Decision Support for managing substance flows within the Berlin water cycle under climate change conditions

M. Rustler[1], D. Scharffetter[2], A. Lompa[1], T. Taute[3], A. Sperlich[2], R. Gnirss[2], G. Grützmacher[1]

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Project financed by:

Aarhus, 21 – 23 , January 2014

Berlin – PREPARED!

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Main Challenges (defined by the city):

1) Water scarcity
2) Heavy rain events

Developed tools / solutions

- assessment tool for CSO impact on surface water quality
- Test of odour sensors for sewer control
- Decision support to avoid substance accumulation in uban water cycles
- Catalogue of implemented climate change adaptation measures

Partners

KOMPETENZZENTRUM WasserBerlin

KRÜGER

Berliner Wasserbetriebe

INSA

Berlin Senate for the Environment

Demonstration / pilot scale tests:

- Simulation of the effect of different combinations of CSO control measures
- Biofilm monitoring in distribution systems
- Pre-validation tool for sensor data from gw level loggers

SUCCESS STORIES:

- Close cooperation between research, operation & authority,
- Demonstrated tools handed over to end-user for further use / development

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VEOLIA EAU
Berliner Wasserbetriebe

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Outline

1. **Introduction**

2. **The Berlin Water Cycle**
   - Present situation
   - Future challenges
   - Water managements options

3. **Conclusions & Outlook**

Introduction

Challenges for Berlin's water supply

- **Climate change:** discharge reduction of up to 41% until 2055 expected ➔ reduced dilution of WWTP effluents in Berlin`s surface water bodies
- **Socio-economic development:** termination of open pit lignite mining (since 1990s) ➔ rising sulphate concentrations in River Spree (~ 300-350 mg/l in 2015)

Objectives of this study

- Development of a decision support system that is able to:
  - Simulate water and substance flow within the urban Berlin water cycle
  - Scenario analysis: assess the impact of changing boundary conditions (e.g. rising SO_4 concentrations) on raw water quality of the WW
- Derive recommendations for an optimised design and operation of the WW

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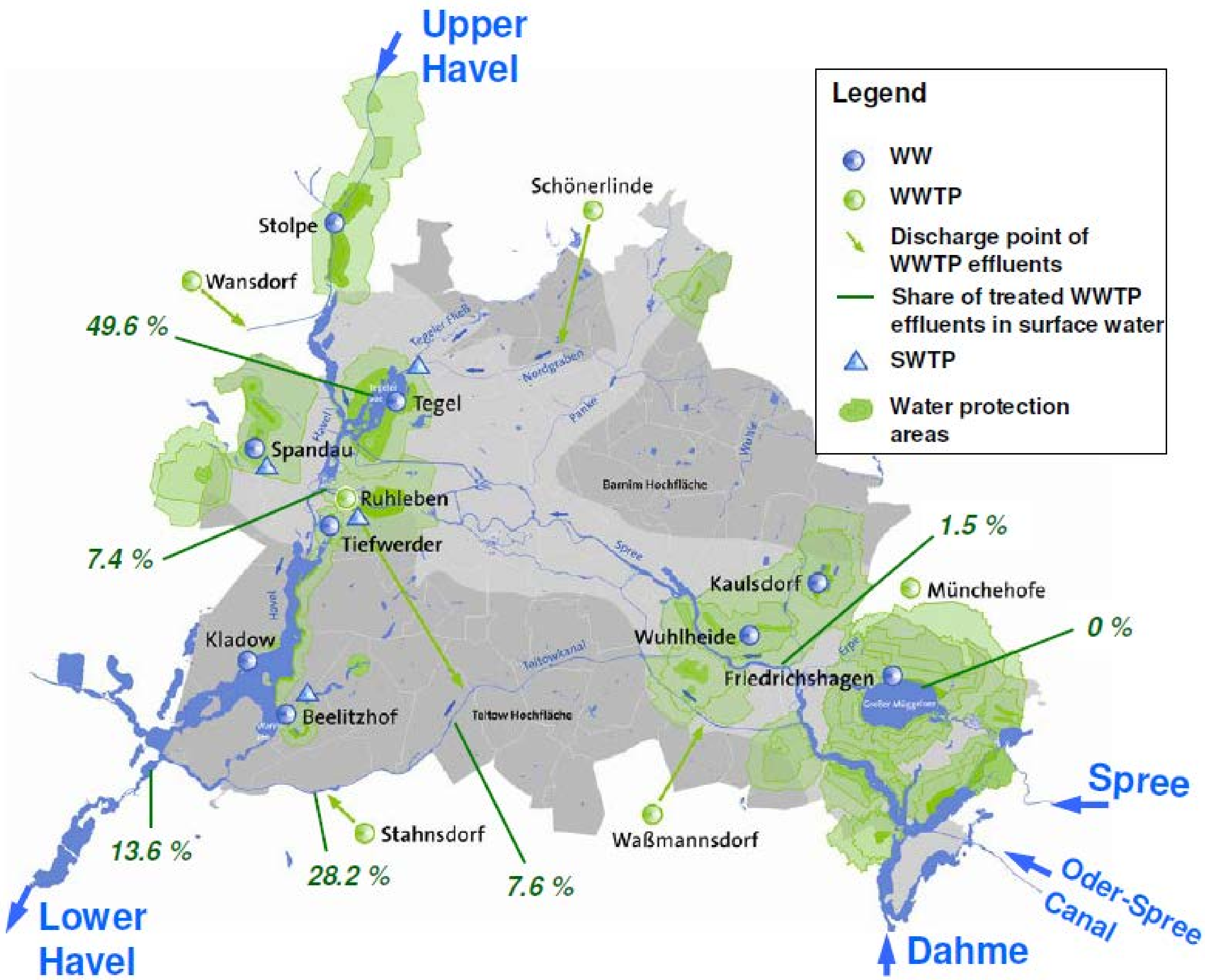
The Berlin water cycle: present situation



The Berlin water cycle: present situation

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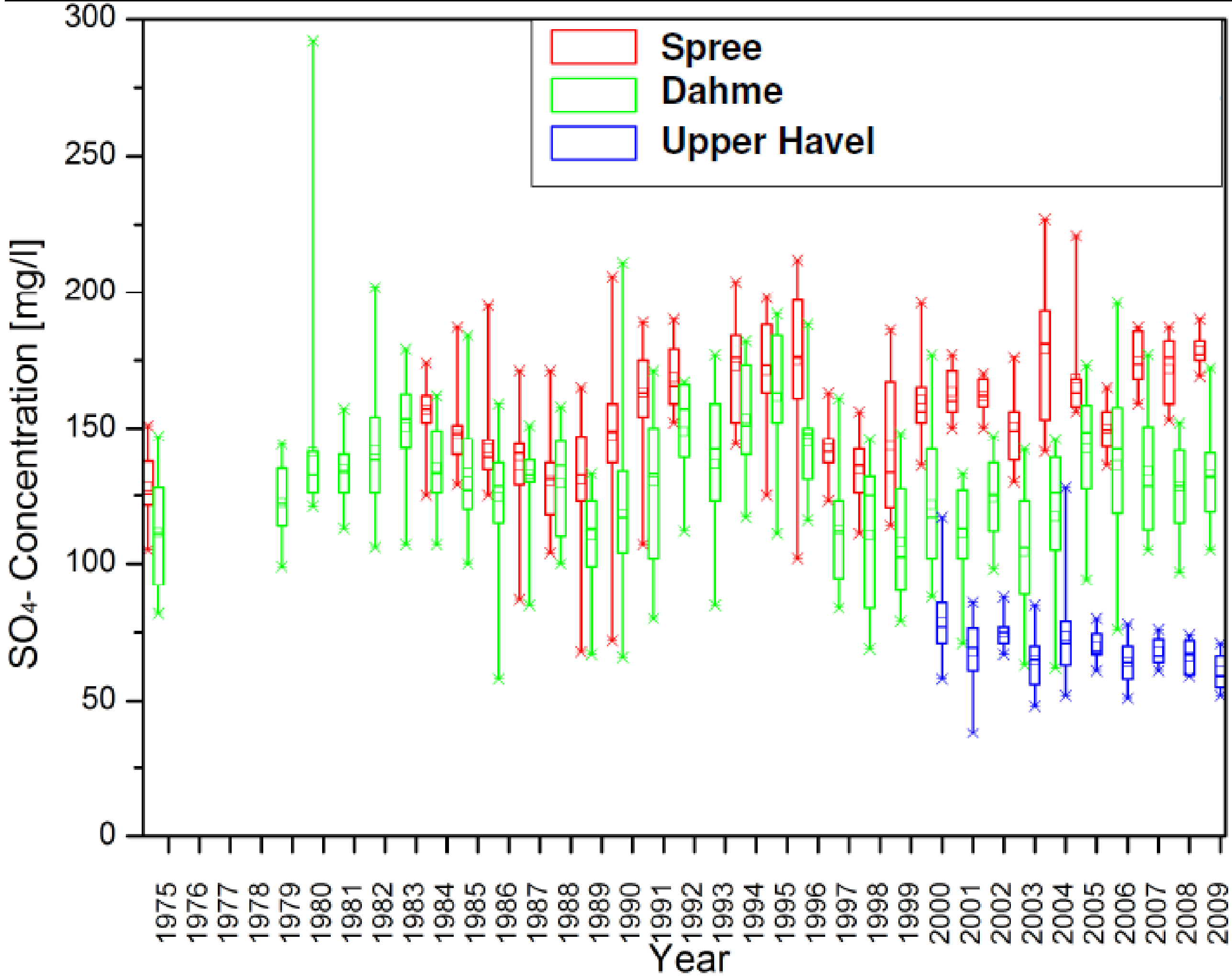
Surface water:



The Berlin water cycle: present situation

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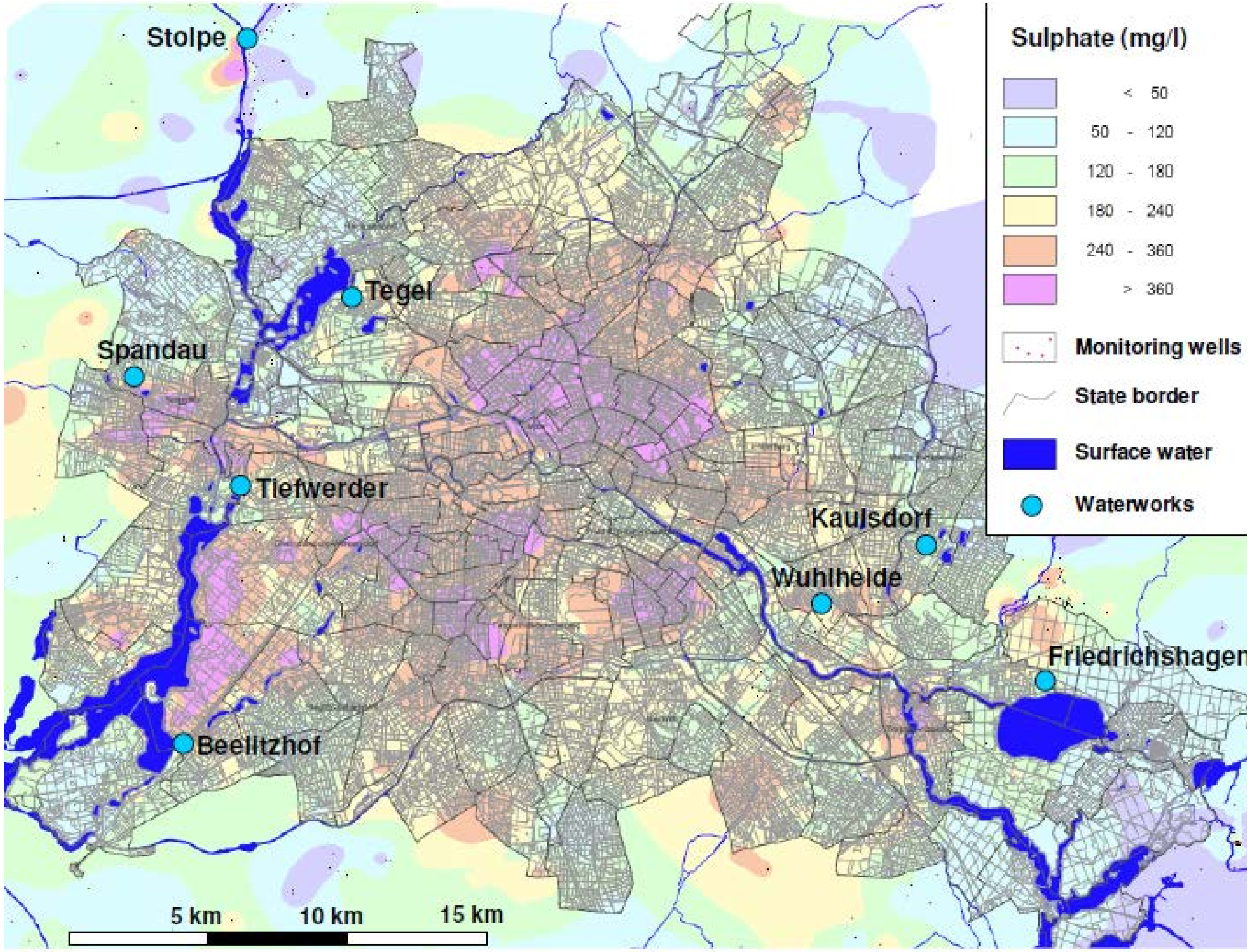
Groundwater:



The Berlin water cycle: present situation

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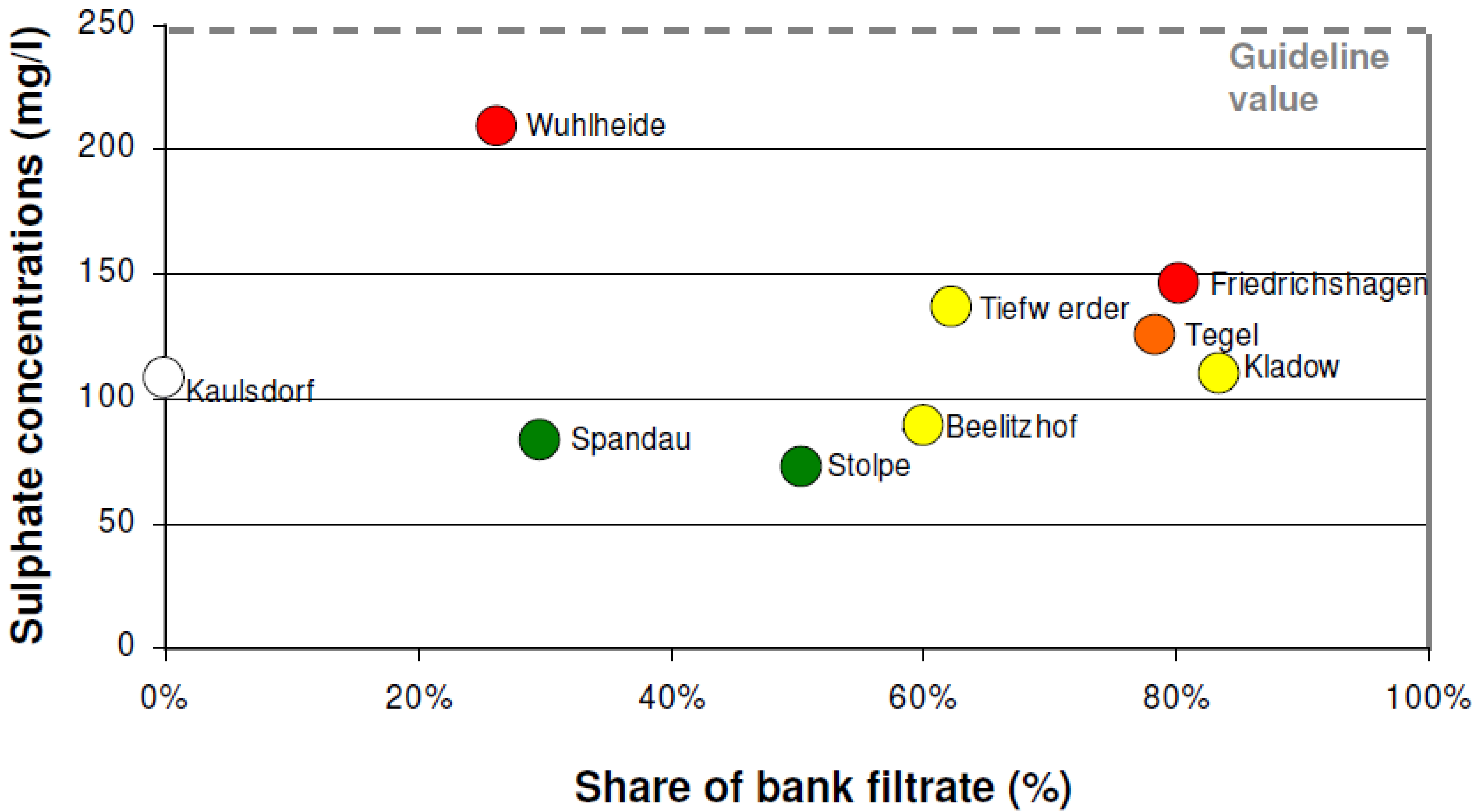
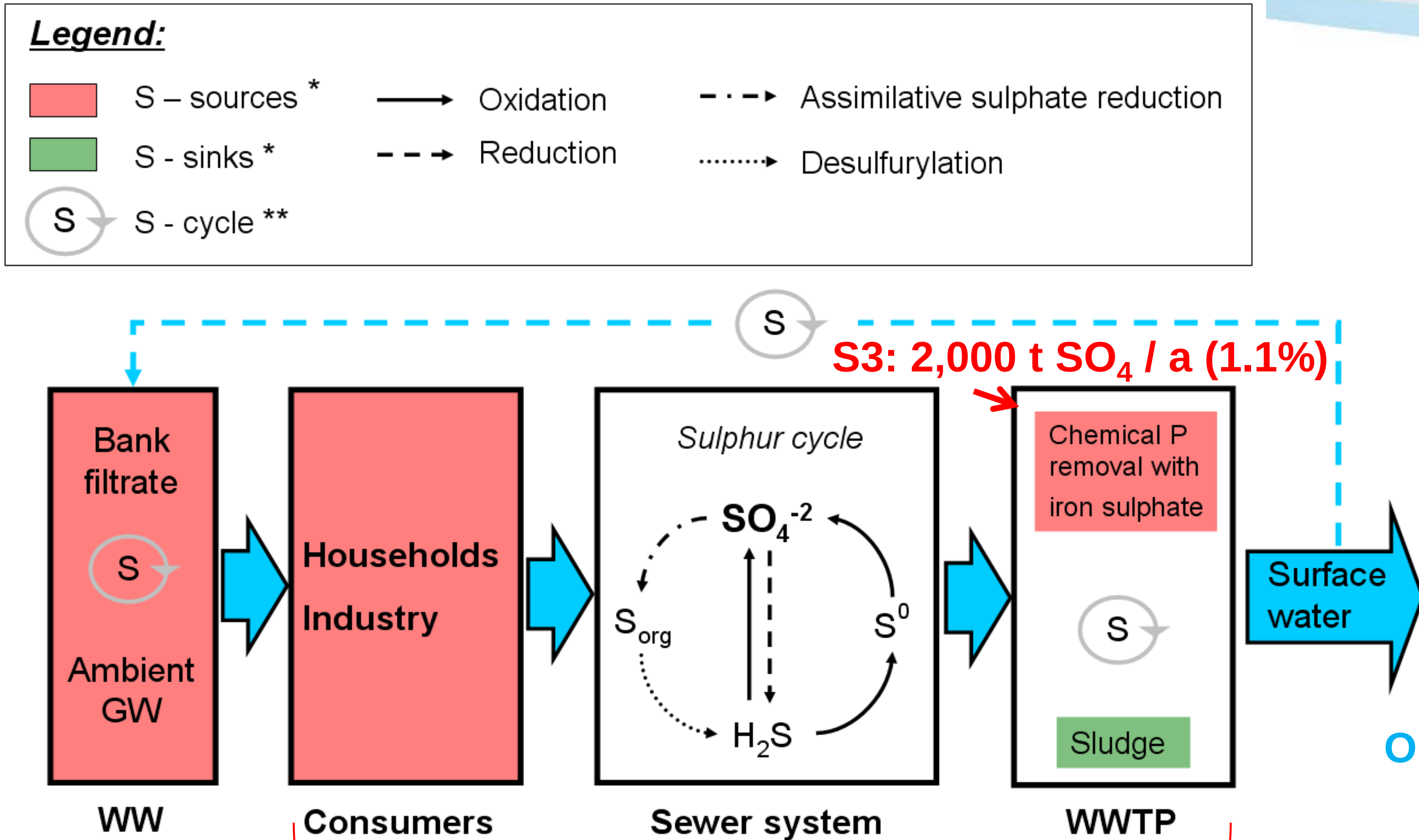
Drinking water:



The Berlin water cycle: sulphate mass balance



In = 167,000 t SO_4 / a (93.3%)

Out = 180,000 t SO_4 / a (100%)

In + S1,2,3 = 183,800 t SO_4 / a (102.7%)

S1: Ambient GW 7,000 t SO_4 / a (4%)

S2: Net consumer & WWTP inputs (WWTP outflow – drinking water load): **7,500 t SO_4 / a (4.3%)**

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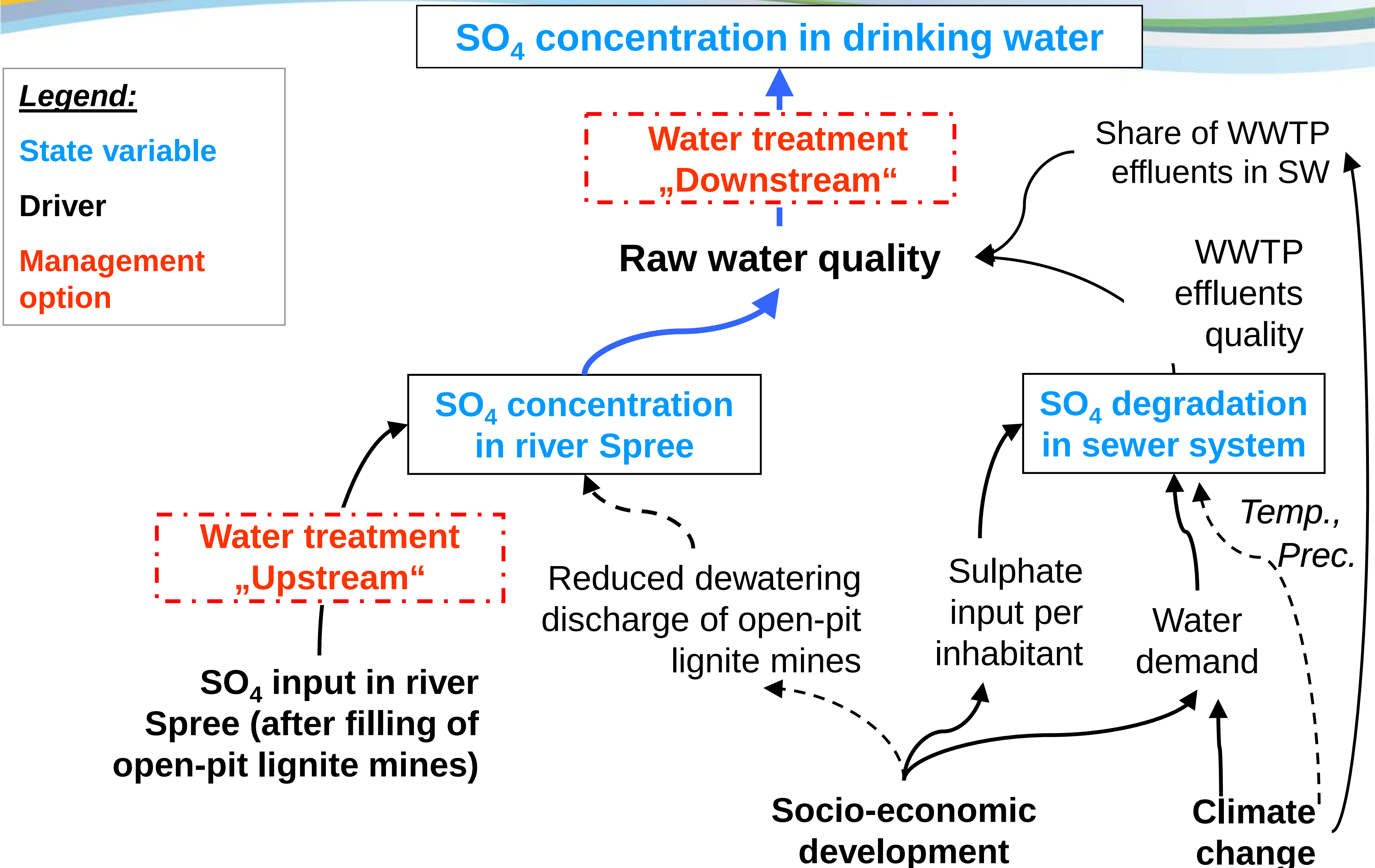
The Berlin water cycle: future challenges



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Management option: water treatment

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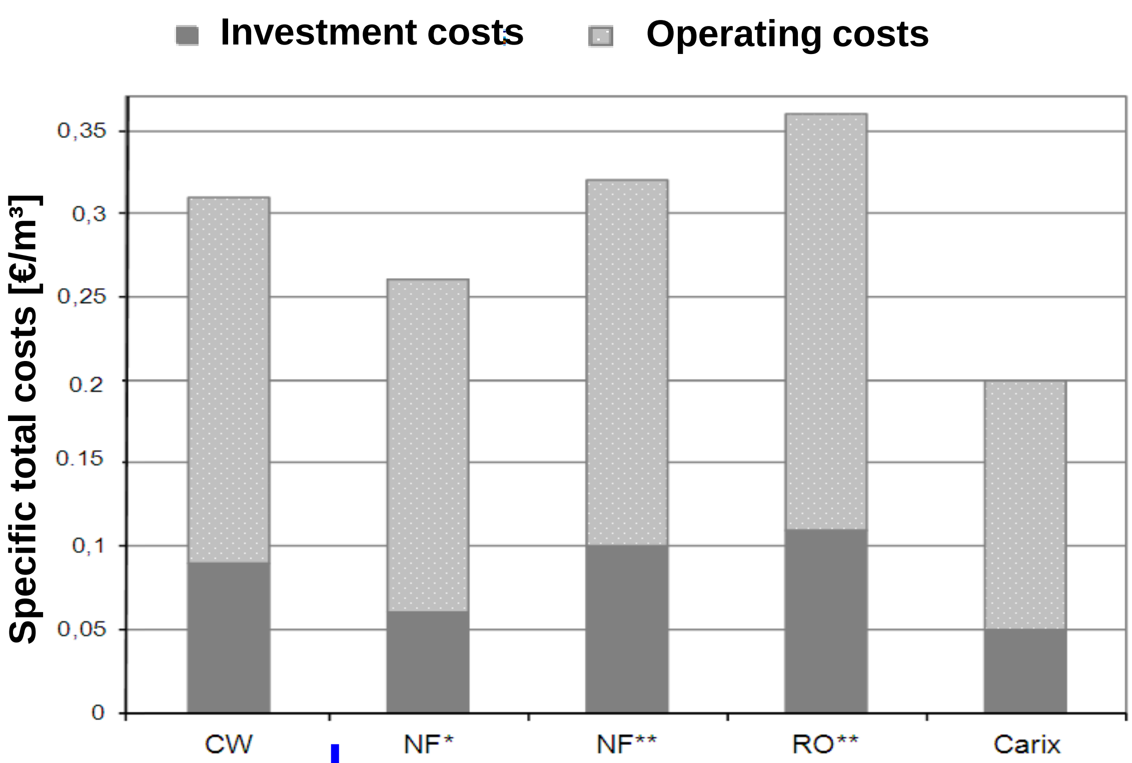
Results of literature review:

	Treatment scheme	SO_4 - reduction [%]	Pro/Cons
Upstream	**Natural wetland (Spreewald)**	35 (wet year) 55 (dry year)	- Large area demand - Low SO_4-reduction in Winter - Moderate SO_4-elimination - No cost estimate possible
	Constructed wetland	45 - 75	- Large area demand - Moderate SO_4-reduction - High costs
Downstream	**Nanofiltration**	96	+ High SO_4-reduction - High costs for concentrate disposal
	Reverse osmosis	> 99	+ High SO_4-reduction - High costs for concentrate disposal - High treatment costs (energy!)
	Ion exchange (Carix®)	81 - 88	+ High SO_4-reduction

Management option: water treatment

Results of literature review: comparative cost analysis



`Upstream`

`Downstream`

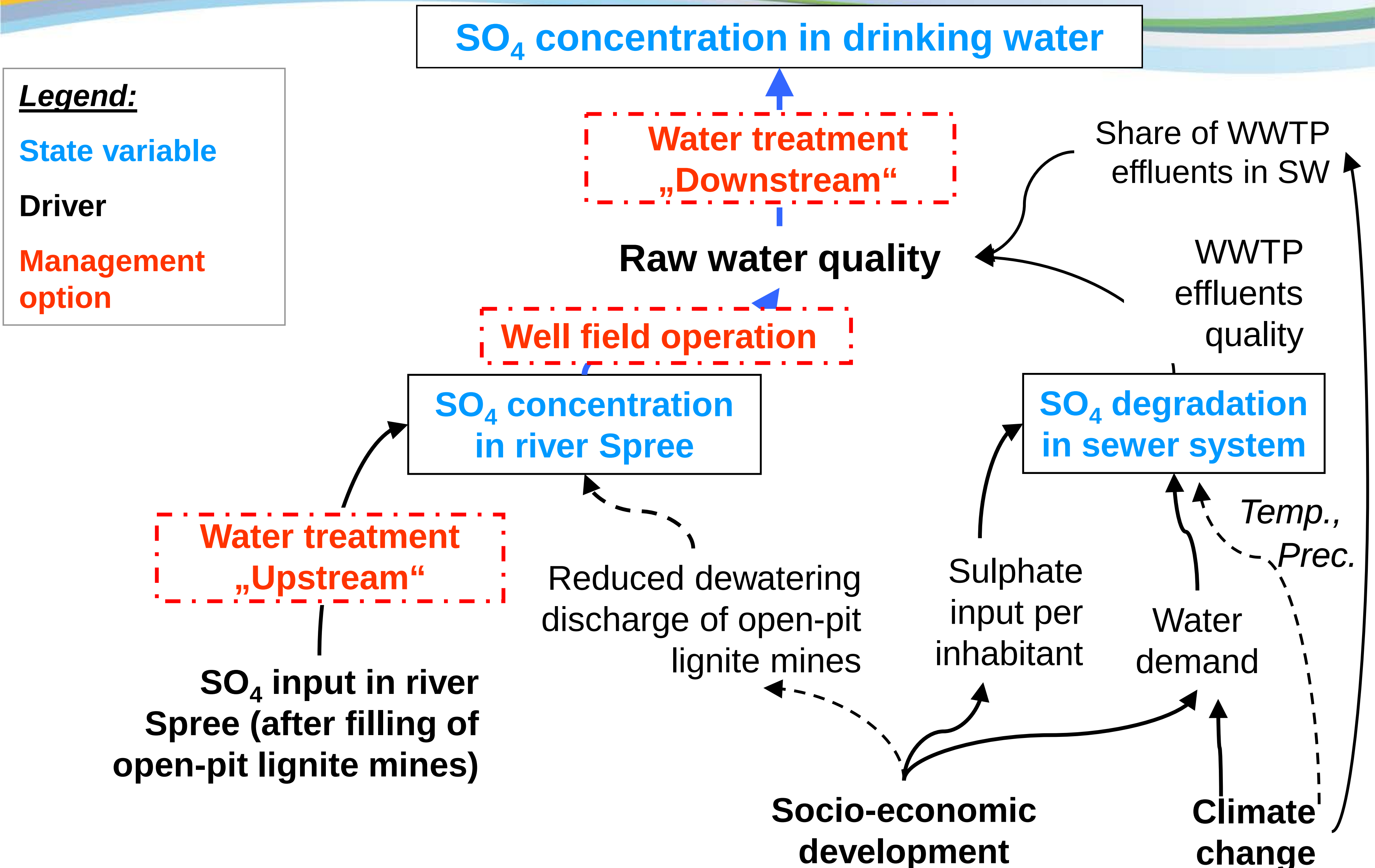
MQ_{Spree}= 14.3 m³/s

$MQ_{WW\ Friedrichshagen}$= 1.6 m³/s

Conclusion:

„Upstream“ much more expensive compared to „Downstream“, because a much higher volume has to be treated!

The Berlin water cycle: future challenges



Management option: well field operation

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Problem:

Can we optimize well field operation to improve the raw water quality in WW?

(1st approach: multivariate statistics (PCA))

2nd approach:

Develop a simple process-based model for a water quality based well field management

- Taking key parameters $\boldsymbol{SO_4}$ und $\boldsymbol{NH_4}$ as examples (prediction of raw and potable water quality)
- Depending on actual well field operation

→ ***Derive optimised well field operation schemes in order to to avoid critical potable water quality***

→ ***Define critical abstraction shares for each well field***

Management option: well field operation

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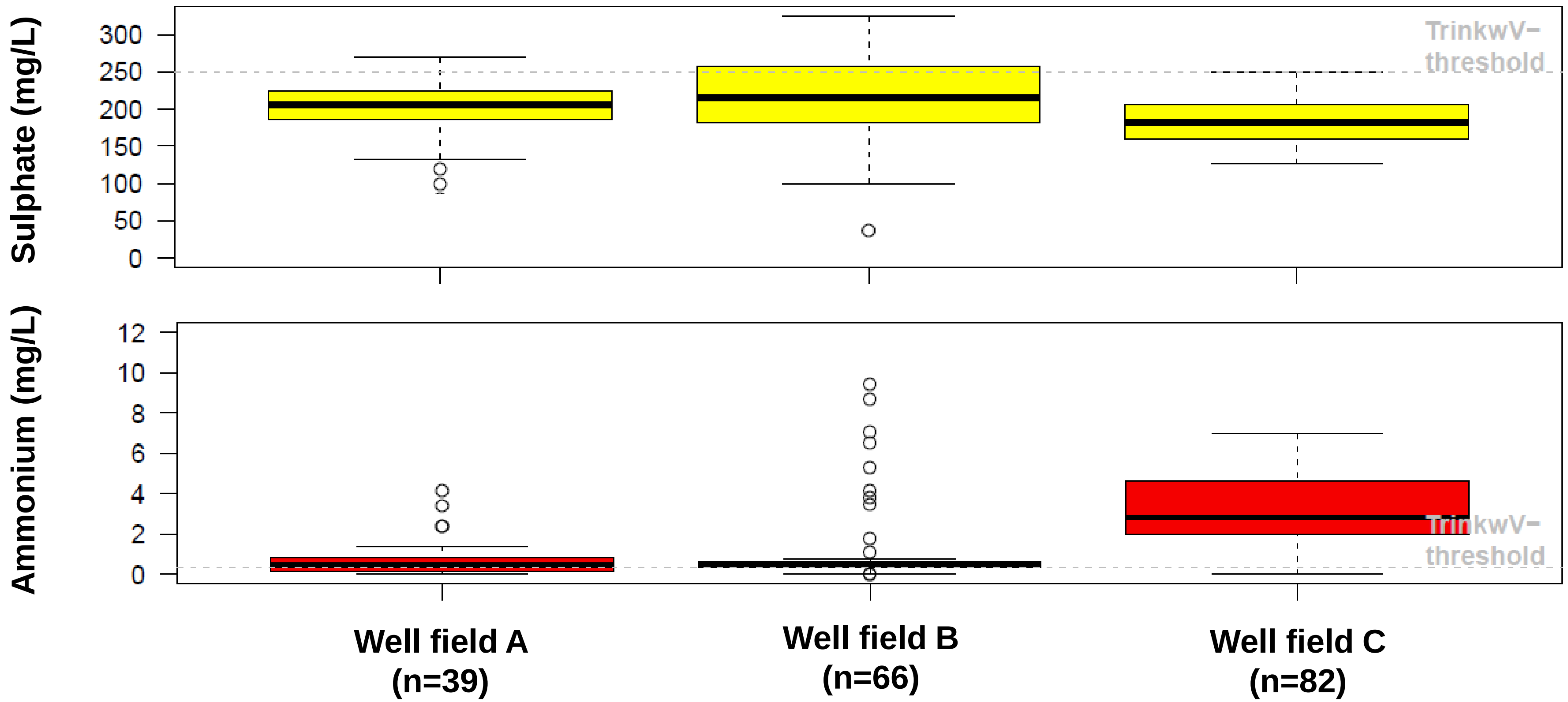
Water quality data of well fields:



Data: BWB (Time period: 1999-2010)

Management option: well field operation

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GW quality (SO_4, NH_4)

+ Temp., Fe^{2+} , Mn^{2+}

Temporal resolution:
~ annual/bi-annual

Well fields:
A, B, C

Time periods:

- 2003-2006
- 2007-2010

Statistical measures:

- 10%-percentile
- Median
- 90%-percentile

1st process
conservative mixing

2nd process
chemical oxidation

GW abstraction

Temporal resolution:

- Monthly (< 2005)
- Daily (> 2005)

Relative distribution:

- Well field A, B, C

Results: pumping regime dependent prediction of

- SO_4: raw-/potable water
- NH_4: raw water / **potable water**

Management option: well field operation

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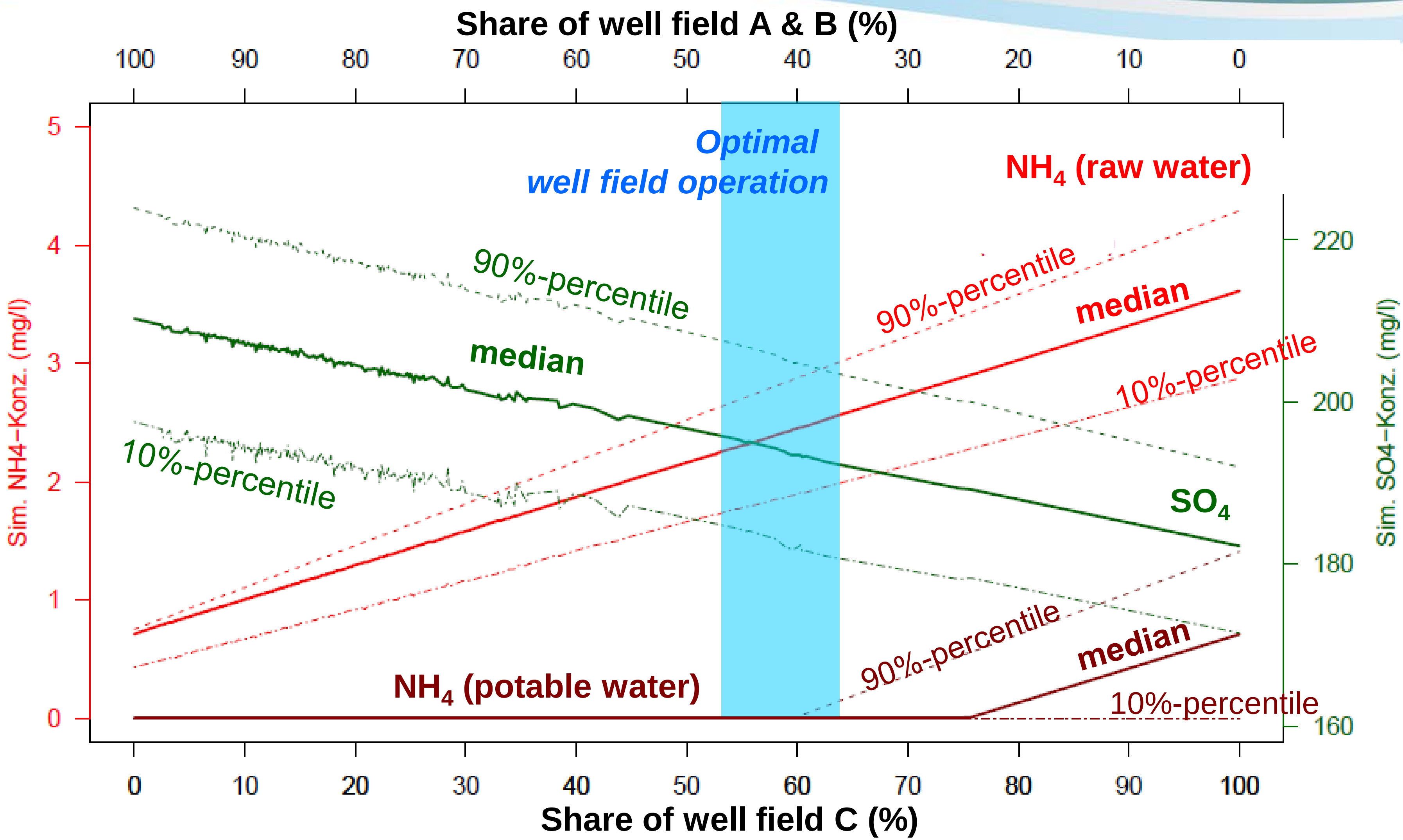

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Conclusions

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Present situation: sulphate loads in the Berlin water cycle

- Surface water inflow: 91 % / net water usage: 9 %

  ➡ **Limited potential of reducing SO_4 loads within Berlin through an optimised water usage (e.g. replacement of iron sulphate flocculation in SWTP Tegel)**

  ➡ **Development of SO_4 concentrations in surface water inflows (Spree, Dahme) key driver for future raw water quality in production wells!**

Management options:

- ***Water treatment***
  - \`downstream\` (e.g. NF) SO_4-elimination is more economic than \`upstream\` (i.e. constructed wetland) treatment
- ***Water quality based well field management***
  - Smart well field management: - 20 % of SO_4 concentration for studied WW possible
  - But: reduction needs to be weighed against the risk of increased concentrations of other potentially harmful water substances

Outlook

Planned further studies:

- Laboratory experiments for evaluating the performance of the ion-exchange treatment scheme (e.g. in comparison to nanofiltration)
- Nanofiltration pilot plant for SO_4-reduction / elimination of trace substances
- Validation of sulphate balance by quality sampling
  - Sewerage system: Quantification of SO_4-reduction
    - Long-term monitoring (≥ 1 year) of all S species at:
      - Representative sewer inputs (quantification of S-input)
      - WTTP influent (quantification of S-turnover in the sewer system)
  - WWTP: quantification of sludge as S-sink

Thank you very much for your attention!

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