Summer Course 2022

"NATURE-BASED SOLUTIONS (NBS) TO CONFRONT WATER EXTREMES IN EUROPE: DESIGN AND MODELLING TOOLS"

(Within the project TRITON; https://triton.wasser.tum.de/)

Process-based modeling of technical retention measures for mitigating floods and droughts

Prof. Dr.-Ing. Markus Disse

Chair of Hydrology and River Basin Management

Technical University of Munich

Athens, 06.09.2022, 09:00-09:30

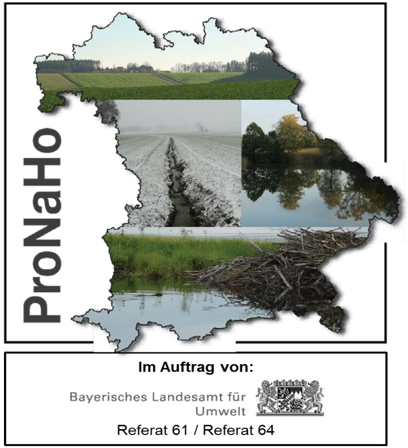
Project ProNaHo (Process based modelling of natural and decentralized flood retention measures for the analysis of event and catchment dependent efficiency)

Modeling approach: Coupling based on “Windachstudy” (Rieger, 2012):

WaSiM *(Hydrology)* – HYDRO_AS-2D *(Hydrodynamics)*

Hydrology

- Land-use scenarios
- Decentralized small-scale retention reservoirs



Hydrodynamics

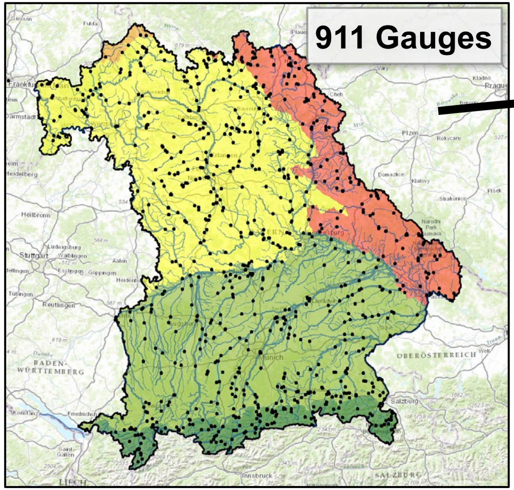
- River restauration
- Floodplain vegetation scenarios
- Beaver dams

ProNaHo

Study area selection and description

Study area selection

Approach and conclusion



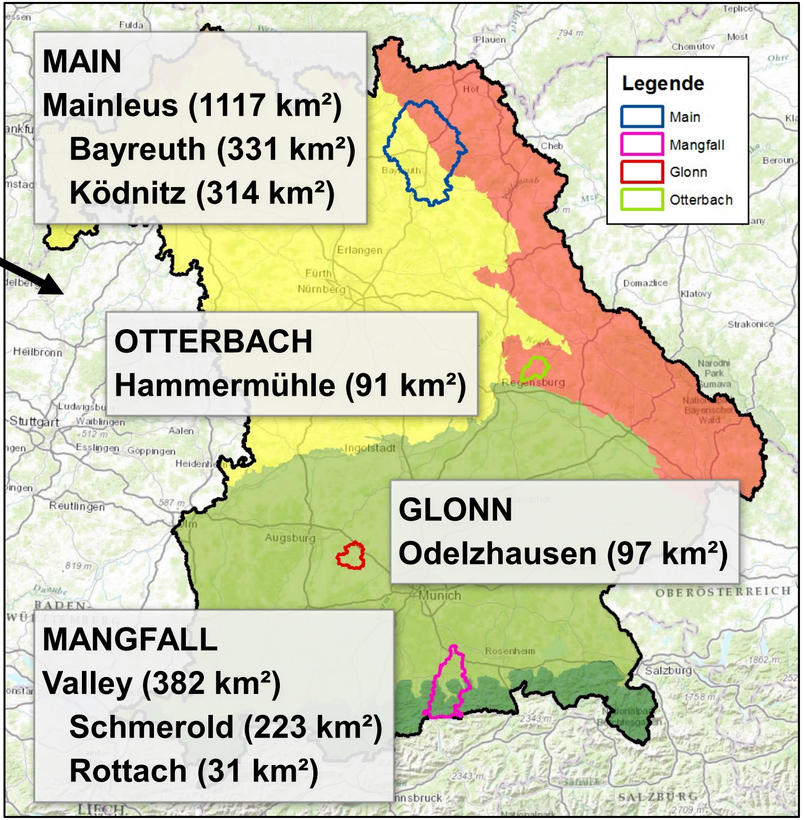
13 Selection criteria:

- **1-6: Reduction of number of gauges** (Region, gauging timeframe, topography, suitability to model, size)
- **7-13: Suitability for scenarios** (density of gauges, land-use distribution, existence of beaver populations, …)

Goal:

4 study areas (+ 4 TG)

- 1 x ~ 1000 km²
- 1 x ~ 150-550 km²
- 2 x ~ 100 km²



ProNaHo

Decentralized retention reservoirs

Methods

Approach

Reservoir site analysis

- Potential locations for reservoir
- Water level – Volume – Relation

Reservoir pre-selection

Two groups:
- Potential feasible sites
- Hydrologically effective sites

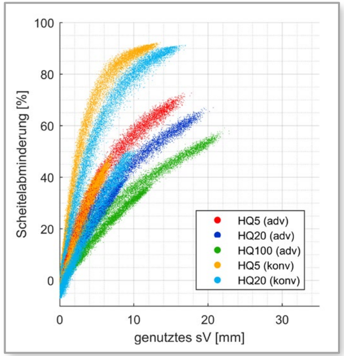
Efficiency Analysis

<u>Random reservoir combinations :</u>
- Number of Reservoirs (10 possibilities)
- Spatial layout in catchment (about 300)
- Dimensioning target (5 scenarios)
- Scenarios (5 precip. scenarios)
- Reservoir groups (2)

→ ca. 150 000 combinations per study-area

<u>Location-optimized reservoir combinations:</u>
- 21 combinations (Number of reservoirs)
- 5*5 (scenarios * Dimensioning target)

→ ca. 525 combinations per study-area



Analysis of influencing factors

<u>Dependability on efficiency</u>
- on the specific volume
- on the number of reservoirs
- on the spatial layout in catchment
- on the characteristics of scenarios
- on the dimensioning target
- on the study-area characteristics
- on super positioning effects

Scenario selection

Parameter variations:

1. Number of basins / spez. Volume *sV* (~ 10 alternatives)
2. Locations in the catchment (catchment-specific, ca. 1000)
3. Discharge for dimensioning at the basin outlet (5 events)
4. Return period and event characteristics (5 events)

$$\mathrm{sV}\,[\mathrm{mm}] = \frac{\text{basin volume}\,[\mathrm{m}^3]}{\text{catchment area}\,[\mathrm{km}^2]} \cdot 10^{-3}$$

→ ca. 250 000 combinations per catchment (ca. 2 000 000 in total)

Sources:
TESCHEMACHER, S., BITTNER, D. & DISSE, M. (2020a): Automated Location Detection of Retention and Detention Basins for Water Management. Water 12 (5), S. 1–32, https://www.mdpi.com/2073-4441/12/5/1491
TESCHEMACHER, S., & DISSE, M. (2020b): Automated location optimization of detention basins as a contribution to an efficient flood mitigation strategy, EGU2020-18342, https://doi.org/10.5194/egusphere-egu2020-18342
TESCHEMACHER, SONJA (2021): Gebietsübergreifende Retentionspotenzialanalyse agrarwirtschaftlicher und konstruktiver Maßnahmen des dezentralen Hochwasserrückhalts, Dissertation, https://mediatum.ub.tum.de/?id=1586359

Site selection procedure

data preparation | ArcMap
(dgm, dgm_fill, dir, acc, gew_gross, landuse, pur, ezg)

basin position analysis | MATLAB
(fun_Programm_Durchlauf.m)

user input
- Maximum water depth, max. and min dam length
- Raster length & threshold for river definitions

raster analysis
- River analysis: characteristics of river points
- Land use classification (restriction areas)

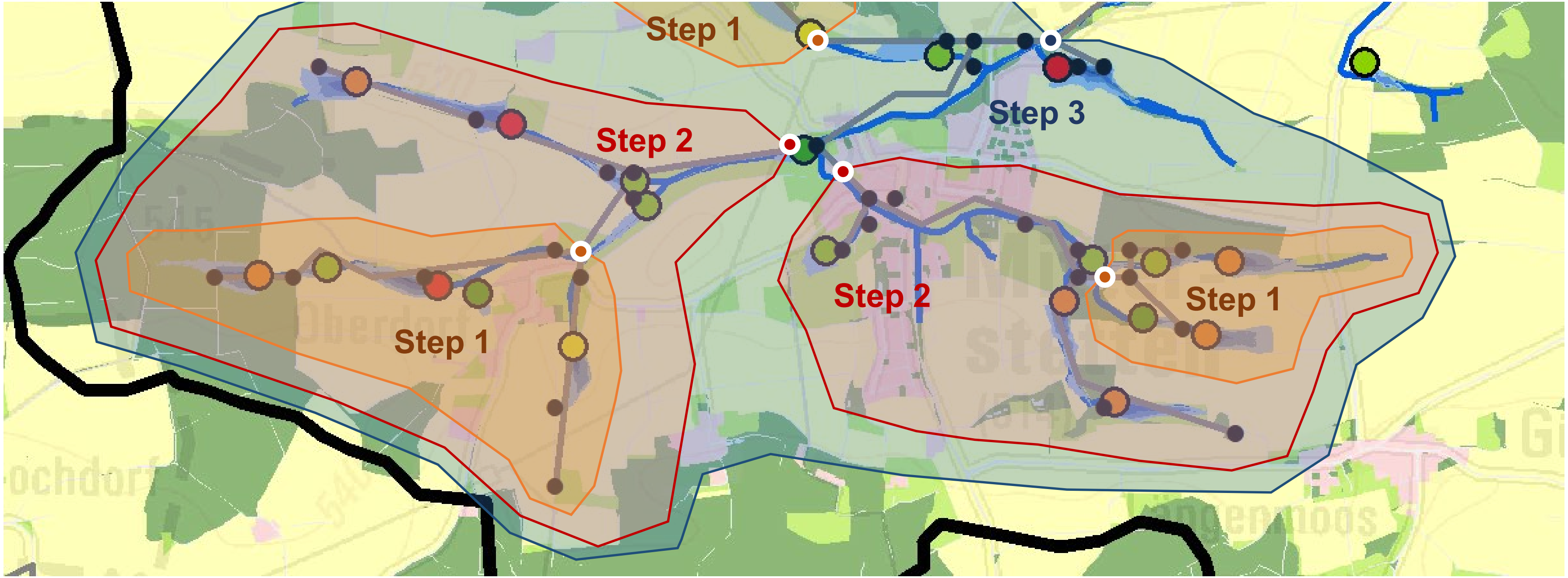
dam analysis
- Detection of shortest dam for every river point
- Determination of dam characteristics

basin analysis
- Calculation of basin area and volume
- Determination of evaluation criteria

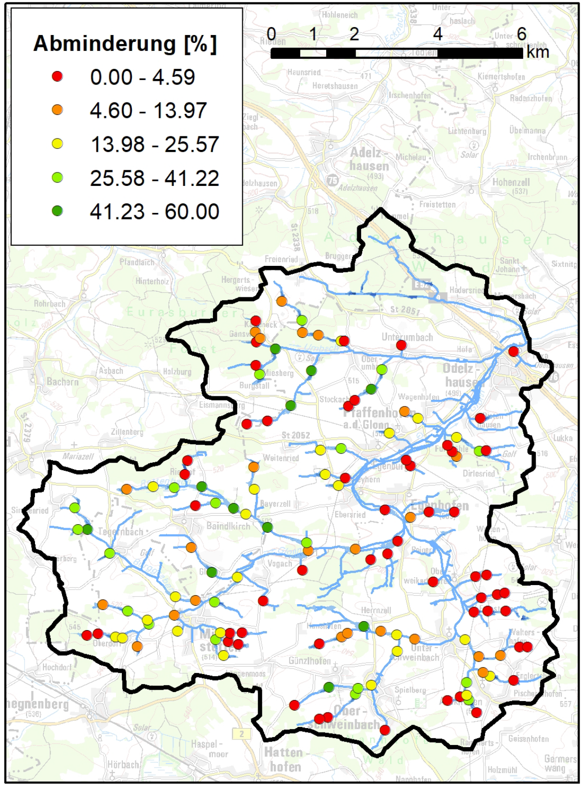
basin selection
- Analysis of evaluation criteria and overlapping basins
- Selection of a potential basin combination

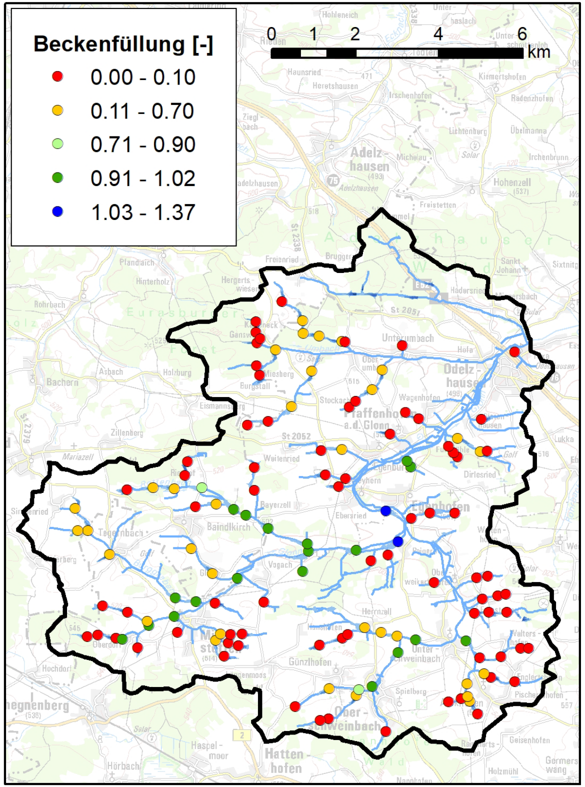
Methods

Location-optimization

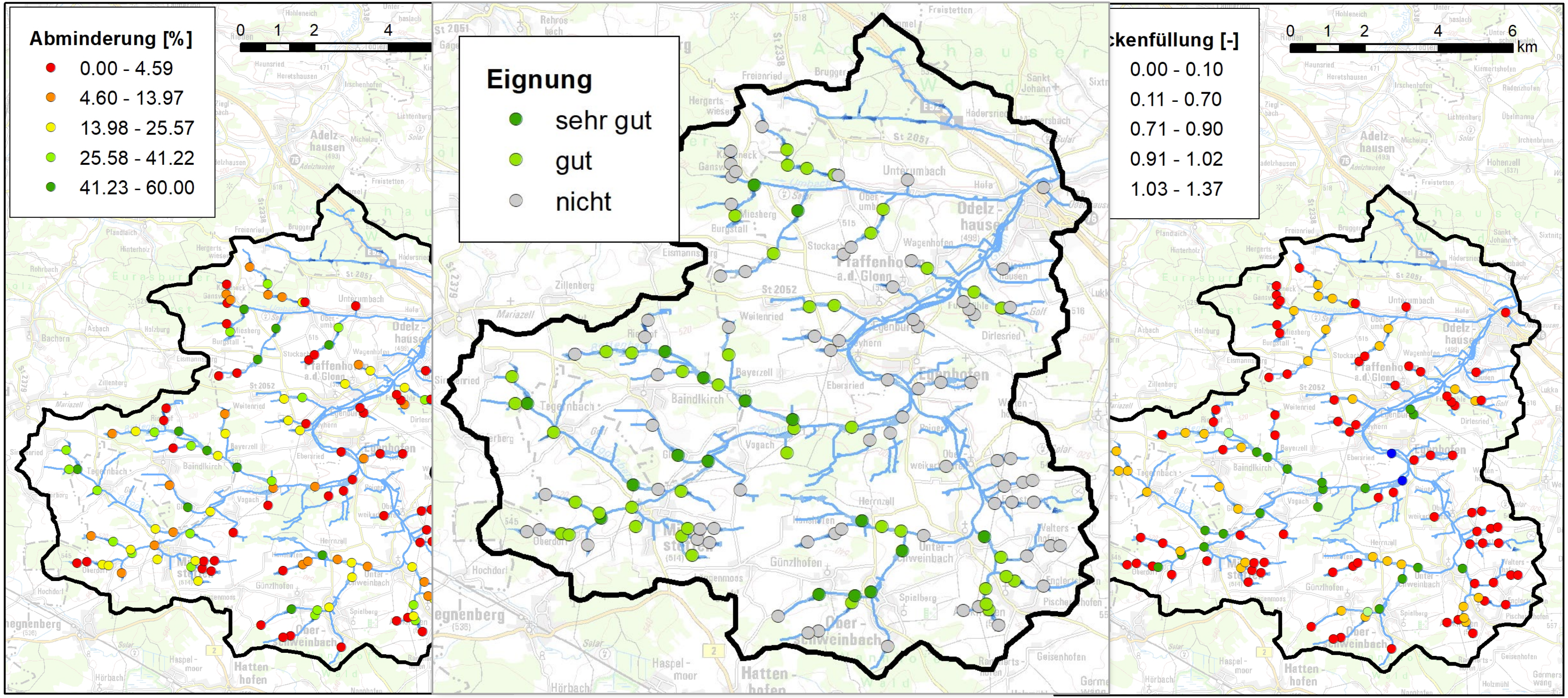


Site evaluation





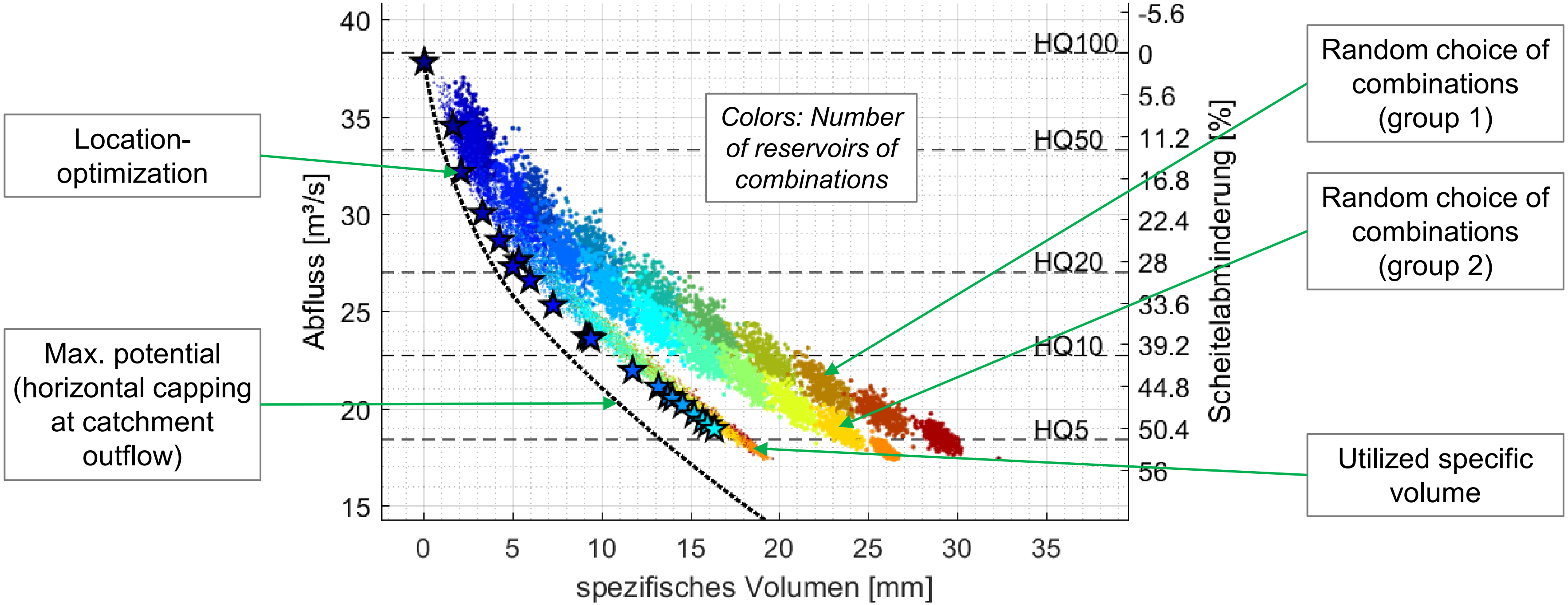
Site evaluation



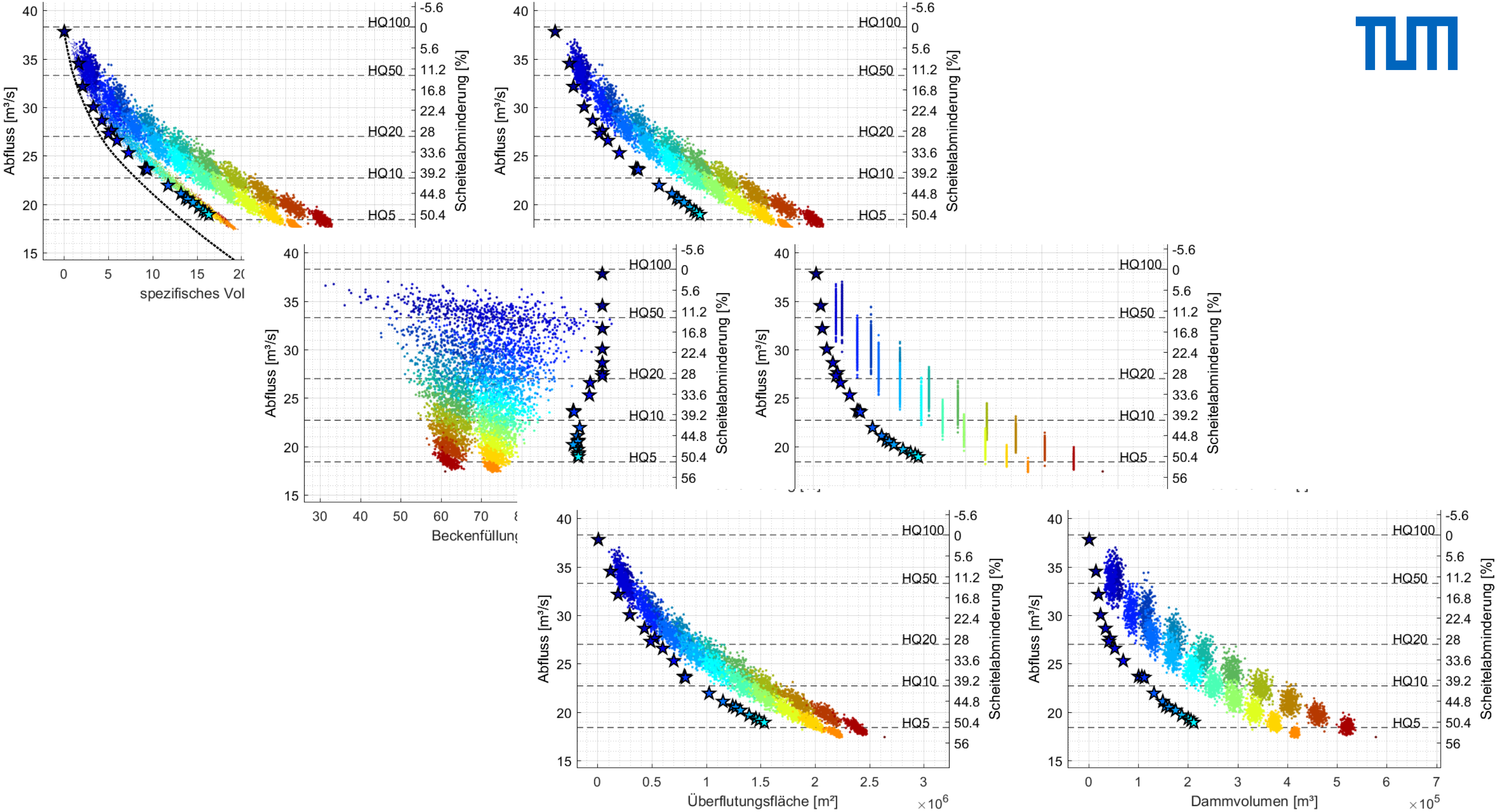
Results

Efficiency depending on various Influencing factors

Gruppierung		Berücksichtige Kriterien
Gruppe 1	*Alle potentiell möglichen Standorte*	• Sinnvolle Zuordnung im hydrologischen Modell möglich • V_{Damm}: 0 bis 4 m • V_{HWE}: 5 000 bis 50 000 m³
Gruppe 2	*Hydrologisch wirksame Standorte*	• Beckenfüllung bei seltenem Ereignis größer 40 % • Ausschluss wenn $\Delta HQ < 0{,}05\ \mathrm{m^3/s}$ und Kriterium 2 > 0,5 • Ausschluss wenn $BHQ > 80\ \mathrm{m^3/s}$

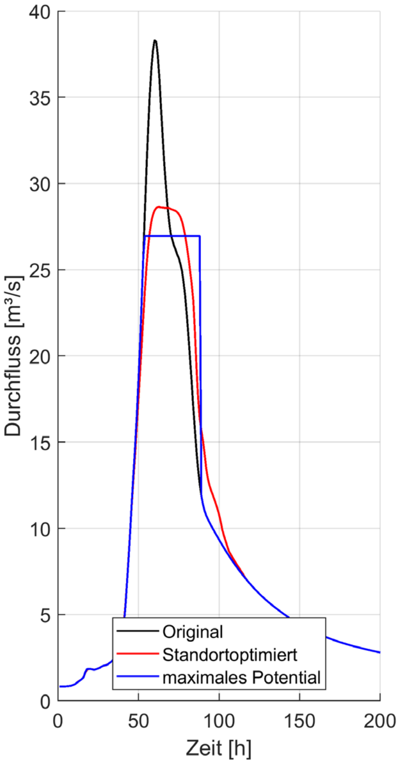


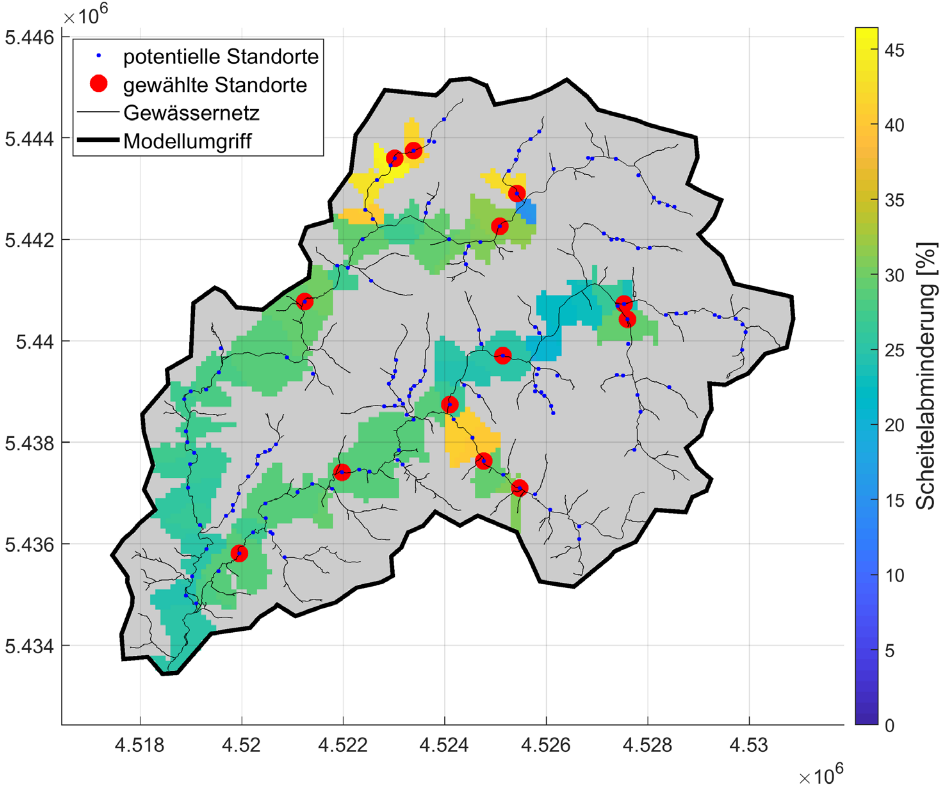
E.g.: Otterbach, HQ100 (adv.)


Abfluss [m³/s]
Scheitelabminderung [%]
HQ100
HQ50
HQ20
HQ10
HQ5
spezifisches Vol
Beckenfüllung
Überflutungsfläche [m²]
Dammvolumen [m³]
×10^6
×10^5

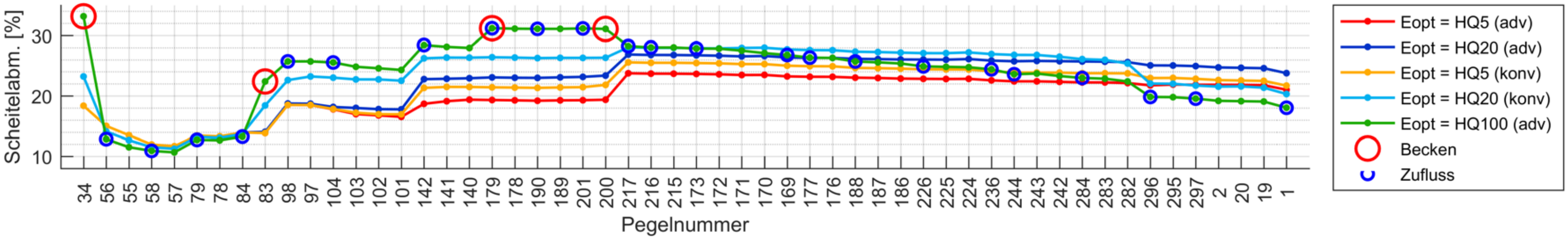
Results

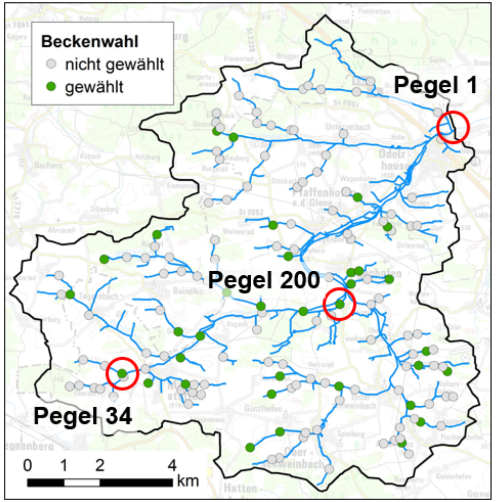
Assessment of location-optimization

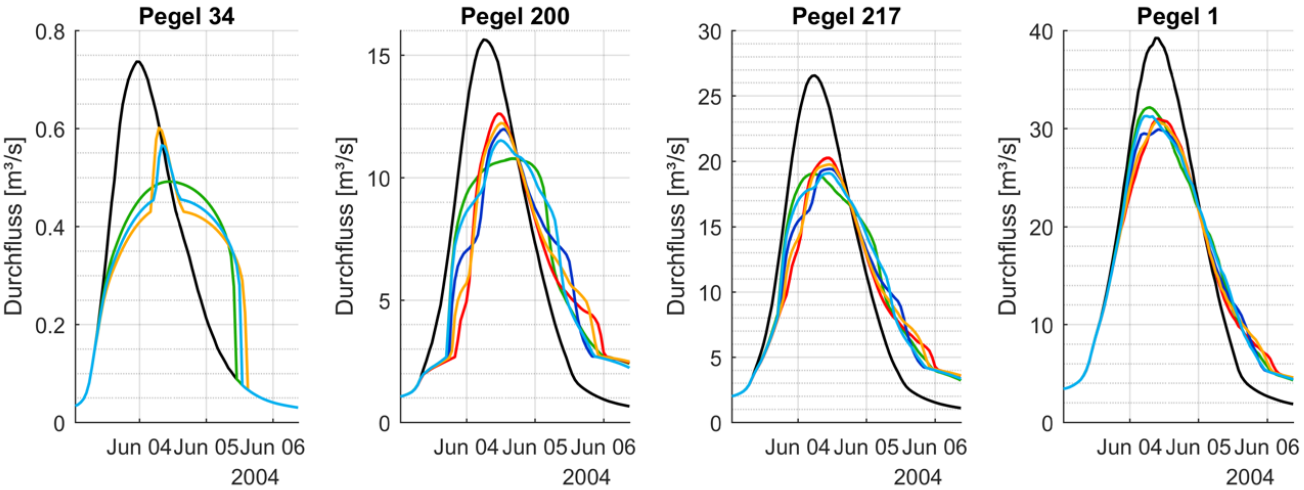




E.g.: Otterbach, HQ100 (adv.), sV = 4,3 mm







Top: Course of peak attenuation over the watercourse for different attenuation optimizations, bottom left: spatial distribution of basin locations, bottom right: hydrographs for different attenuation optimizations for selected basin locations (Glonn catchment)

Conclusions

Methods for site analysis, location optimization, throttle optimization and efficiency analysis have large potential for flood defense concepts

In-depth analysis of the impact of scenario characteristics on the throttle width and the resulting peak-discharge
→ various temporal and spatial precipitation distributions

Small retention basins can also be used for groundwater recharge → combined effect of flood retention and drought mitigation

Thank you for your attention!
Questions?