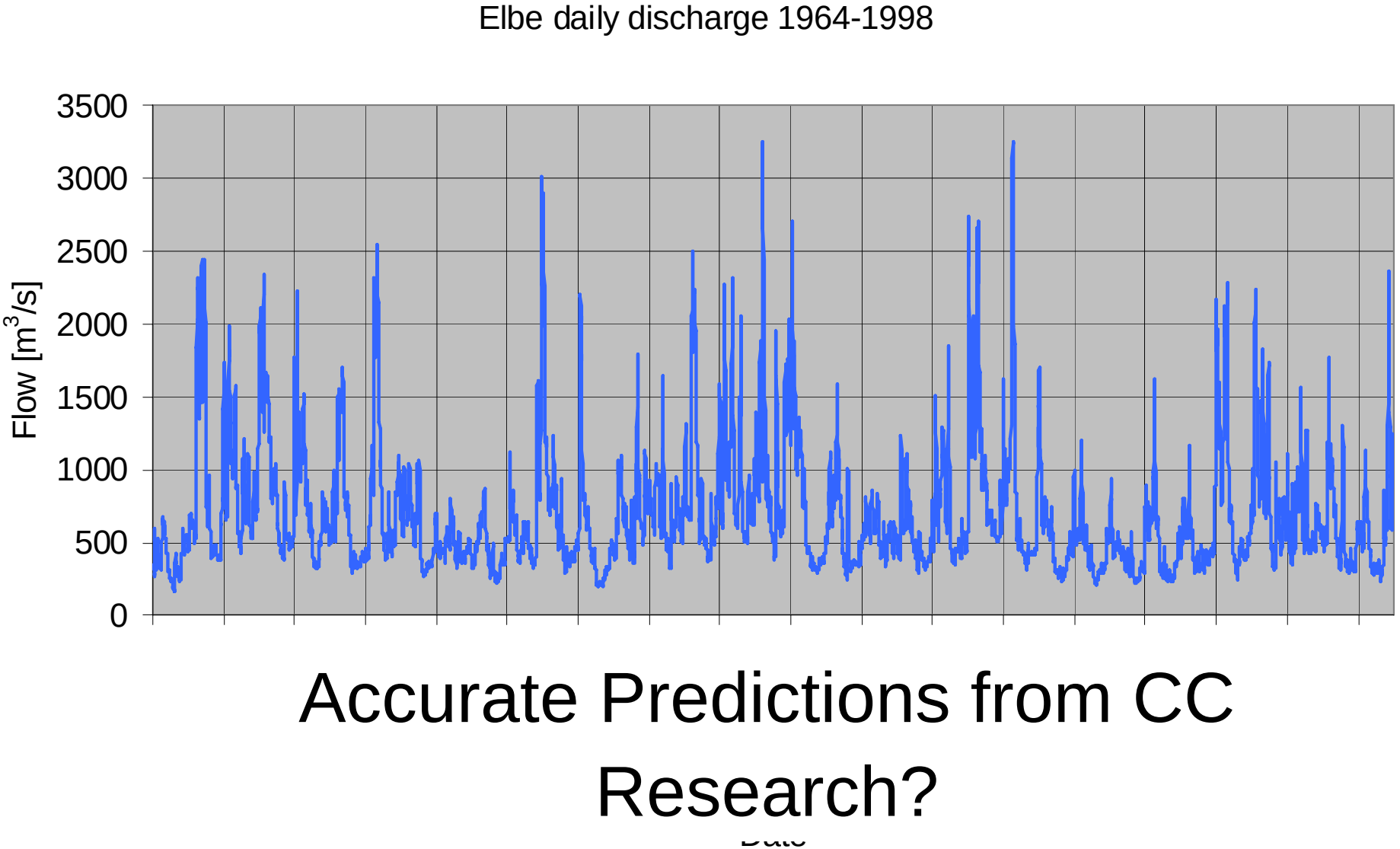
Need for quantification of the fluxes

Validation of Surface water flow Simplification (stability computational demand)

Justification for sur-sub decoupling

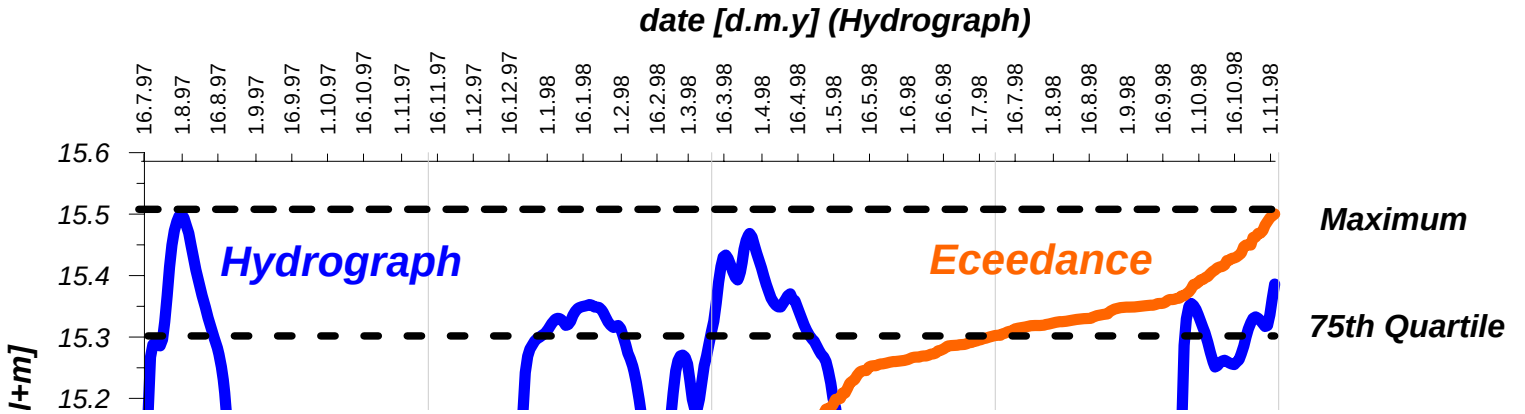
# GW Regime Changes and Evolution of Plant Diversity

# Long Time GW-Simulations Based on Discharge Dynamics

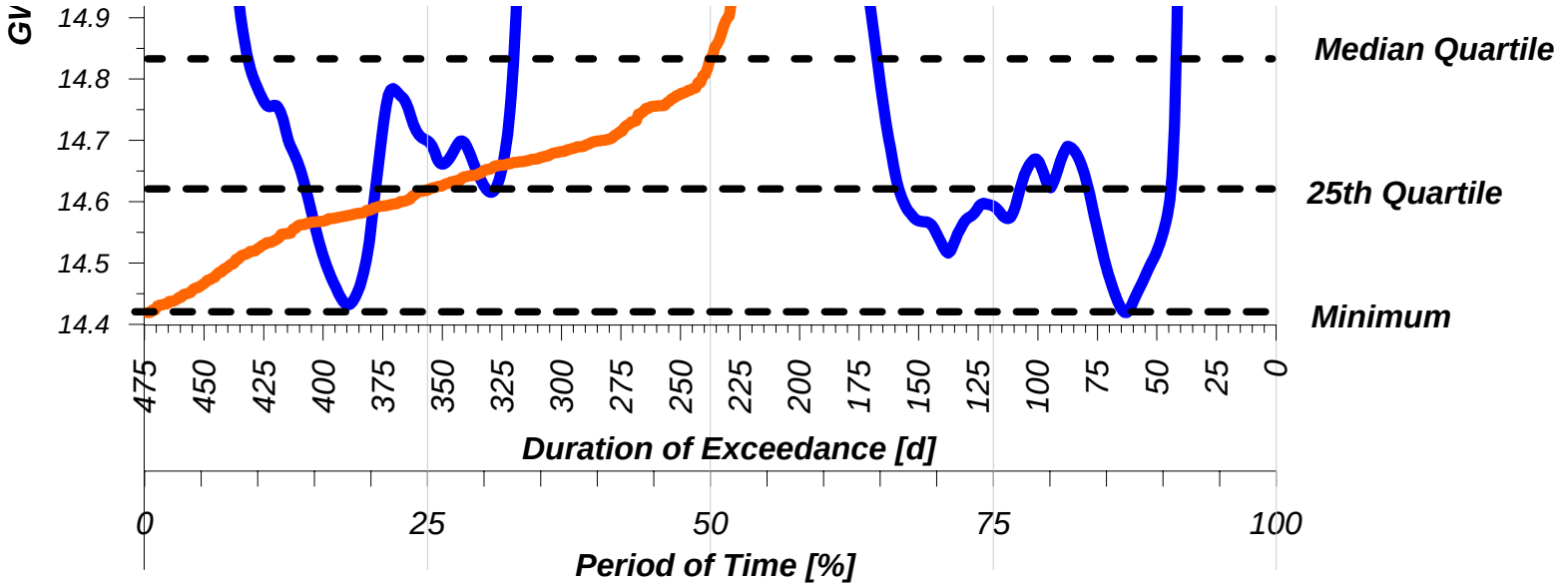



Accurate Predictions from CC Research?

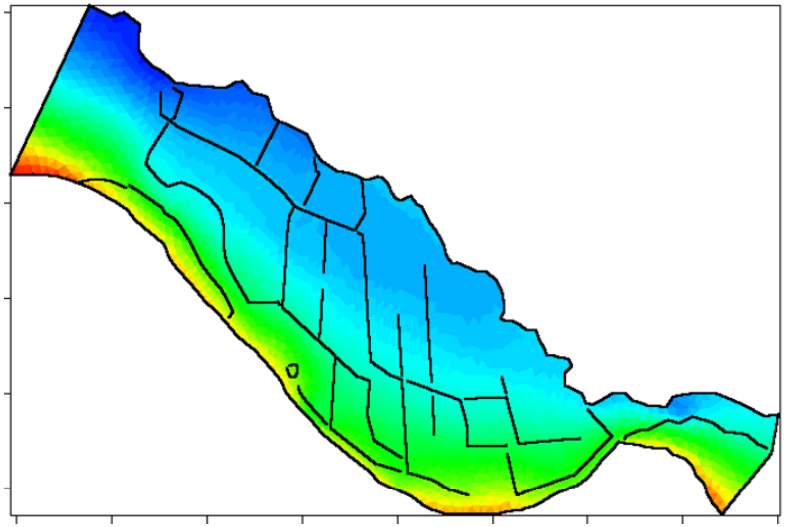
# Characterization of GW-Dynamics

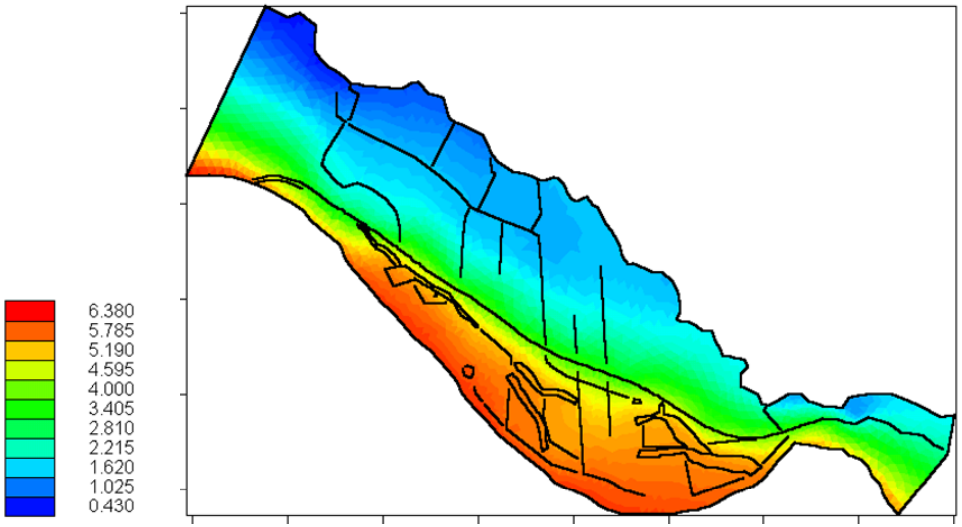



# Evaluation at each nodal point



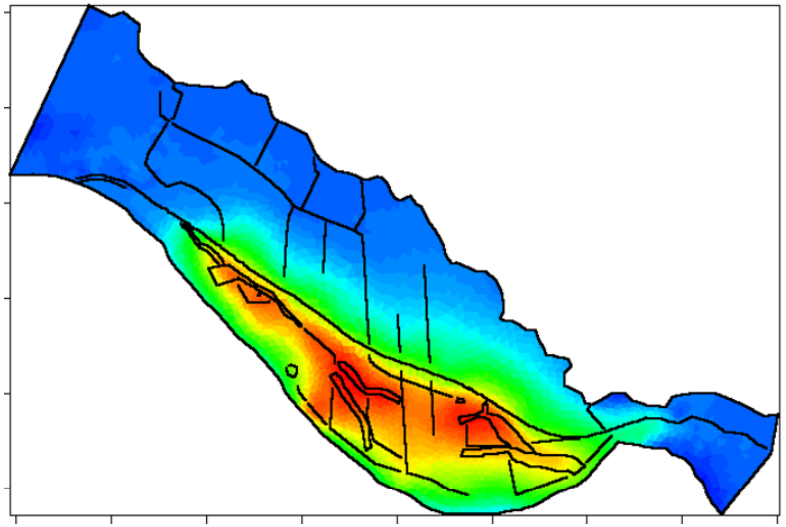
# Max-Min GW-head Differences During Vegetation Period

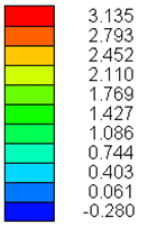













Based on 1964-1998 Elbe discharge dynamics

# Conclusions

- Investigation site with defined GW boundary conditions
- GW-dynamics *before opening* are well understood
- Surface waterflow lab experiments, model predictions and field observations are consistent
- Field observations yield a valuable data set for surface and subsurface flow model validation
- Is a surface-subsurface coupling justified?
- Simplification of surface water flow modelling needed for long time predictions