Model-based selection of WWTP for quaternary treatment with minimum costs to meet EU-EQS for diclofenac

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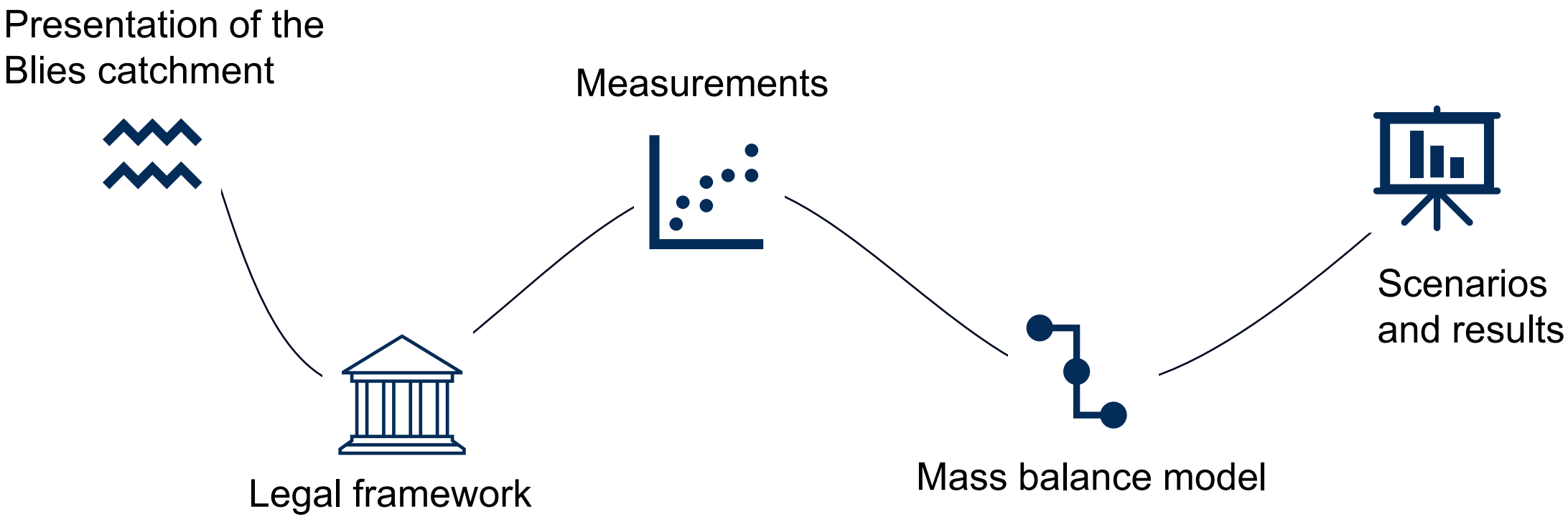
SAARLAND

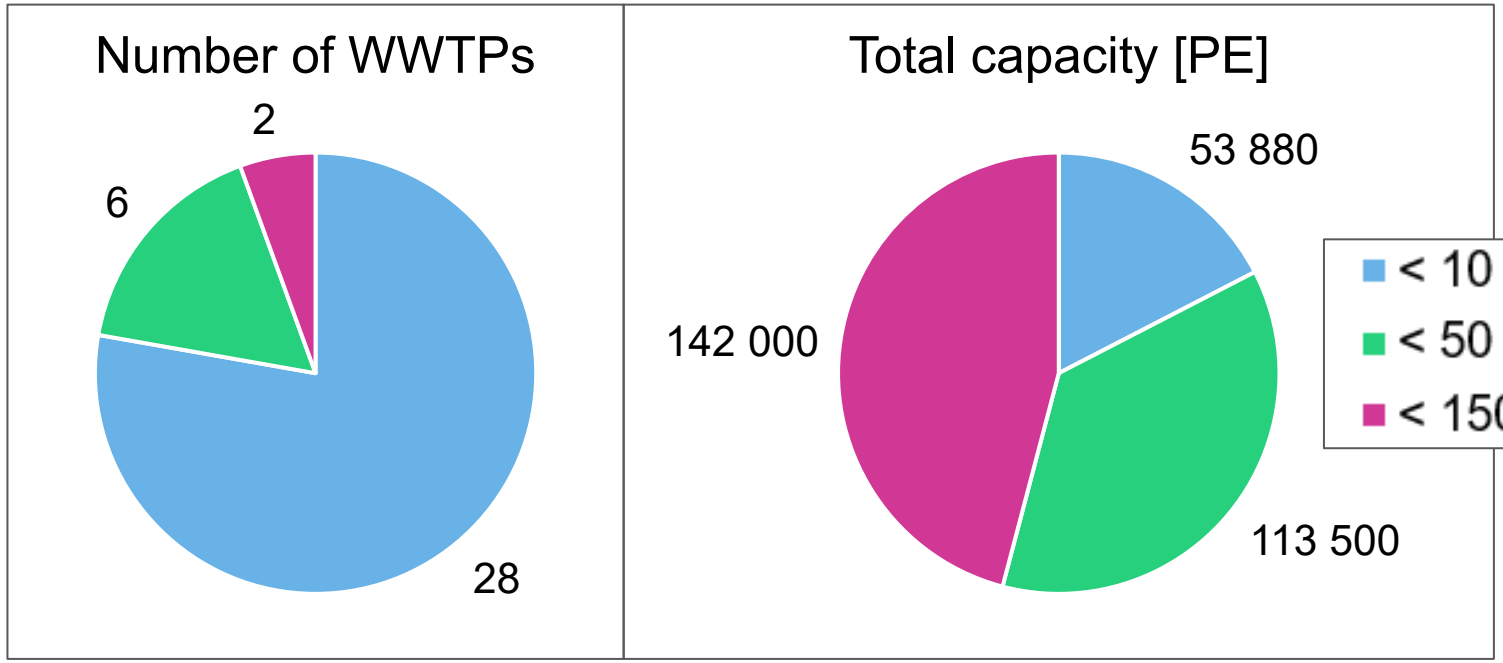
River **Blies** upstream of the confluence with the River Saar

Content


Presentation of the Blies catchment
Measurements
Scenarios and results
Legal framework
Mass balance model

Catchment of the River Blies

- Length **upper Blies** (from source to the confluence with the river Schwarzbach): **55 km**
- Upper Blies catchment area 445 km²
- 36 Wastewater Treatment Plants with total capacity of 309 380 PE



Legal framework

4.

Secondary clarifier (WWTP Landstuhl, RLP)
(own image)

WWTP

EU-UWWTD

River

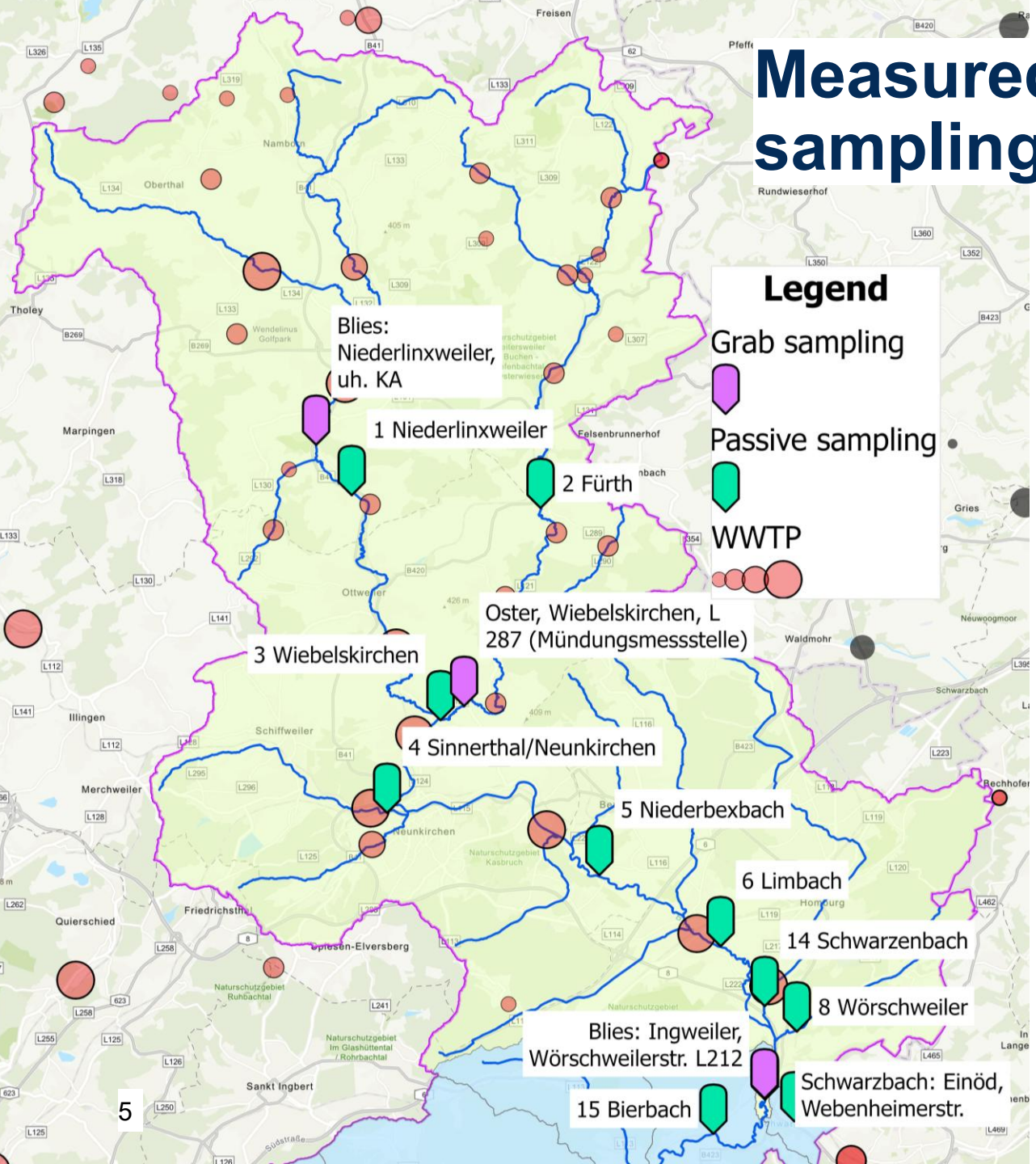
EU-WFD
EU-EQS

River Oster (tributary to River Blies, Saarland)
(own image)

- Requirements for quaternary treatment:
  - Reduction of minimum 80% in relation to the load of the influent
  - Average removal of certain substances
  - At dry weather flow
- Applies to WWTPs depending on size and location

- Aim “good status” (WFD) ≙ below environmental quality standards (EQS)
- April 2026: Publication of the EU-EQS directive
- Diclofenac AA-EQS surface waters **40 ng/l**
  → one of the most critical parameters
  → EQS exceedances in many cases

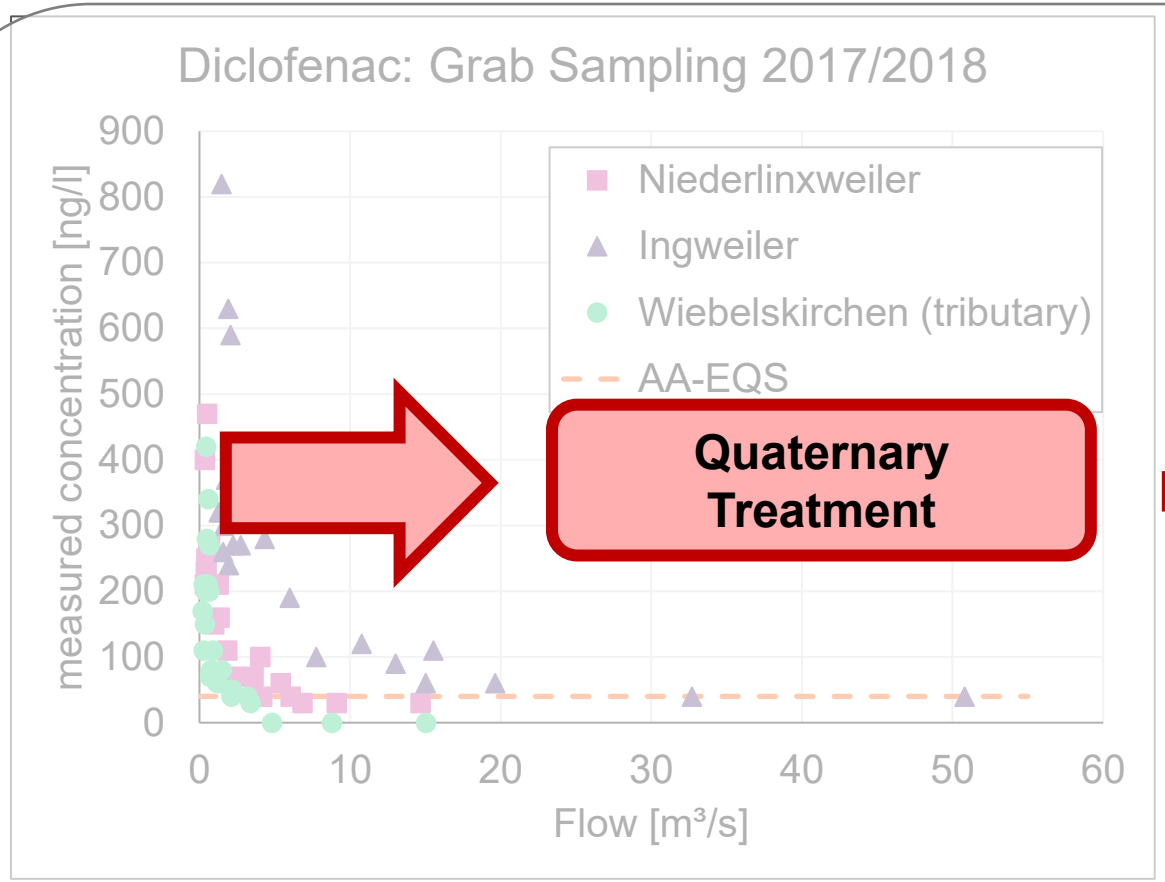
Measured concentrations: sampling sides



Two sampling campaigns in the catchment of the upper Blies

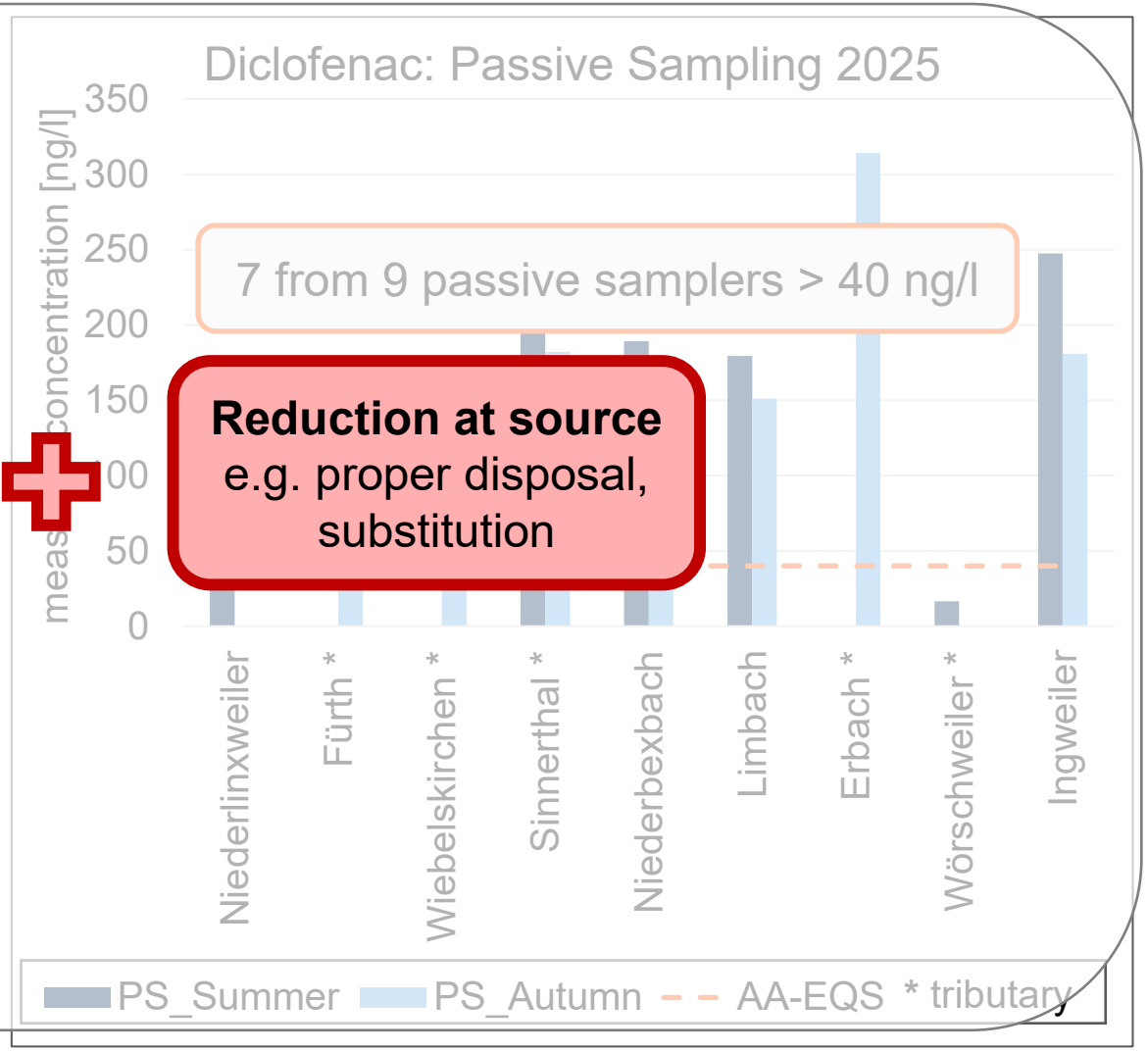
- Grab sampling (n = 26)
  - 3 locations in the river
  - 2017/2018
  - 29 micropollutants
- Passive sampling (n = 2)
  - 8 locations in the river
  - 2025: Summer and autumn
  - 31 micropollutants

Measured concentrations in the Blies



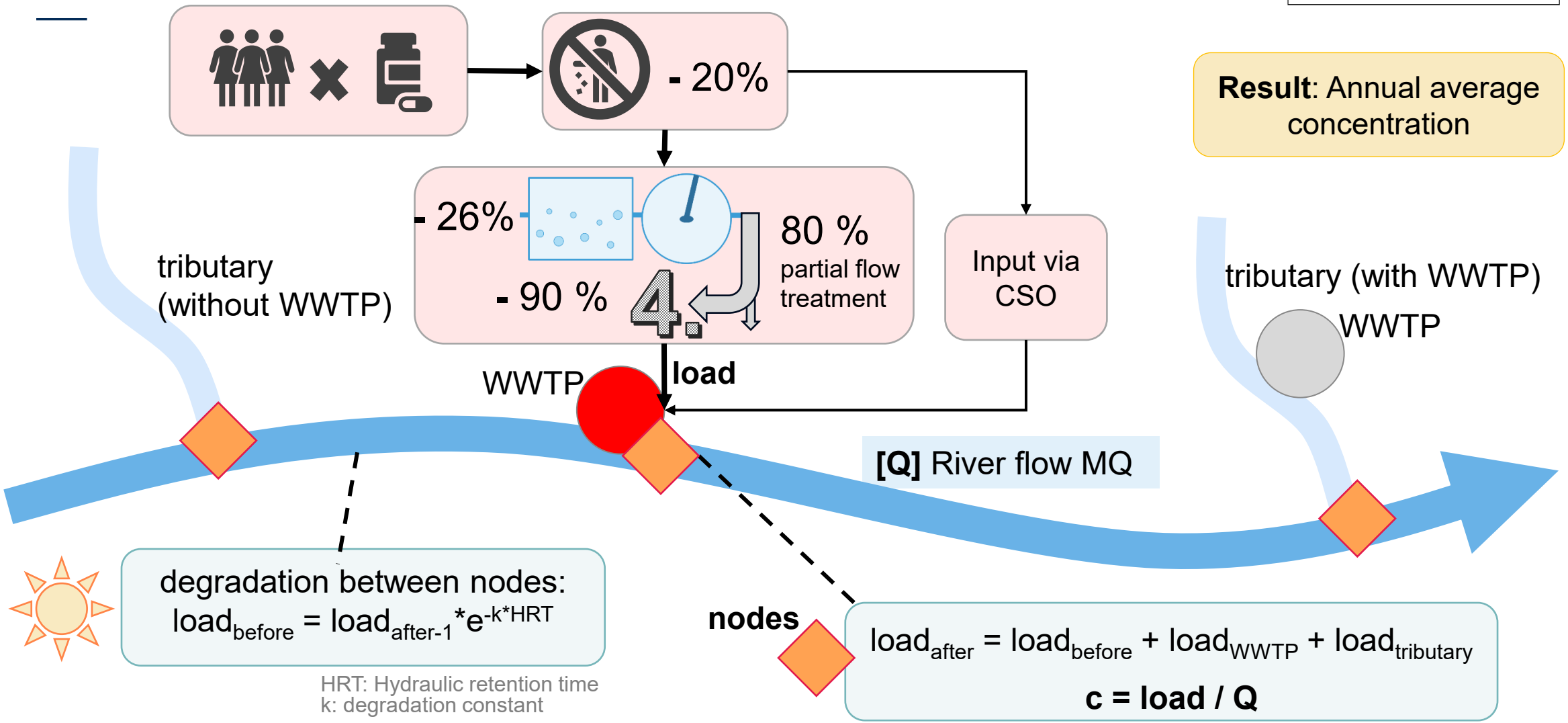
Quaternary Treatment

Ingweiler (end of upper Blies) > 40 ng/l



Reduction at source
e.g. proper disposal, substitution

Mass Balance Model Stoff*FLUSS*

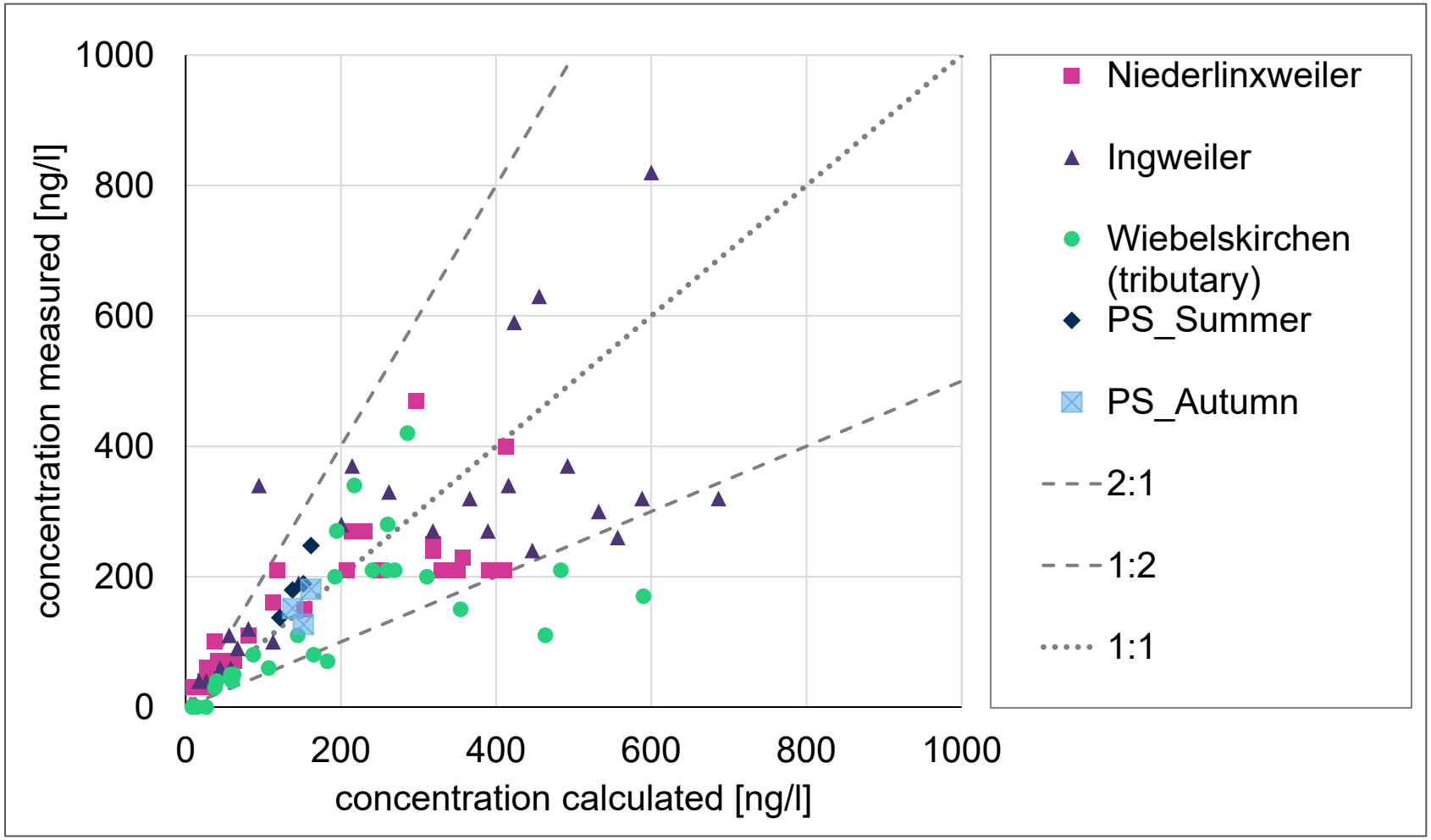


Result: Annual average concentration

HRT: Hydraulic retention time
k: degradation constant

References Stoff*FLUSS*: *Knerr et al. 2020; Venditti et al. 2022, Knerr et al. 2023*

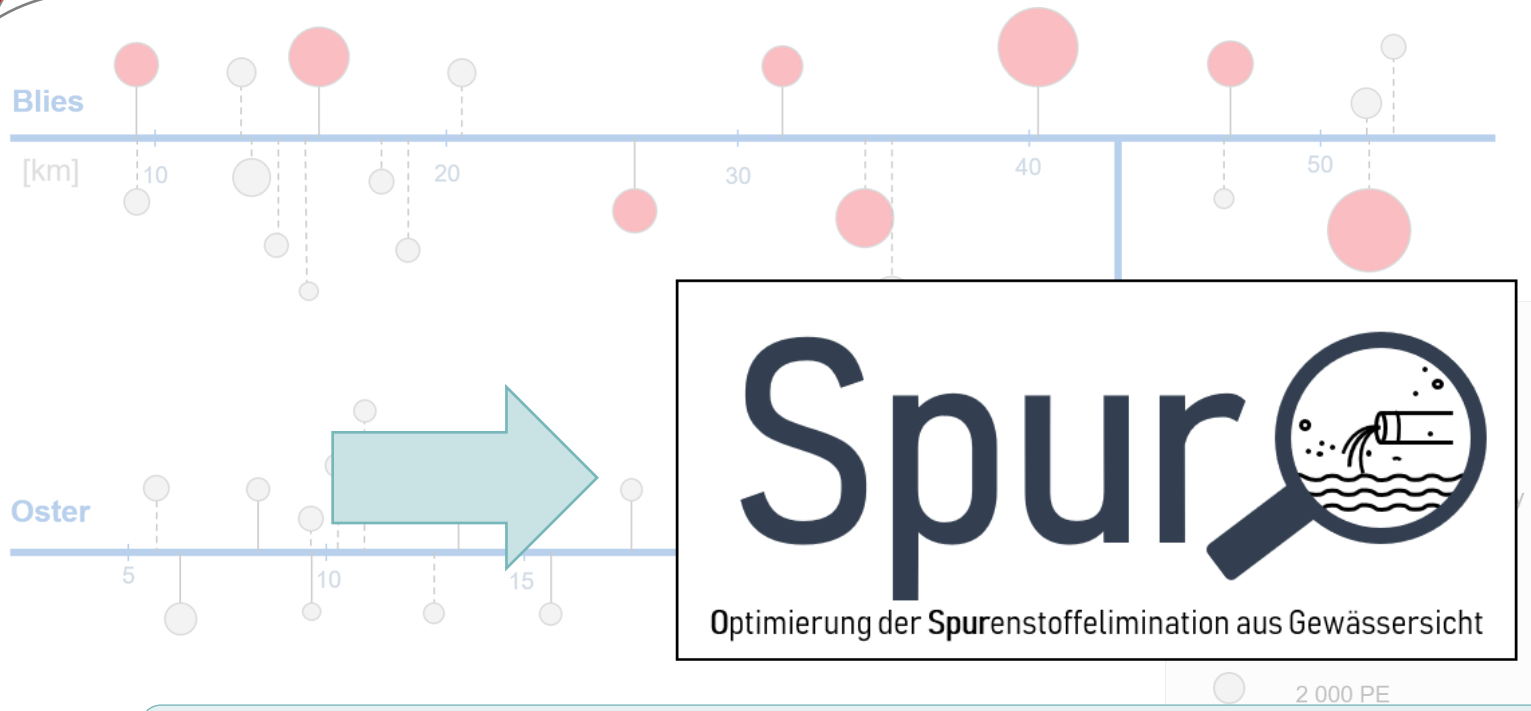
Comparison of measured and calculated concentrations



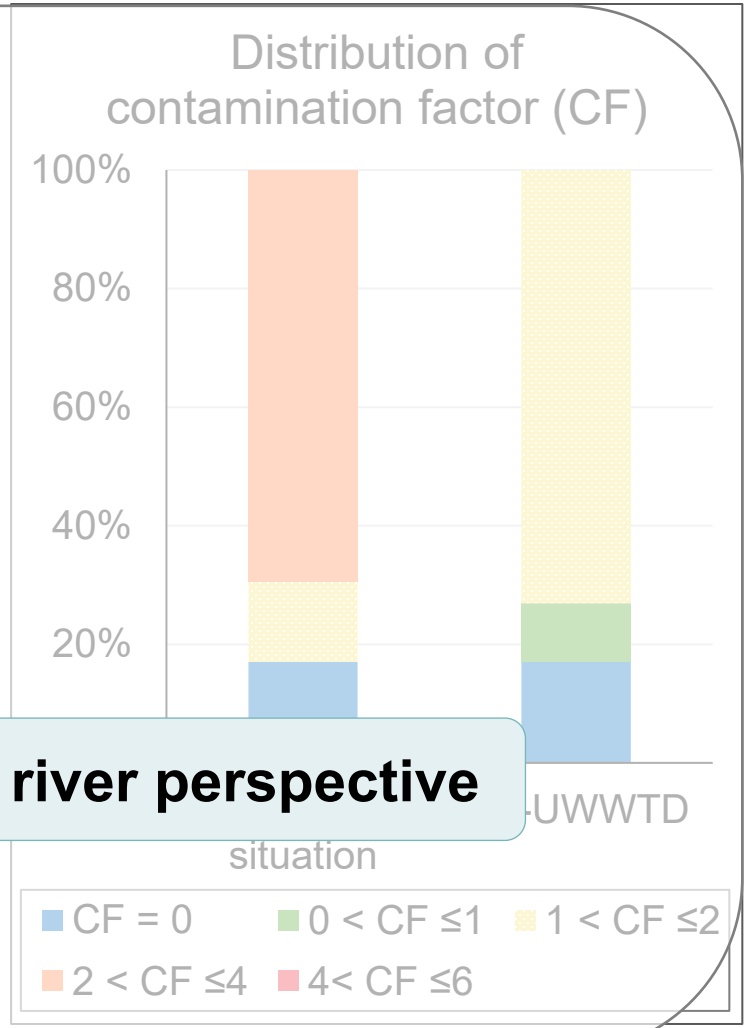
- Calculated concentration: Ratio of annual average load and discharge in river at the day of sampling
- Most of the values inside the range of 1:2 and 2:1

4. WWTP

EU-UWWTD: WWTP ≥ 10 000 PE



Spur
Optimierung der Spurenstoffelimination aus Gewässersicht



Optimisation of the removal of micropollutants **from a river perspective**

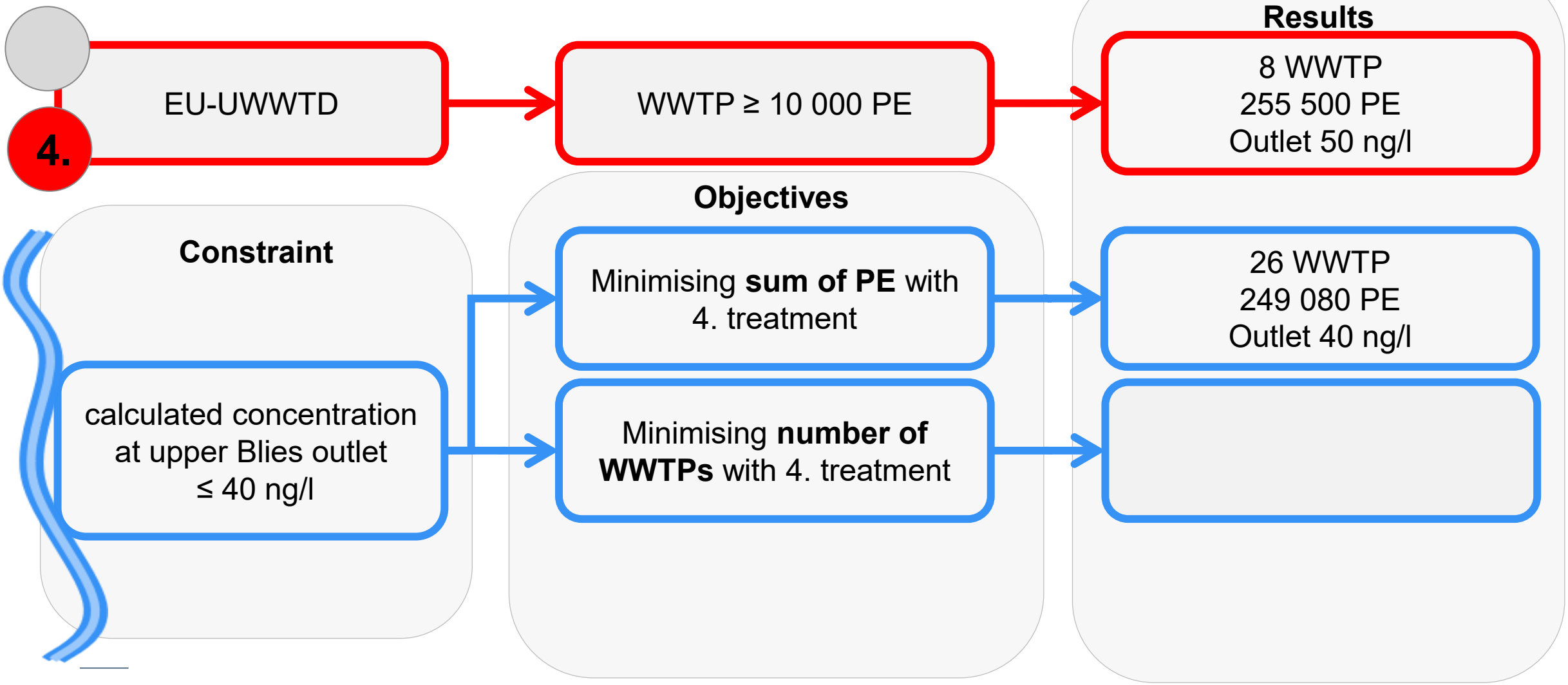
8 WWTP
255 500 PE

→ Concentration at outlet 50 ng/l
→ Most of length higher than 40 ng/l

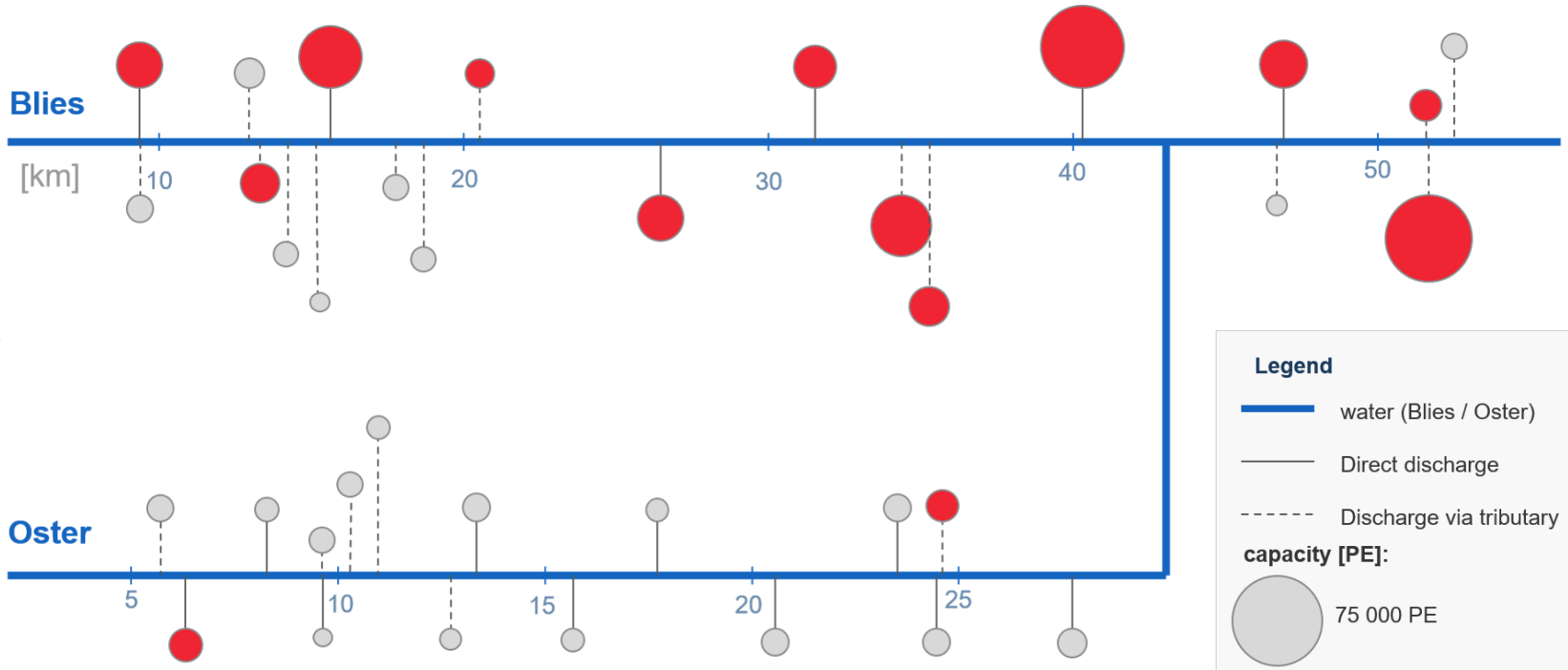
CF = calculated concentration for each section/ EQS

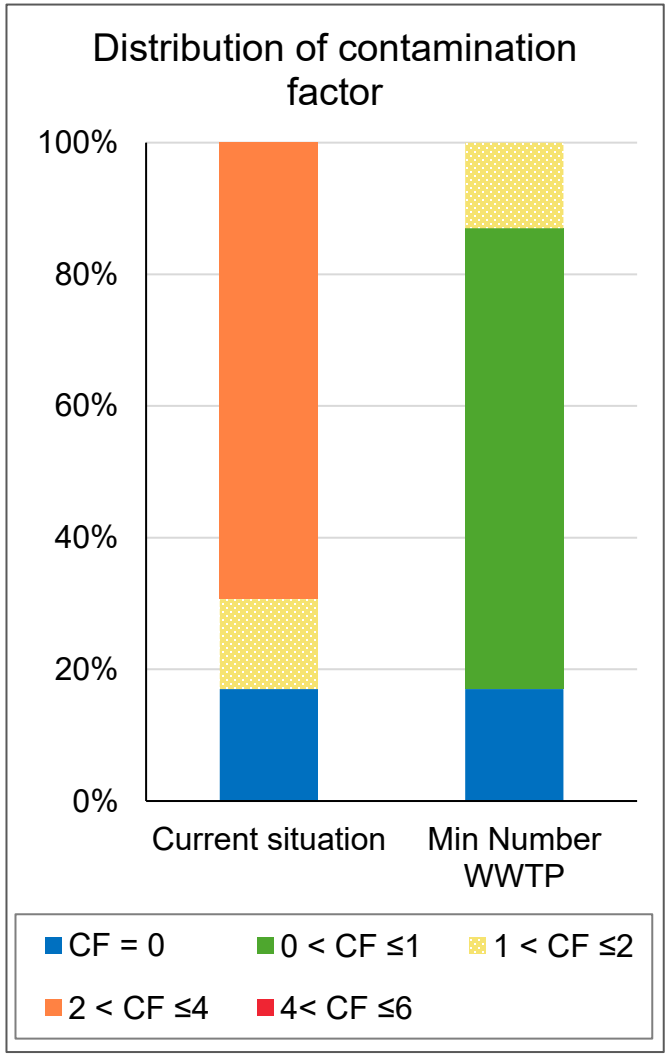
Overview of scenarios

All scenarios:
with 20% reduction
at source



Minimum number of WWTPs



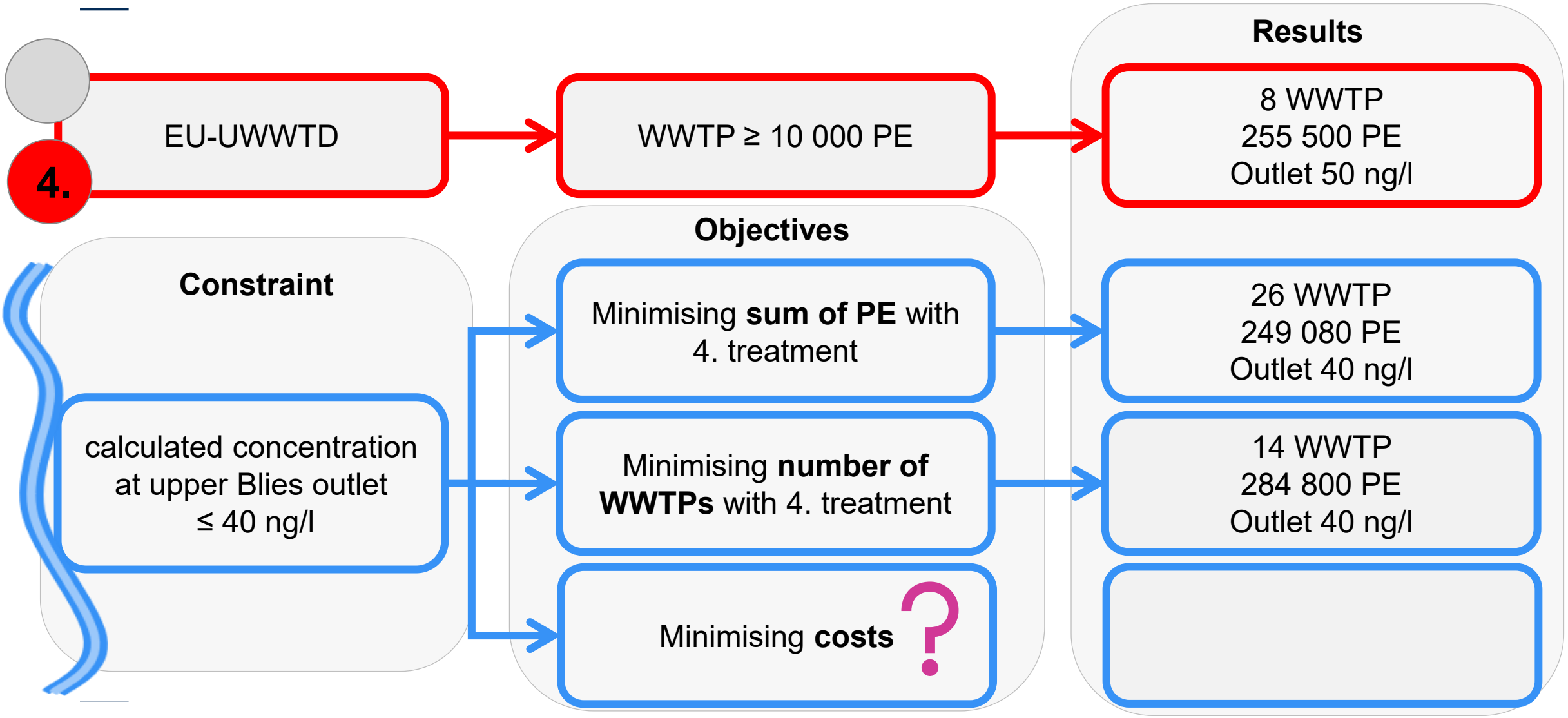


Min Number WWTPs:
14 WWTP
287 100 PE

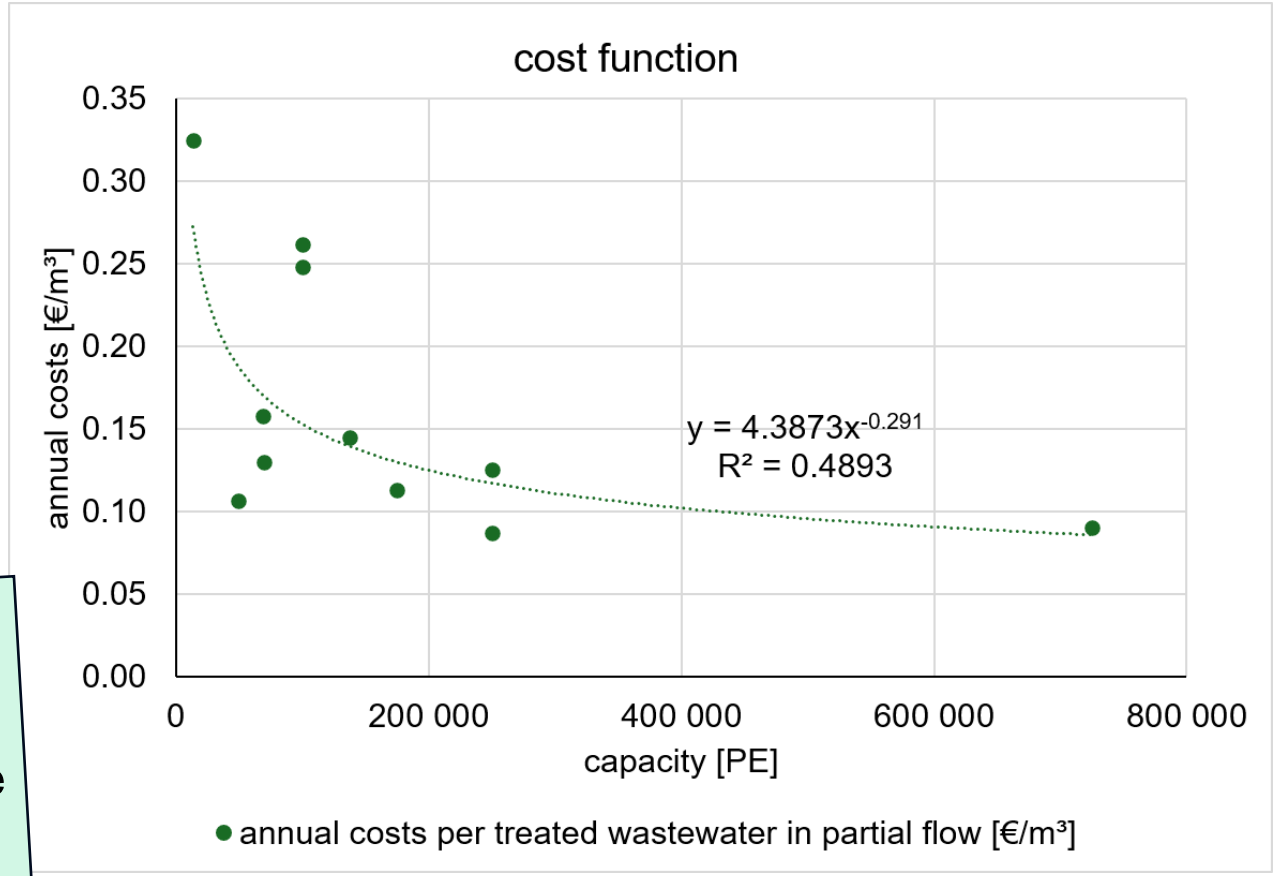
→ Constraint is fulfilled
→ Large part of flow length < EQS

Overview of scenarios

All scenarios:
with 20% reduction
at source



Cost function

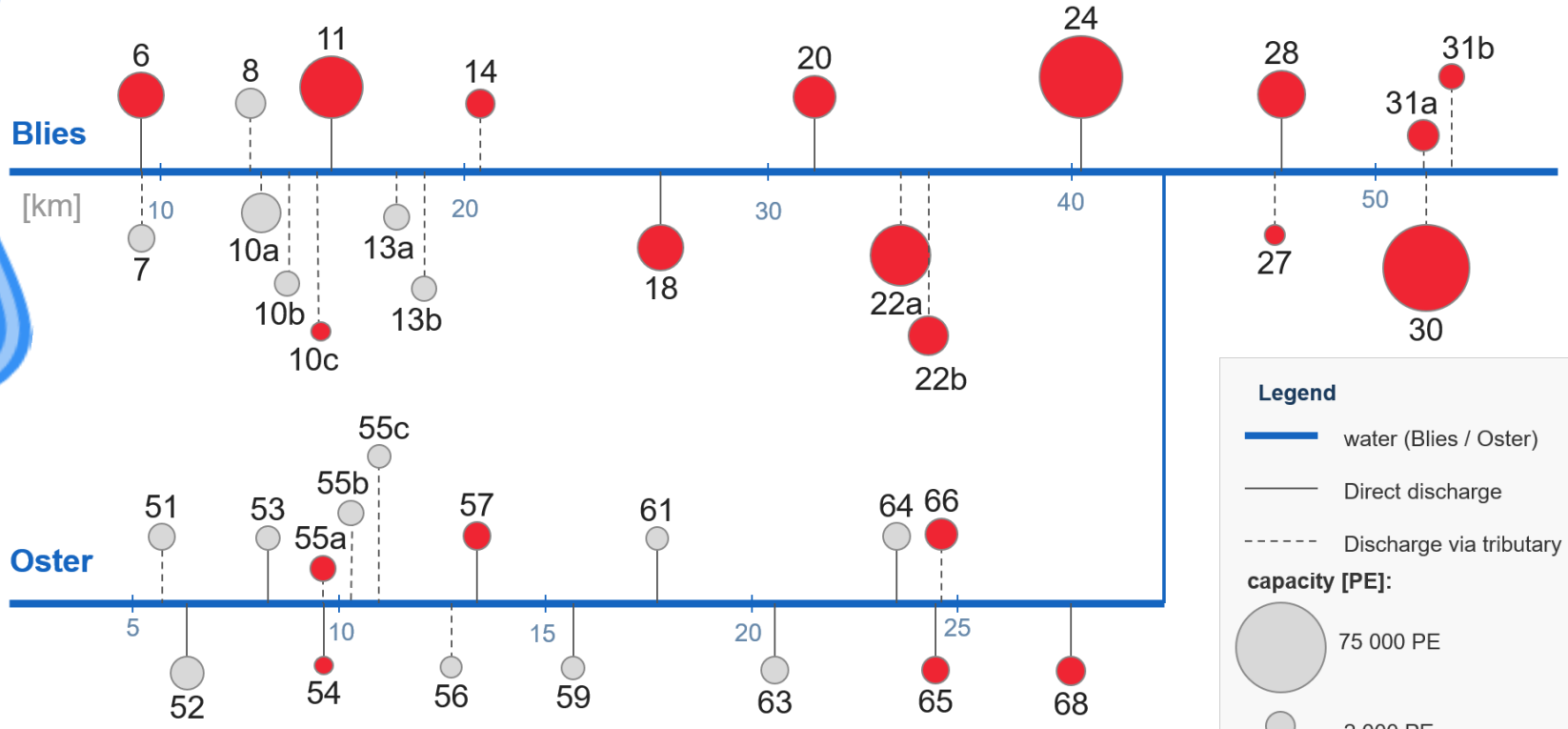


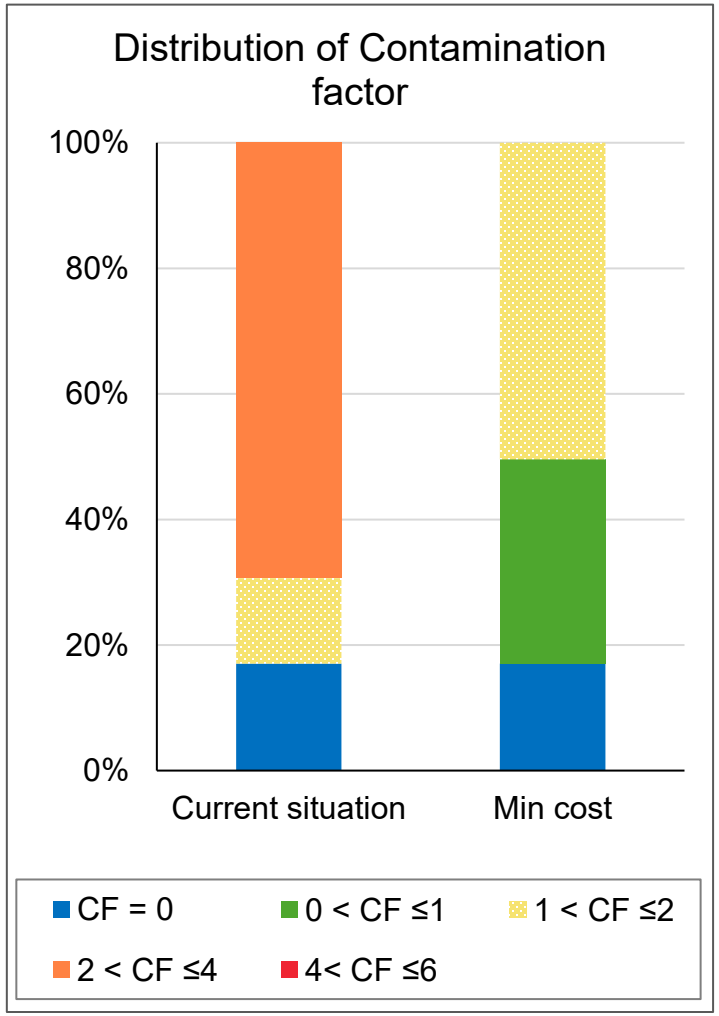
- Actual costs for quaternary treatment from 11 WWTPs in operation (Germany)
- No costs for small WWTPs <13 000 PE available
- Specific costs depend on the size of the WWTP

KOMS (2025): KomS-Langzeitbetrachtung Kosten der gezielten Spurenstoffelimination auf kommunalen Kläranlagen. Stuttgart.

River

Result minimum costs



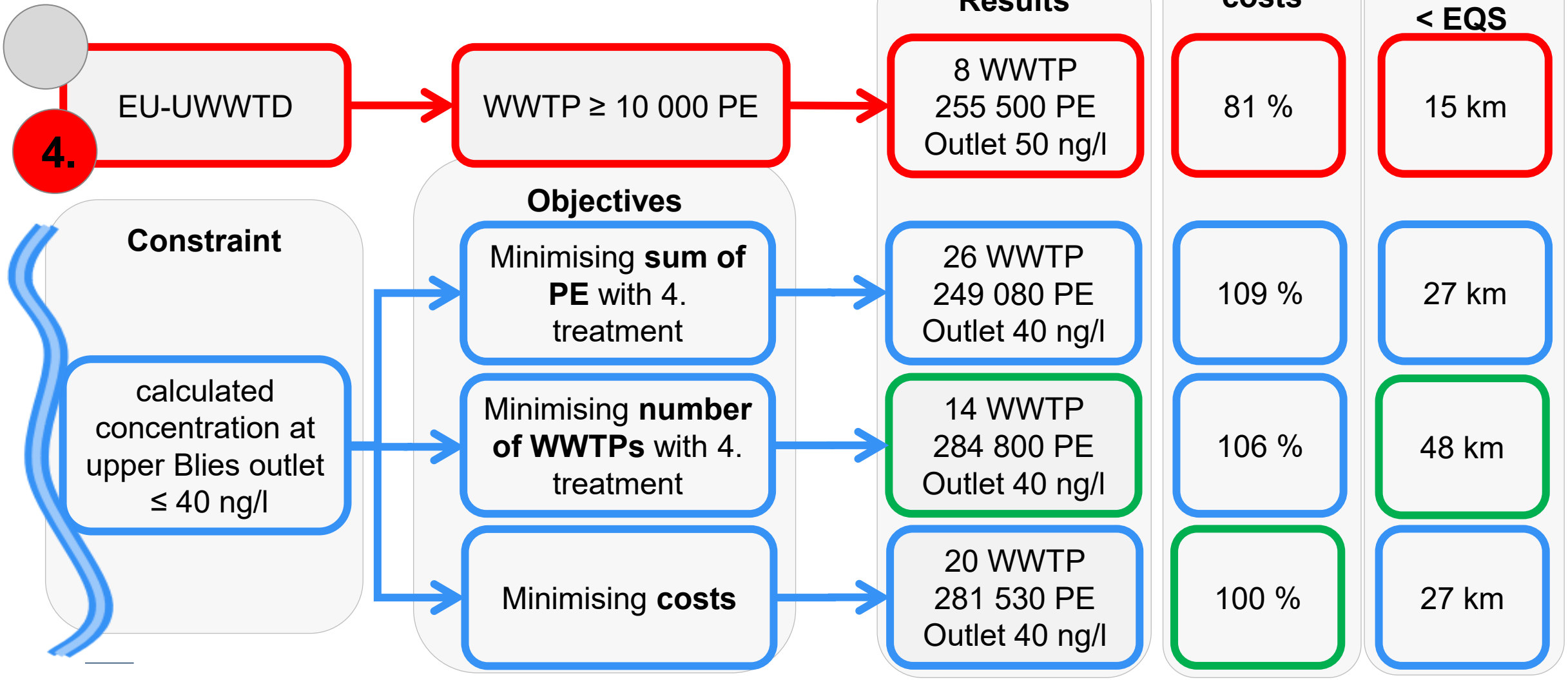


Min Costs
20 WWTP
281 530 PE

→ Constraint is fulfilled
→ 50% of river > EQS

Overview of scenarios

All scenarios:
with 20% reduction
at source



Conclusions

Conclusions apply only for the upper Blies catchment and for the critical parameter Diclofenac.

- Selection of **WWTP (> 10 000 PE)** in accordance with the EU-UWWTD is **not sufficient** to reach requirements by EU-EQS for diclofenac
- Selection of all WWTP without reduction source is not sufficient
  → Equipment of WWTP with quaternary treatment is only one part
  → **reduction at source is needed!**
- Constraints need to be chosen depending on the arrangement of WWTPs in the catchment
- **Minimum number of WWTP** is a suitable target for **practical use**
- **Outlook**: Application of this method to the to the entire Blies catchment, sensitivity analysis, pareto-optimisation

References

KOMS (2025): KomS-Langzeitbetrachtung Kosten der gezielten Spurenstoffelimination auf kommunalen Kläranlagen. Stuttgart.

Knerr, Henning; Gretzschel, Oliver; Valerius, Birgit; Srednoselec, Ivana; Zhou, Junjuan; Schmitt, Theo G. et al. (2020): Modellgestützte Bilanzierung von Mikroschadstoffen in Gewässern. In: gwf-wasser (3), S. 55–65.

Venditti, Silvia; Kiesch, Anne; Brunhoferova, Hana; Schlienz, Markus; Knerr, Henning; Dittmer, Ulrich; Hansen, Joachim (2022): Assessing the impact of micropollutant mitigation measures using vertical flow constructed wetlands for municipal wastewater catchments in the greater region: a reference case for rural areas. In: Water science and technology : a journal of the International Association on Water Pollution Research 86 (1), S. 128–141. DOI: 10.2166/wst.2022.191.

Thank you for your attention!

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