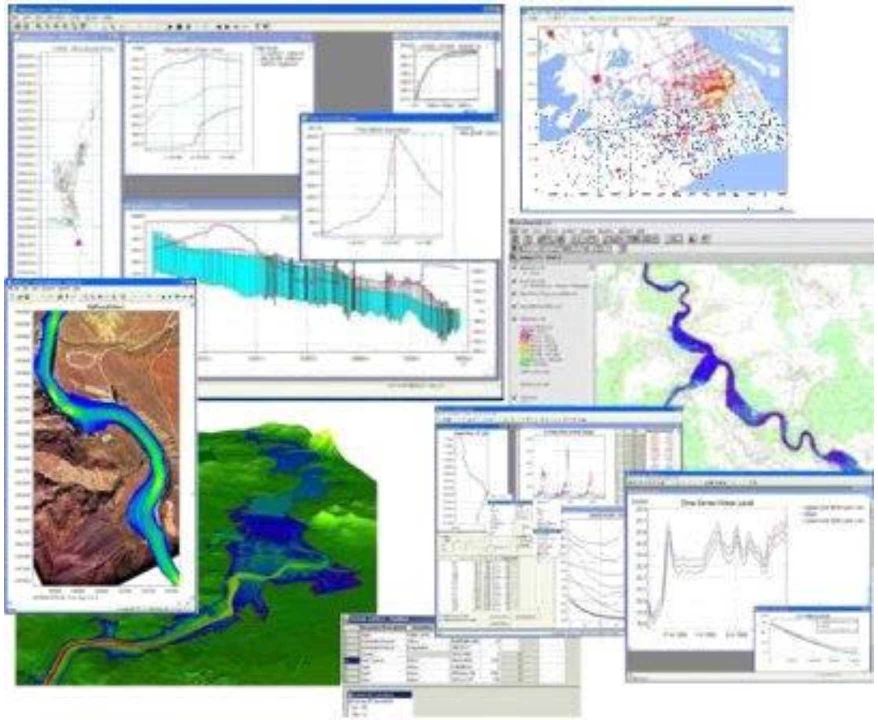
River Modelling



Assignment1: 1D Model Application

Unsteady Model

Modelling Process

Typical Modelling Steps

- data collection and pre-analysis and -processing
- model set-up
- model calibration
- model validation
- **model application**
- data post-processing
- ....

Model Application

1D River Model: Application Options

- 1D model in the river linked to
  2D model in the polder -> January 2023
- simulated water levels
  -> data analysis for flood risks assessment
  and identification of flooding locations
- flood management
  -> analysis of actions to reduce flood risks
- ....

Model Application

Flood Management (Prevention and Protection)

Example: **actions** to reduce the flood risk downstream

- technical flood protection
- renaturation of flood plains
- reactivation of natural retention areas
- new/adapted river engineering structures
- reservoirs and basins for water management
- retention polders
- …

https://www.iksr.org/en/international-cooperation/rhine-2020/balance/fields-of-flood-prevention-and-protection/

Model Application

Flood Management (Prevention and Protection)

Technical Flood Protection

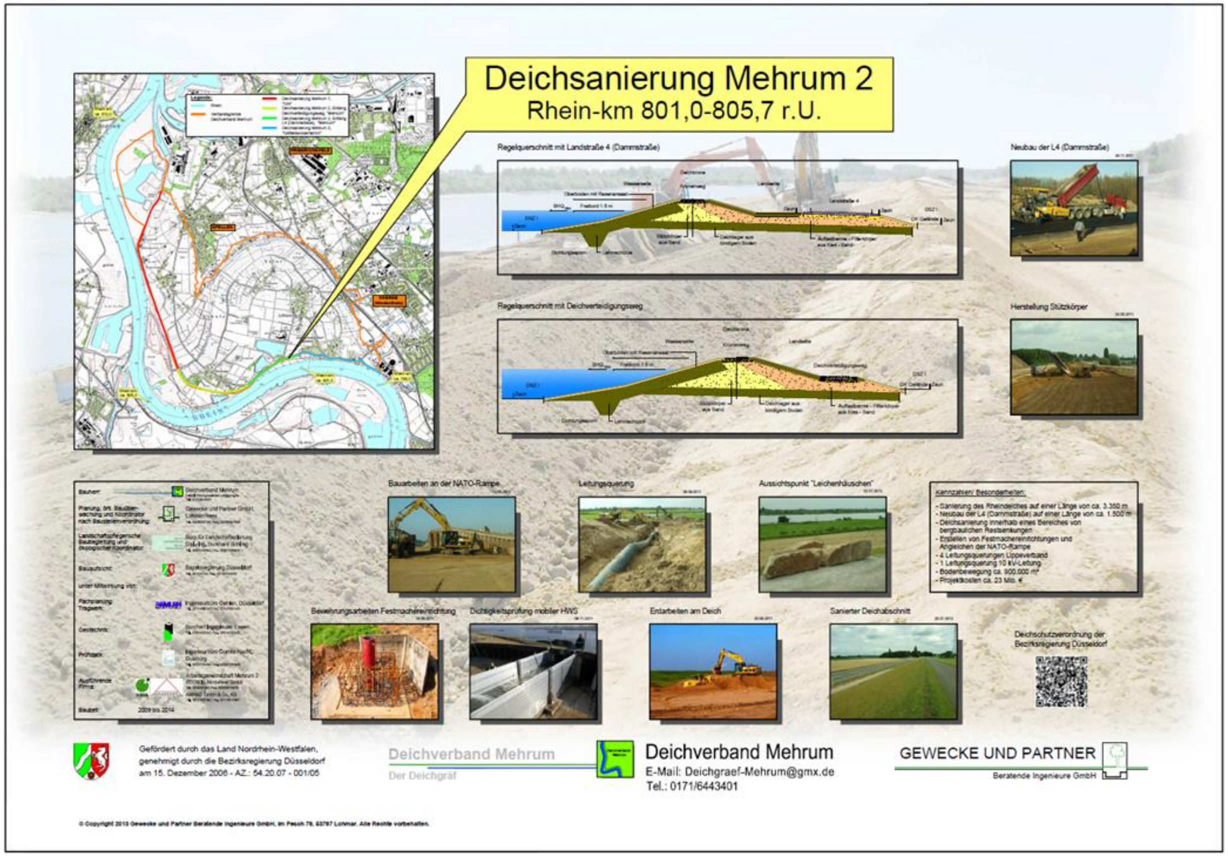
mobile flood protection walls

reference: Stadt Köln

Model Application

Flood Management (Prevention and Protection)

Technical Flood Protection: dyke upgrading



reference: Deichverband Mehrum

Model Application

Flood Management (Prevention and Protection)

Renaturation of Flood Plains (increasing roughness)

Figure 5a: Example of extension on the Alpine Rhine at the mouth of R. Frutz in Au, Vorarlberg, Austria (*Source: Renaturierung Alpenrhein /©: Internationale Rheinregulierung IRR/Hydra-Institute, Peter Rey)*

Model Application

Flood Management (Prevention and Protection)

Reactivation of natural retention areas

dyke relocation: example from downstream Netherlands

Figure 5b: Example of a river extension measure at Lent/Nijmegen, Netherlands. Dike relocation Lent, left: present situation, right: future situation (Programme "*Room for the River*", project "*Room for the R. Waal*" *http://www.ruimtevoordewaal.nl* /©: *Ruimte voor de Waal.)*

Model Application

Flood Management (Prevention and Protection)

New/Adapted River Engineering Structures

e.g. weirs, groynes, reservoirs …
effects to navigation, morphodynamics, ecology, …

Model Application

Flood Management (Prevention and Protection)

Reservoirs and Basins for Water Management

River Ruhr (inflow at 780,1)

Model Application

Flood Management (Prevention and Protection)

Reservoirs upstream Ruhr

- Ennepetalsperre
- Möhnetalsperre
- Hennetalsperre
- …

reference: Ruhrverband

Model Application

Flood Management (Prevention and Protection)

Reservoirs downstream Ruhr

- Hengsteysee
- Harkortsee
- Kemnader See
- Baldeneysee
- Kettwiger See

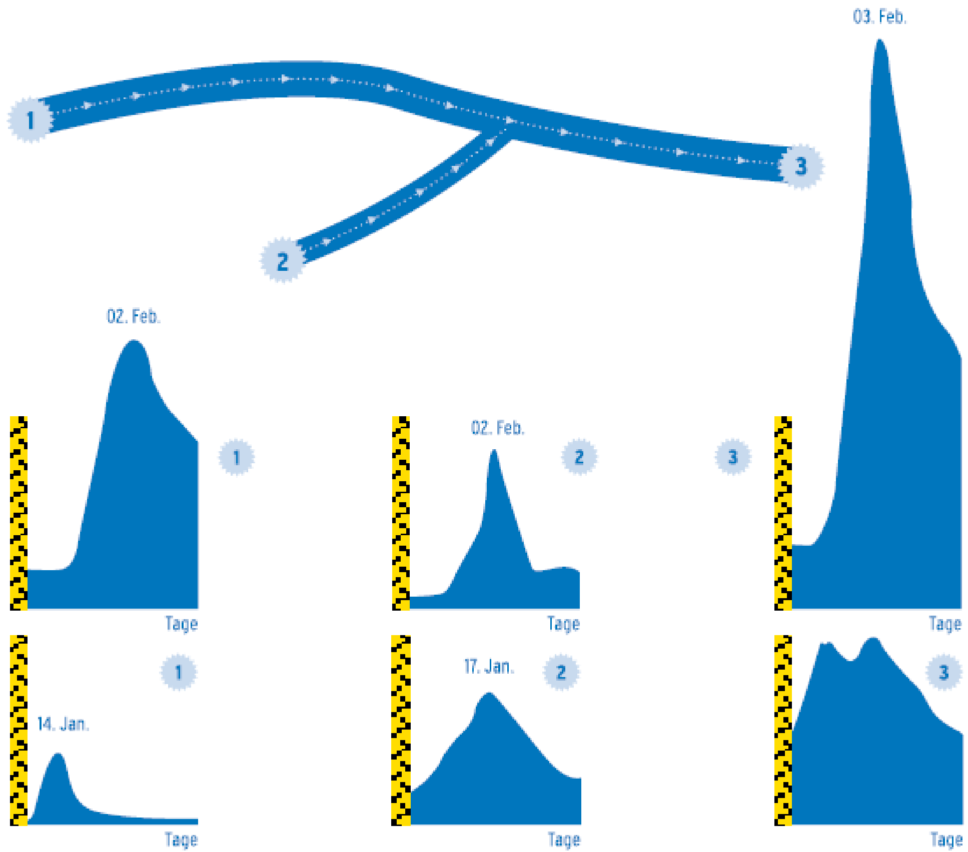
Geobasisdaten der Kommunen und des Landes NRW © Geobasis NRW 2016
Visualisierung / Ergänzungen www.halden.ruhr

Model Application

Flood Management (Prevention and Protection)

Reservoirs as Buffer

avoiding
superposition
of flood waves
at the same time



Model Application

Flood Management (Prevention and Protection)

Retention Polders

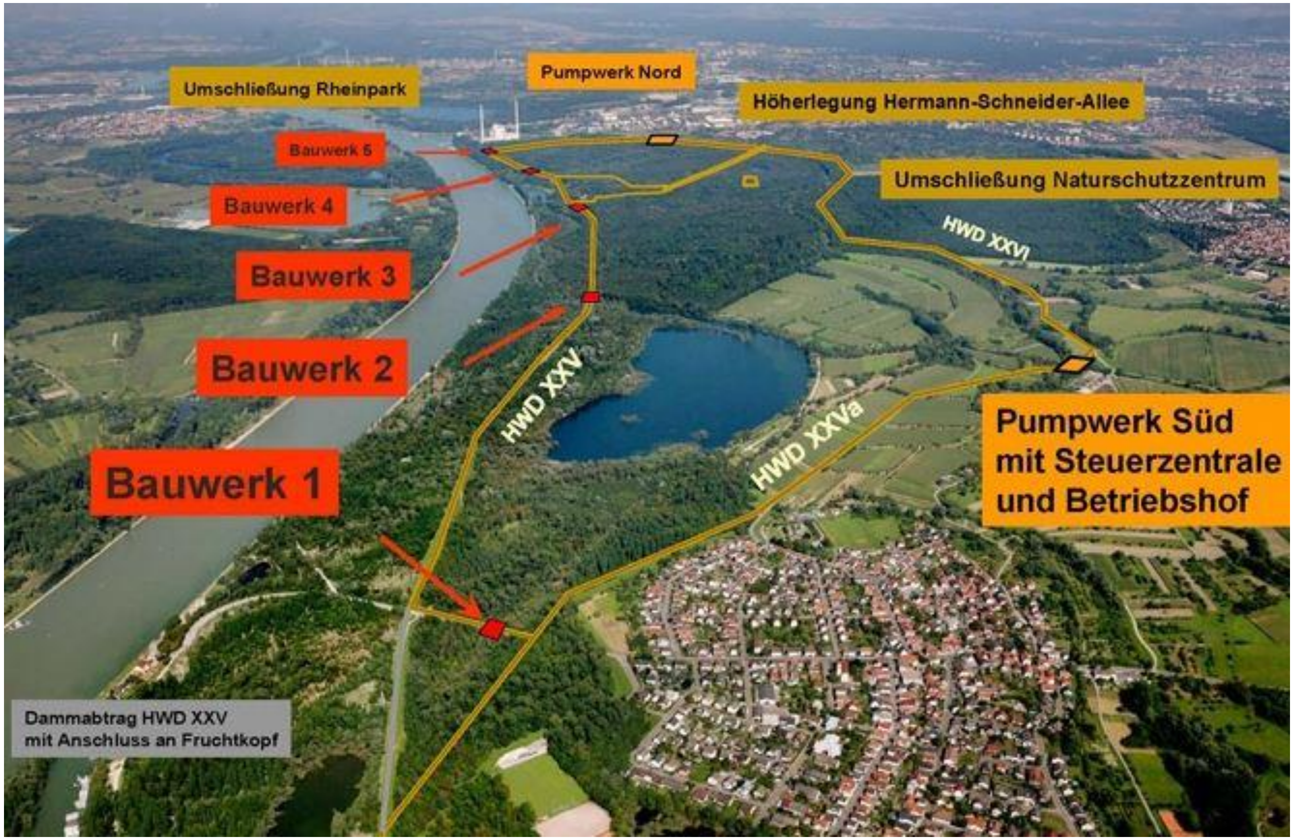
controlled flooding

of polders

to reduce

the discharge

downstream



Model Application

Flood Management (Prevention and Protection)

Retention Polders

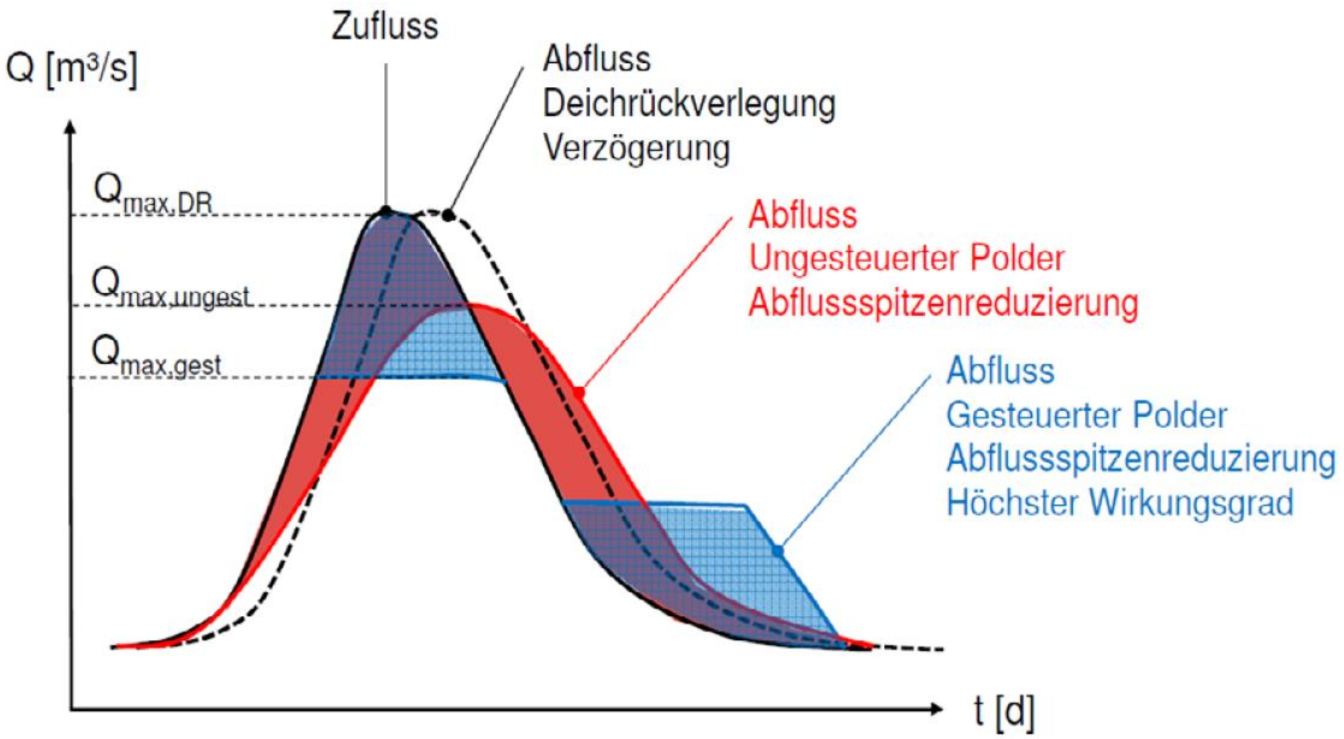
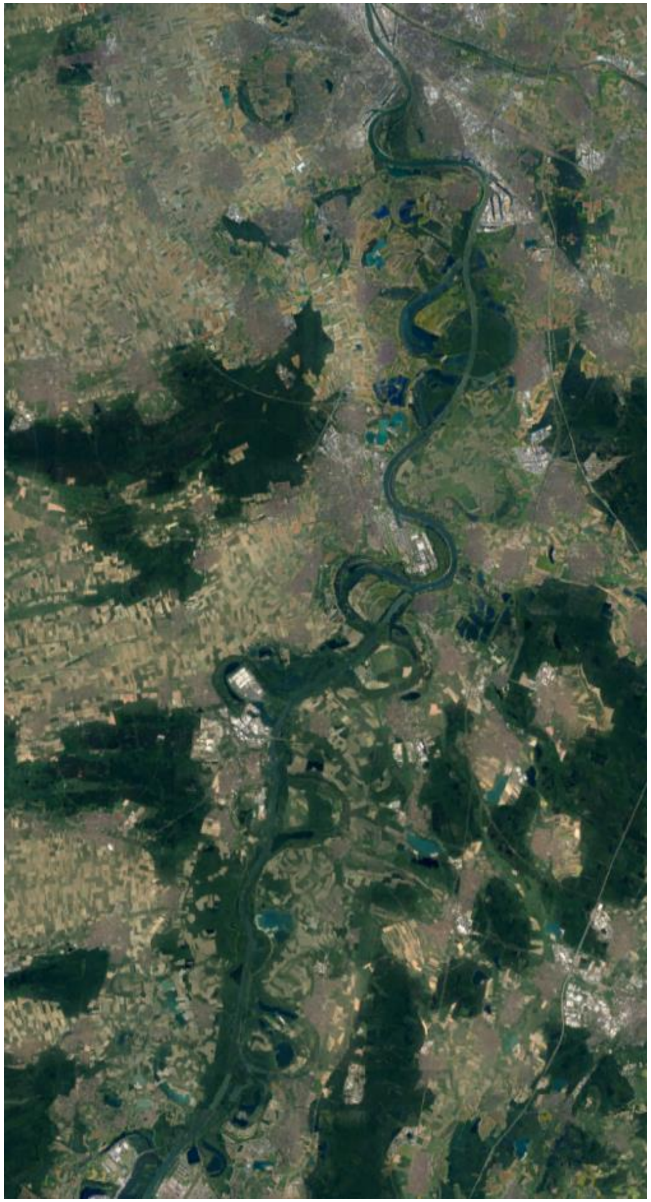


Abb. 10: Planungsvarianten Machbarkeitsstudie Bislich-Vahnum (Quelle: Bez.-Reg. Düsseldorf, BCE)

Model Application

Flood Management

Retention Polder Rheinschanzinsel



Model Application

Flood Management

Retention Polder Rheinschanzinsel

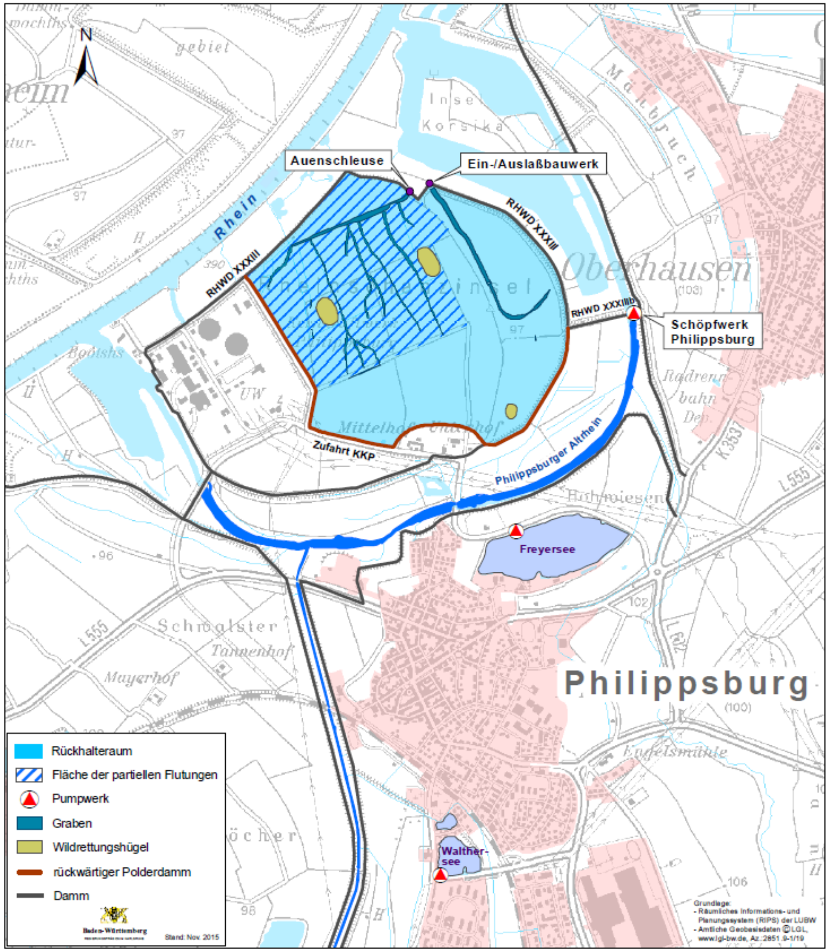
2000

2018

Model Application

Flood Polder for Controlled Retention

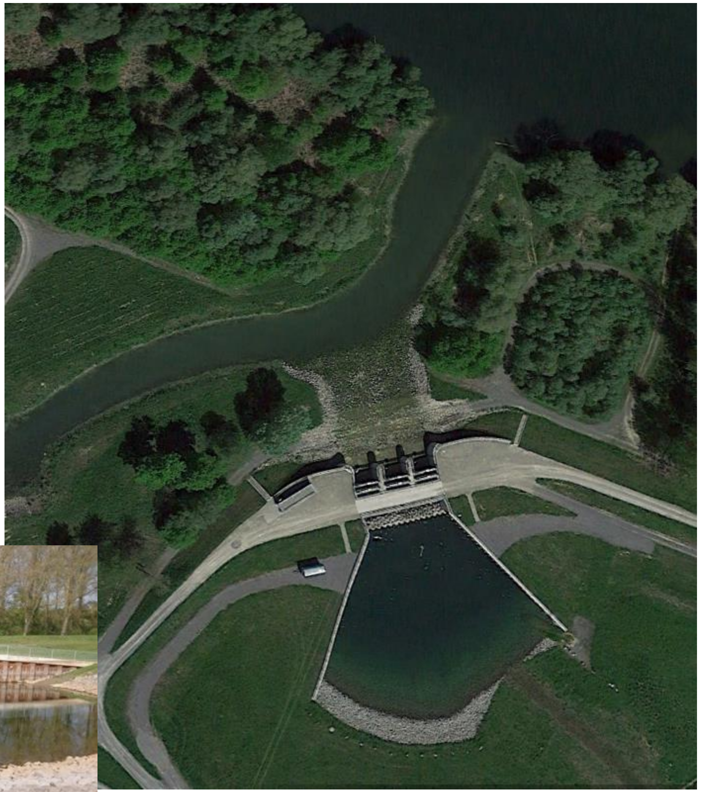
Retention Polder Rheinschanzinsel



Model Application

Flood Polder for Controlled Retention

Retention Polder Rheinschanzinsel



Model Application

Options for River Rhine Section Ruhrort-Wesel

Application of Mike11/HEC-RAS Model -> Polder Mehrum

- Option1: reactivation of natural retention areas
  - adaptation of the crossections with larger flood plains
- Option 2: Retention Polder
  - defining additional inflow / outflow sources
- comparison original model <–> changed model
- impact of a planned action

Application Example

River Rhine – Polder Mehrum

reference: openstreetmap, googlemaps

Model Application

Original Model

Scenario: Oct/Nov 1998

- HQ10 - 10 return period
- max. water level downstream (Wesel): 21,47 m
- aim: decrease of max. water level downstream
  by a new retention polder as part of polder Mehrum
  location: 801.4 m

Model Application

Retention Polder Rheinschanzinsel

in- and outflow gate

- width: 30 m
  length: 15 m
  height: 12 m
- max. discharge: 130 m^3/s

Model Application

Retention Polder

Outflow Discharge

$$Q = \frac{2}{3}\,\mu\,\sqrt{2g}\,w\,\sqrt{H^3}$$

$\mu = \sim 0.5$ broad crest

w = width of the outflow -> assumption 50 m

H = water depth above crest

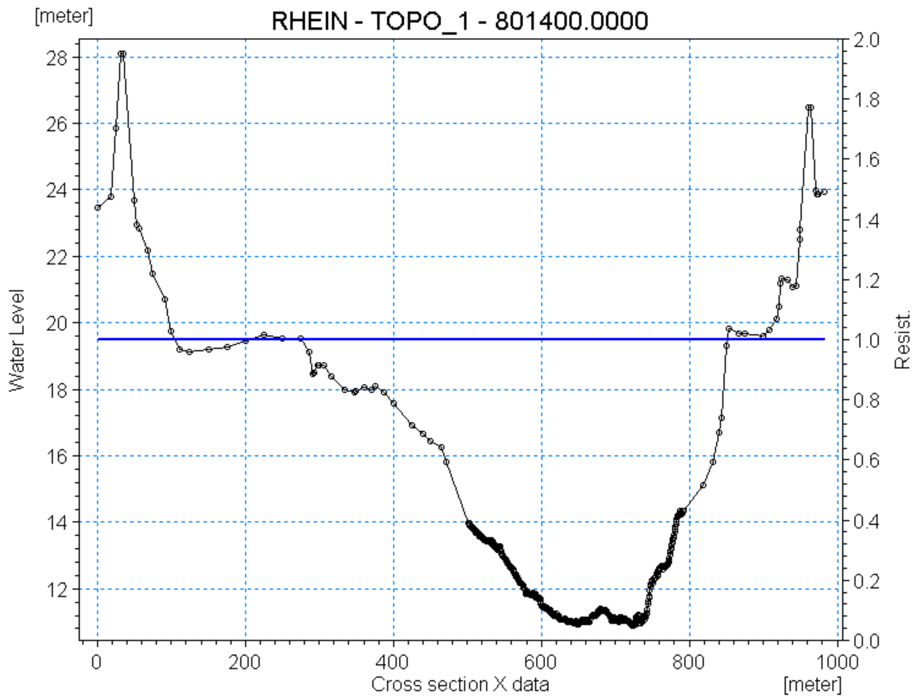
$Q = \frac{2}{3}\,0.5\;4.43\;50\,\sqrt{H^3}$ = 73,8 $\sqrt{H^3}$

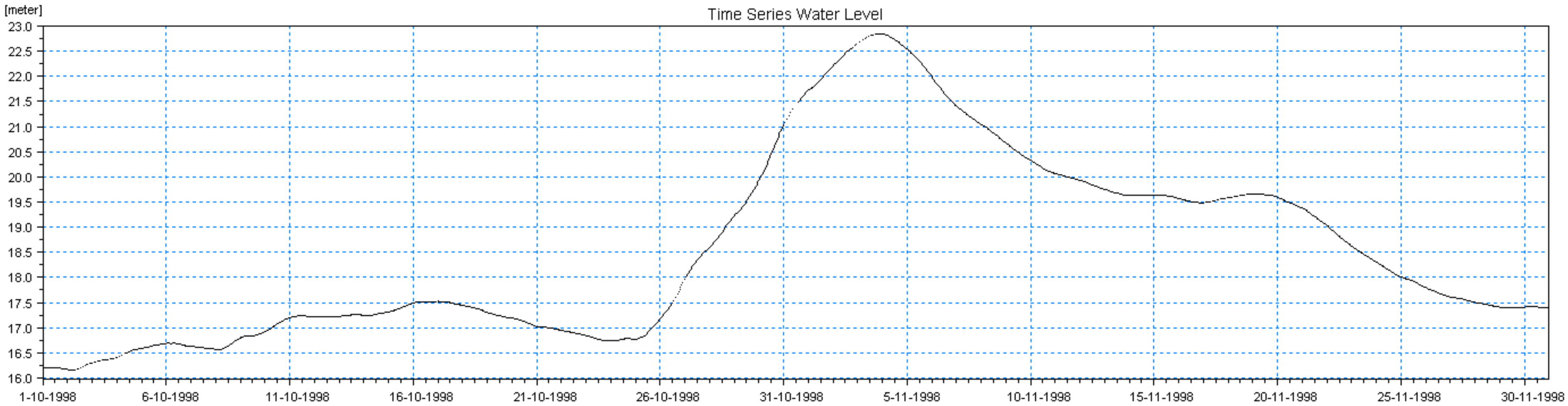
Model Application

Retention Polder

Crossection 801,4

max. water level 22,846 m





Model Application

Retention Polder

Outflow Discharge

$Q = 73{,}8 \sqrt{H^3}$

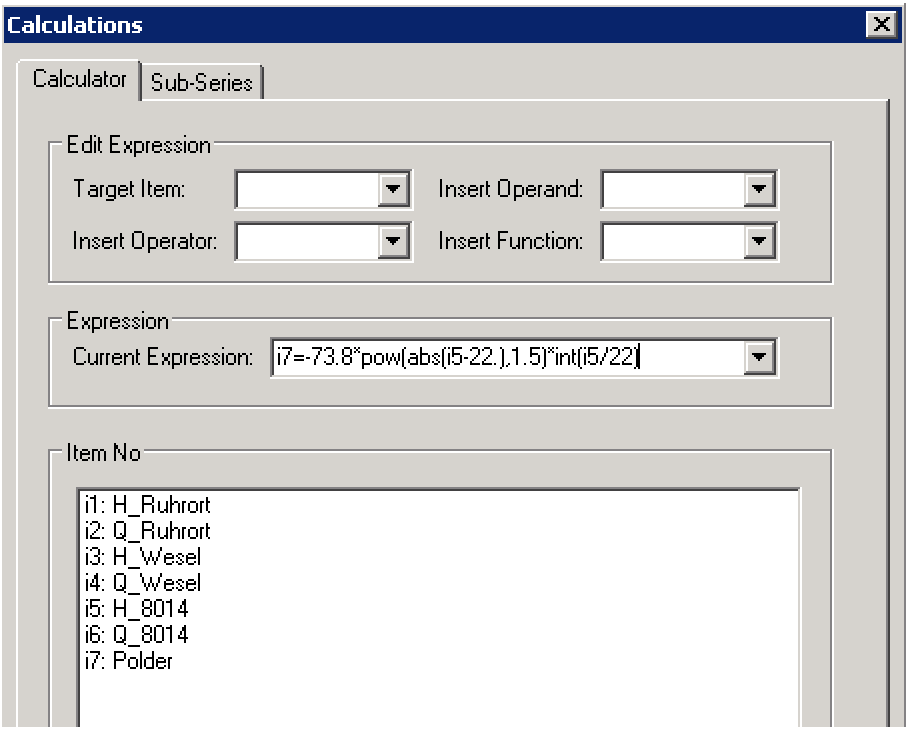
water level > crest level

-> H = water level – crest level

water level <= crest level

-> H = 0

Example crest level 22. m



Model Application

Impact of a Retention Polder

Model Comparison

Model	max. outflow	H peak	Q max	Qmax time
original	0.00 m^3/s	21,47 m	9127 m^3/s	3-11-1998 21:45:00
crest = 22.0 m	57.32 m^3/s	21,44 m	9072 m^3/s	3-11-1998 21:40:00
crest = 21.5 m	115,25 m^3/s	21,41 m	9014 m^3/s	3-11-1998 21:34:59
crest = 21.0 m	185,10 m^3/s	21,38 m	8945 m^3/s	3-11-1998 21:34:59
crest = 20.5 m	265,01 m^3/s	21,33 m	8865 m^3/s	3-11-1998 21:34:59