Variation of loading of WWTP - seasonal influences

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The coast line of Germany

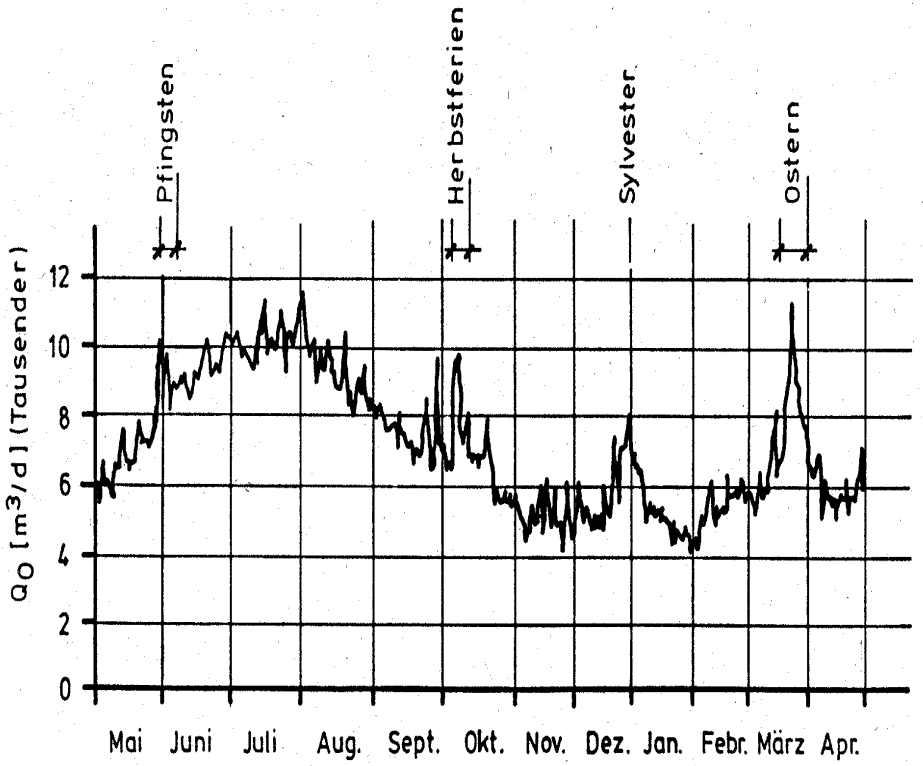
Wastewater disposal in regions of tourism

Special qualities

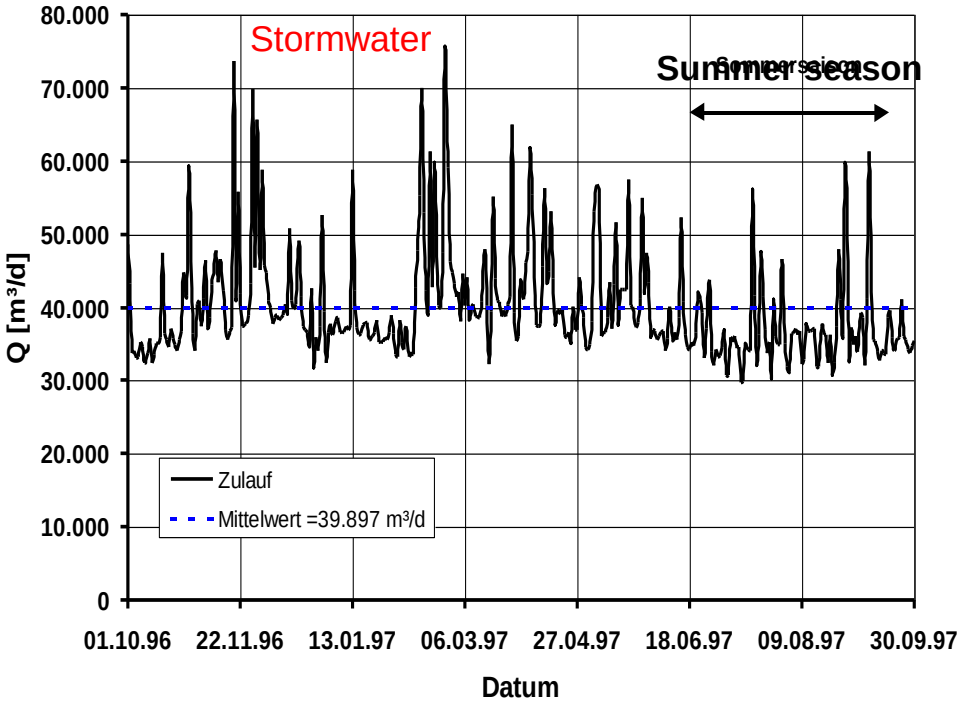
- Hydraulic and pollution caused load fluctuations
  - ➡ Seasonal changes
  - ➡ Sudden peaks within a few days (very problematic)
- Strict effluent demands (discharge into bathing water)
- Increased amount of chemical toilets and fatty substances
- Often low alcalinity
  - ➔ Especially when using water supply out of dunes
- Design and operation of the sewage network and WTP
  - ➔ Problems with sediments, odour and corrosion in the sewers
  - ➔ Choice of wastewater treatment process
  - ➔ Case study of loading and dimensioning (e.g. dynamical simulation)

Comparison of daily fluctuations

Small costal town (KW Westerland)

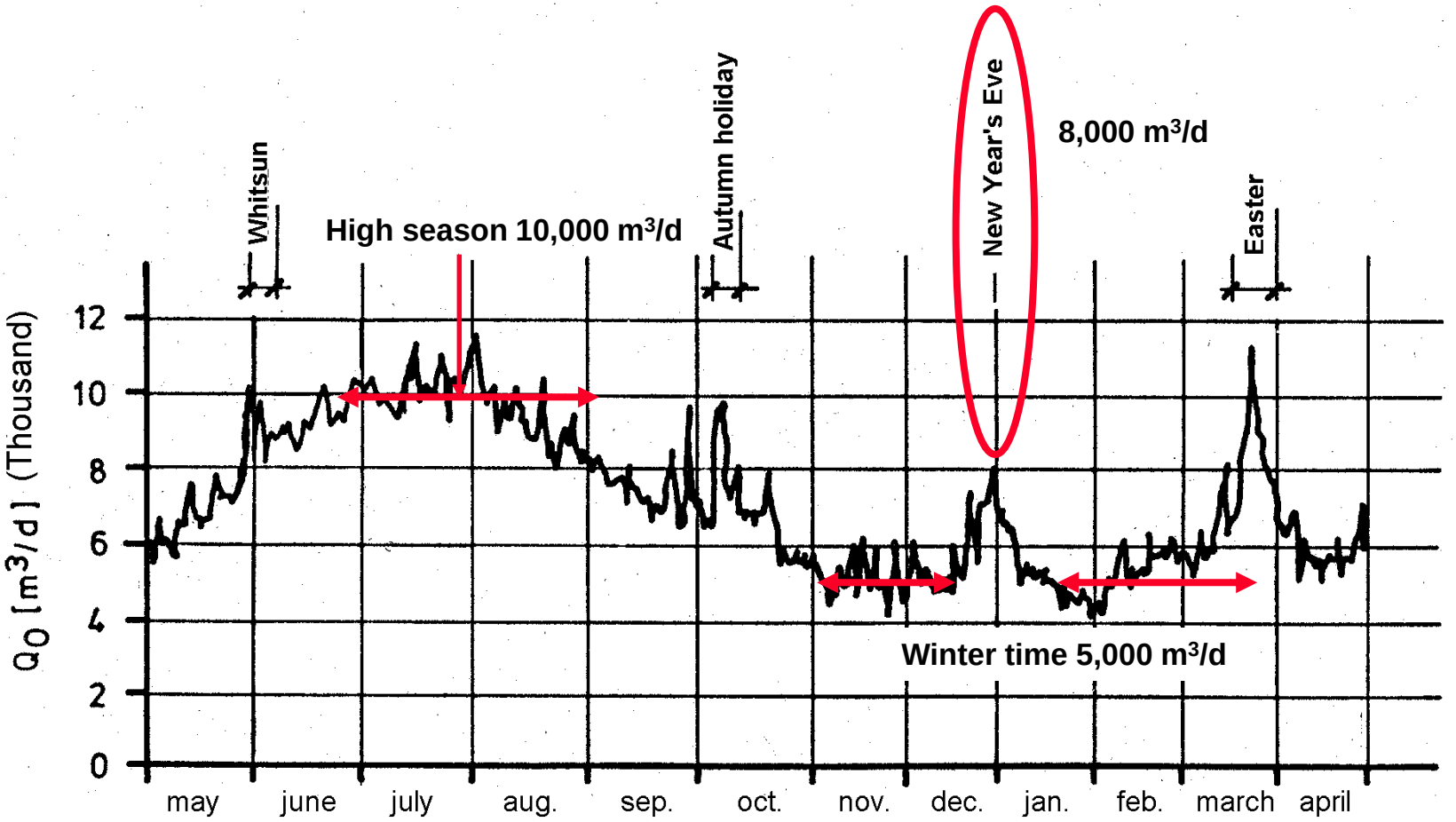


Large costal town (KW Rostock)



Typical variation of the daily inflow

Seaside resort (Westerland/Sylt)



Changes of the wastewater content

- Increase of the concentrations during season
  - Organic Matters (BOD_5 u. COD) — from 10% to 40%
  - Nitrogen (KN or NH_4-N) — from 20% to 100%
  - Phosphorus — up to 50%
  - Suspended solids (SS) — from 15% to 50%
  - Increase of fatty substances

- Sudden peaks (example New Years Eve):
  - ➔ Doubling of the wastewater amount
  - ➔ 2.5-times of the organic load
  - ➔ 3-times of the load of nitrogen

Wastewater discharge systems

Special requirements

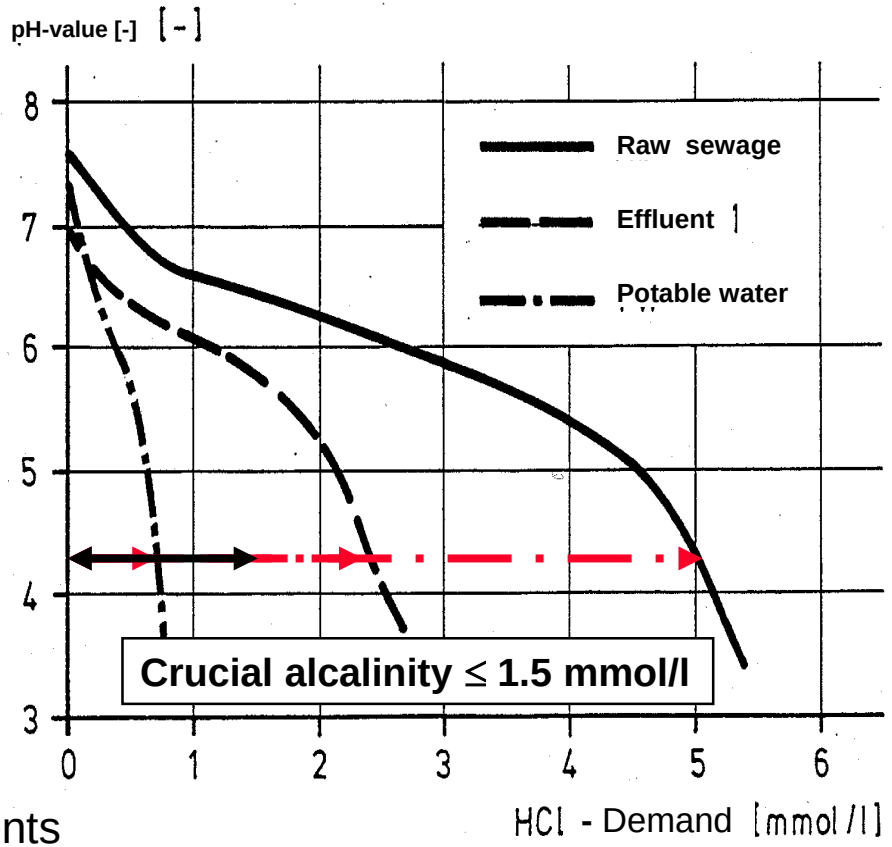
- Gravity sewer system
  - ➔ Dimensioning with $Q_{h,max.}$
  - ➔ Increase of deposits (higher frequency of rinsing necessary)
  - ➔ Higher amount of infiltration water
- Pressure pipe systems
  - ➡ Dimensioning with maximum flow (m^3/h) in the season
  - ➡ Pumps (Twin Pump station, frequency regulated pumps, etc.)
  - ➡ Parallel pipes with different nominal size
- Odour and corrosion problems
  - ➡ Flushing with pressured air
  - ➡ Biofilter for odour treatment
  - ➡ Dosage of agents with chemical or biological effect (e.g. $FeCl_3$, NO_3)

Joint treatment
- content of chemical toilets

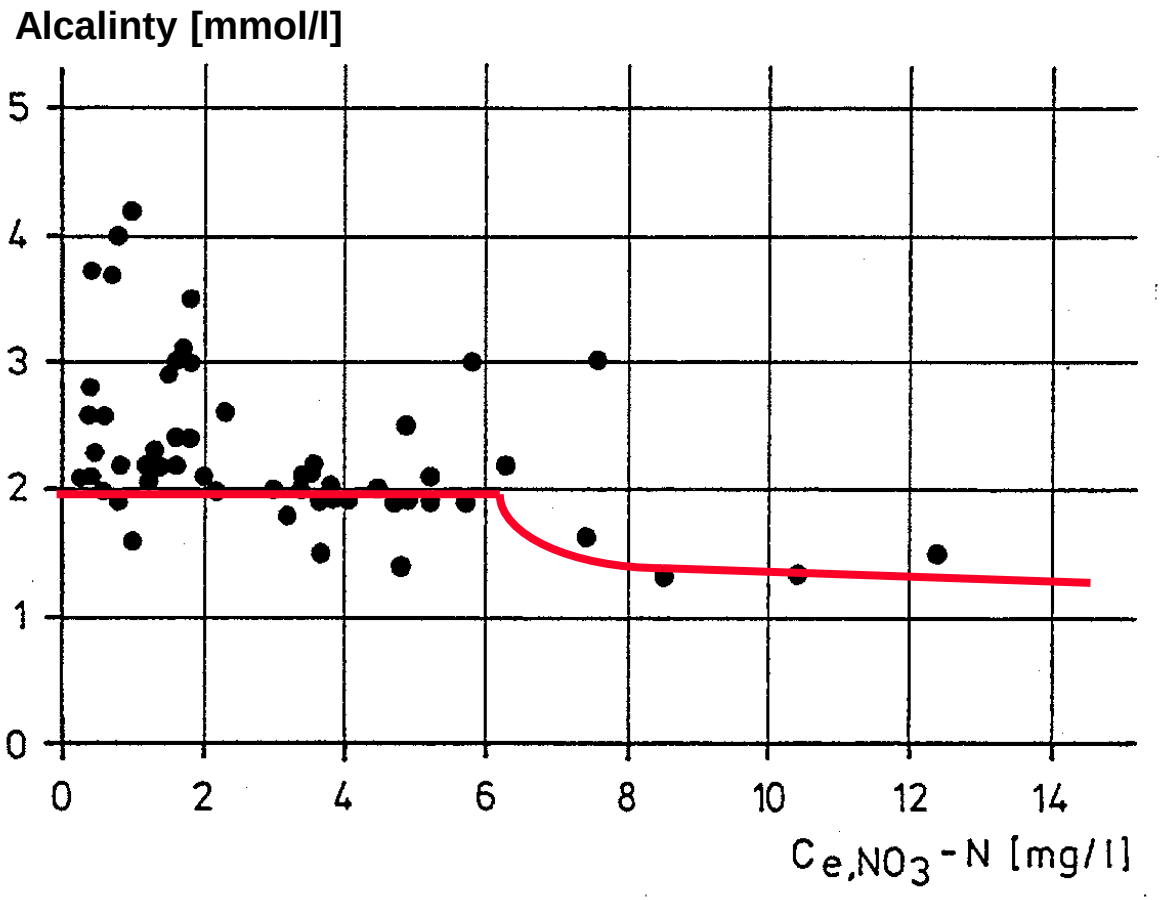
- Origin
  - Delivery directly to WTP
    e.g. via camper vans, tanker or buses, cruiser ships)
  - Discharge into the public sewer system (problem of control)
- Loads
  - Toxic substances
  - About 40-times higher COD
  - About 1,000-times higher nitrogen concentrations
- Important conditions for joint treatment
  - Determination of actual capacity of treatment plant
  - Least capacity of the WTP is 10,000 PE
  - Equalised dosage; regarding a 20-times dilution ratio

Alkalinity

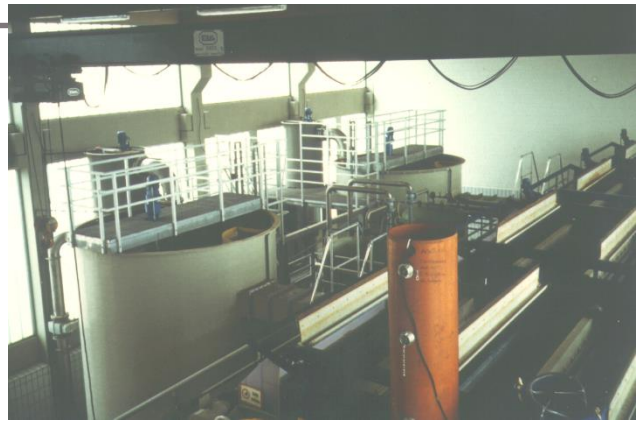
- Determined by
  Alkaline hardness of potable water
  +Hydrolysis of KN
- Negative influence on nitrification
- ✶ Destruction of the floc structure leads to sludge discharge
  - ➢ Decrease of the sludge age and loss of nitrification
- ✸ Decrease of the pH-value
  - ➢ Inhibition of the nitrifyers
- Solutions:
  - ➔ Dosage of alkaline precipitation agents
  - ➔ Denitrification to highest degree



Denitrification to highest degree



Methods of wastewater treatment



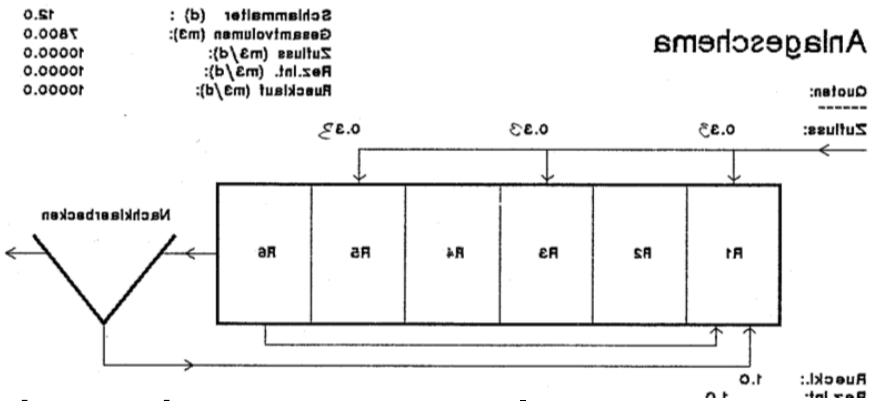
- Several lines
- Chemical-treatment
  - ➔ Dosage of chemicals during season
    - – Precipitation and flocculation agents
    - – External carbon-sources
  - ➔ Separate line during season (no nitrogen removal)
- Activated sludge system
  - ➡ ”Raising” of the content of dry solids (MLSS) up to the technically possible limit
  - ➡ Hybrid system suspended biomass plus moving bed
  - ➡ **Regulated raw sewage storage tank**
  - ➡ External storage tanks for nitrifyers
  - ➡ Hybrid method („two-stage“ in time of peak load, one-stage during normal operation)
- Combination of activated sludge and biofilter

Dimensioning the activated sludge system

- **Case studies of loading is necessary!**
  - **Maximum BOD_5 load**
    - **High surplus sludge production, unfavourable for nitrification**
  - **Worst BOD_5/N ratio**
    - **Unfavourable for denitrification**
  - **Average load during the season**
  - **Considering of peak loads**
    - **Low temperature and crucial holidays**
- **Tools for design and calculation**
  - **Stationary Methods**
    problem: short term fluctuations can not be recorded
  - **Dynamic simulation, e.g. according to ASM1 or ASM 2 of IWA**
  - **Semi-technical investigations**

Dimensioning using dynamic simulation calculation

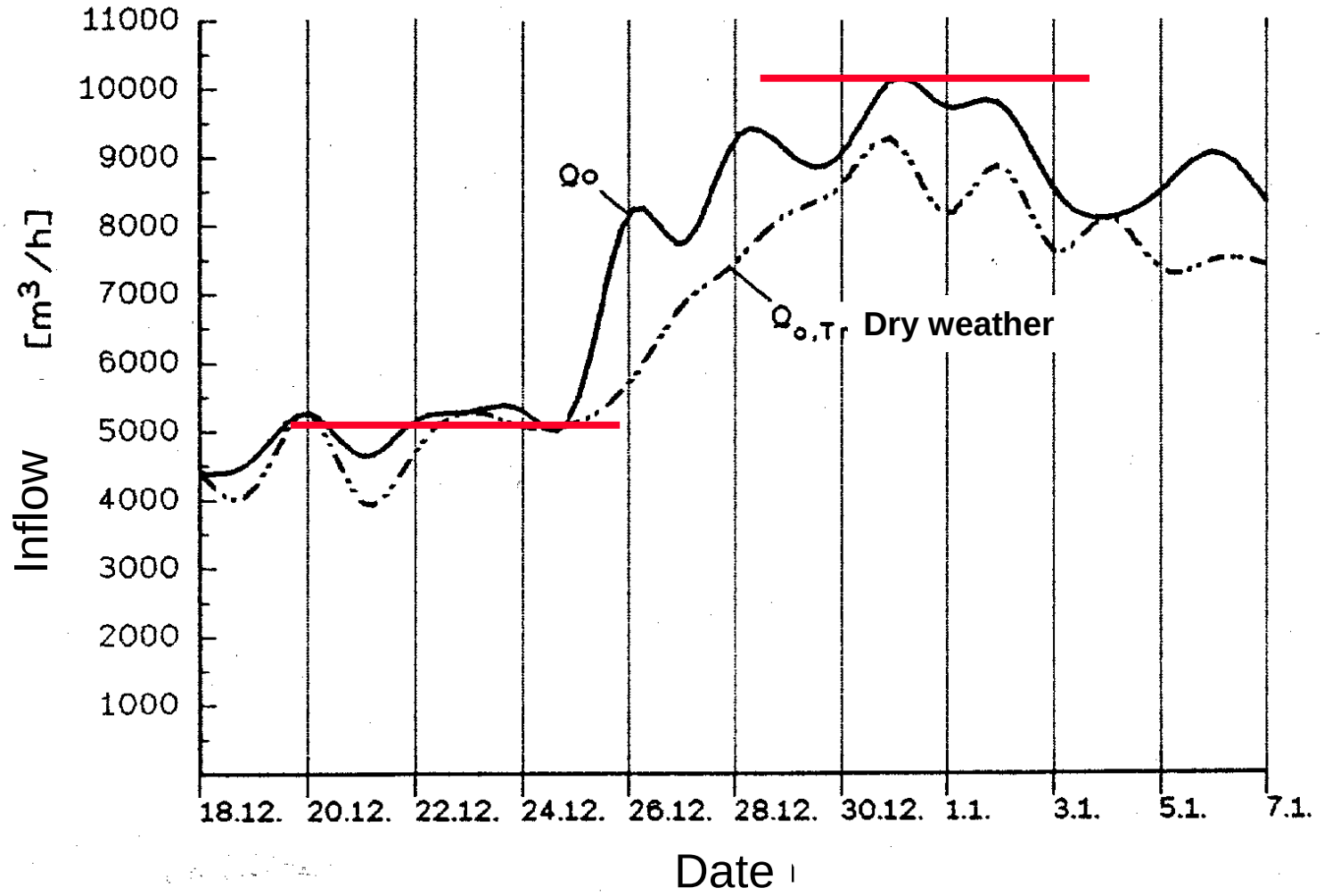
- Measuring series to record
  - Peak loads
  - wastewater parameter (e.g.: 2-h-samples COD; KN, NH_4, NO_3, tot.P.)
- Determination of biological parameters from the pilot plant (μ, yield, inhibition effects etc.)
- Building up a model of the existing plant



- Verification of the model
- Modelling various new designed treatment plant concepts
- Proof of the efficiency for different case studies

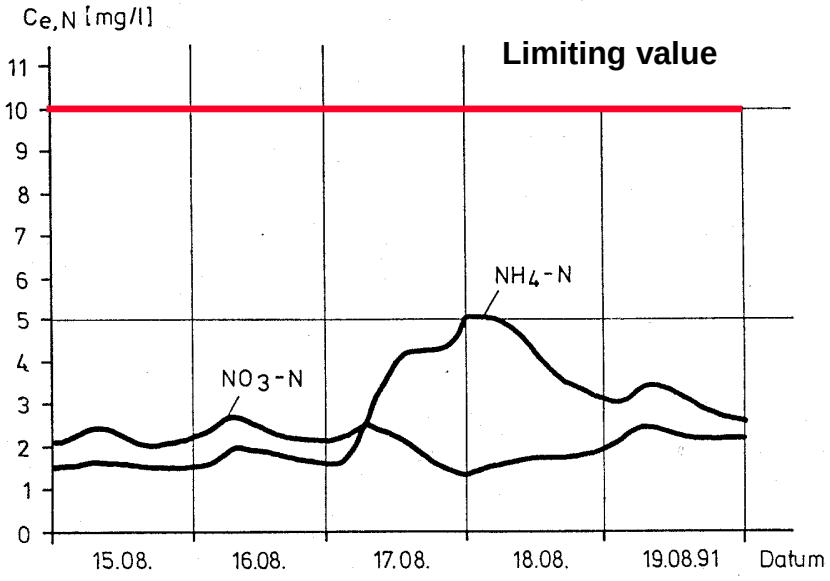
Sudden Peak at Christmas/New Years Eve

Example WTP Westerland/Sylt

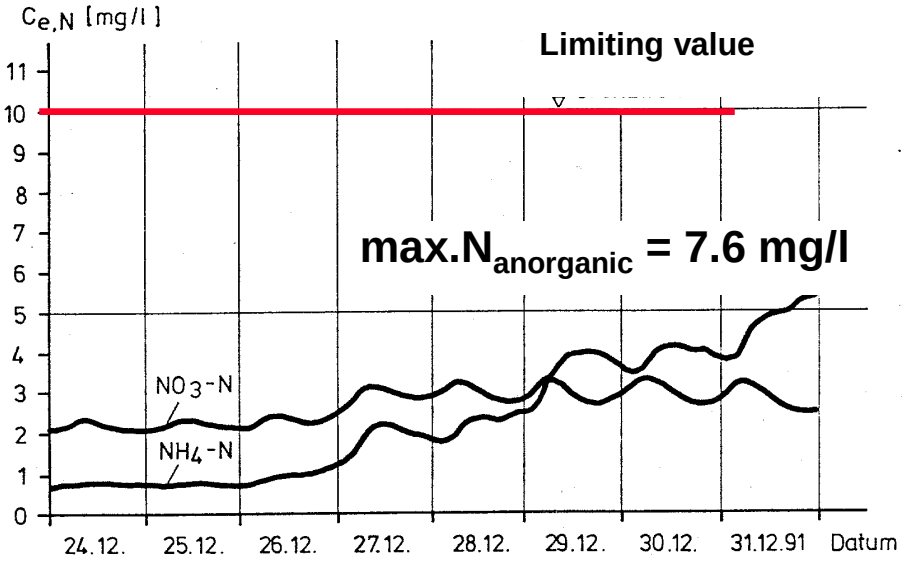


Results of dynamic simulation
Example WWTP Westerland

Load case:
“Thunder strom” Summer
max.$N_{anorganic}$ = 6 mg/l

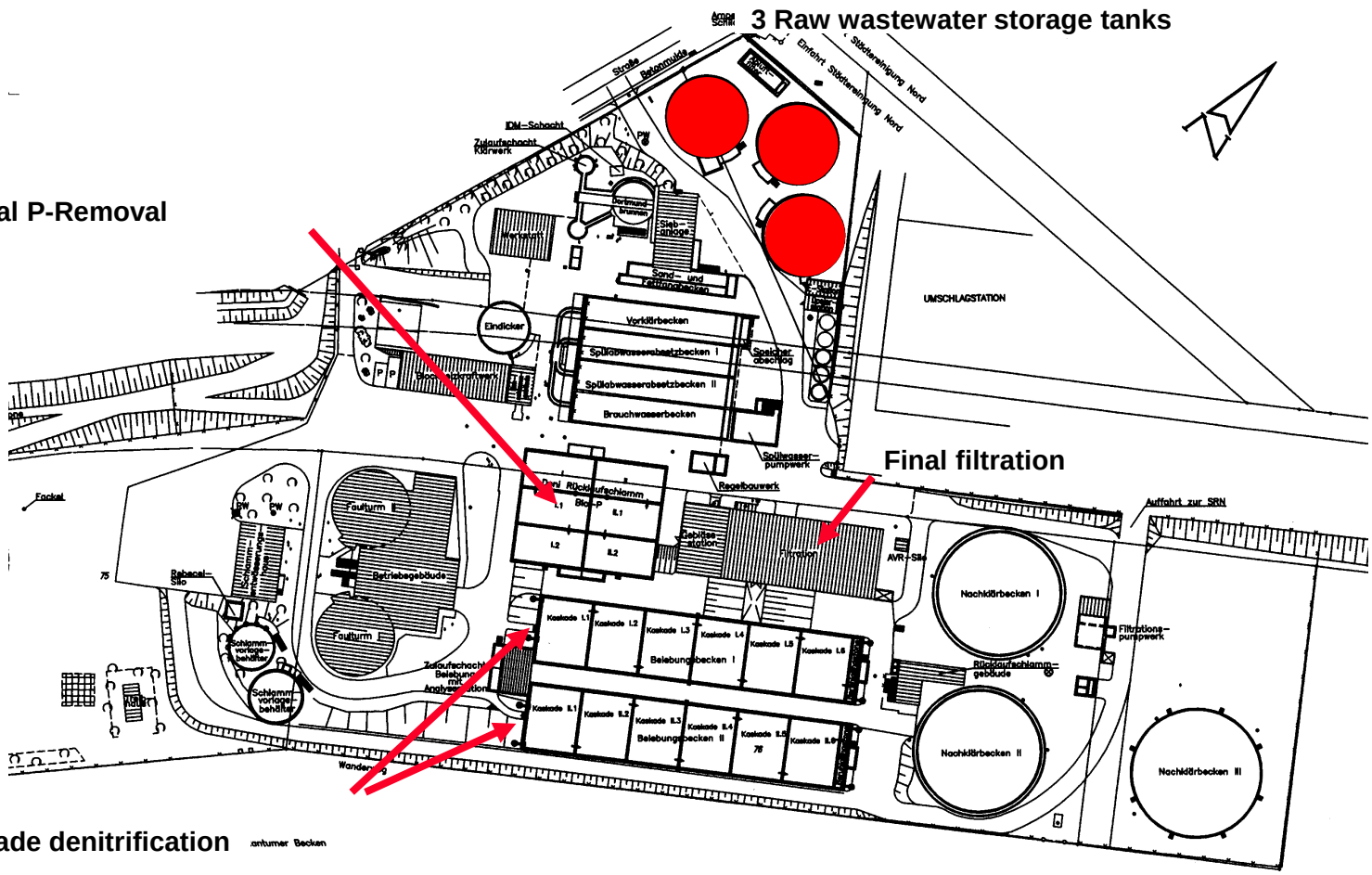


Load case
Christams/New years eve
max.$N_{anorganic}$ = 7,6 mg/l

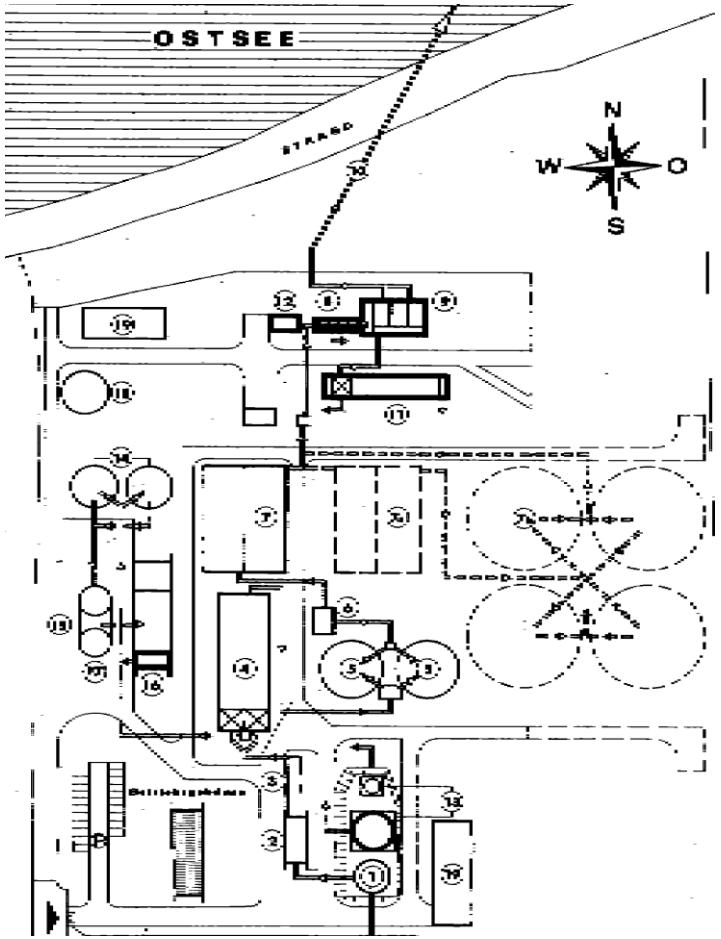


Limiting value $N_{anorg.}$ 10 mg/l

Final design of the WTP Westerland/Sylt



Example KA Lütjenbrode
Expansion for final Denitrification



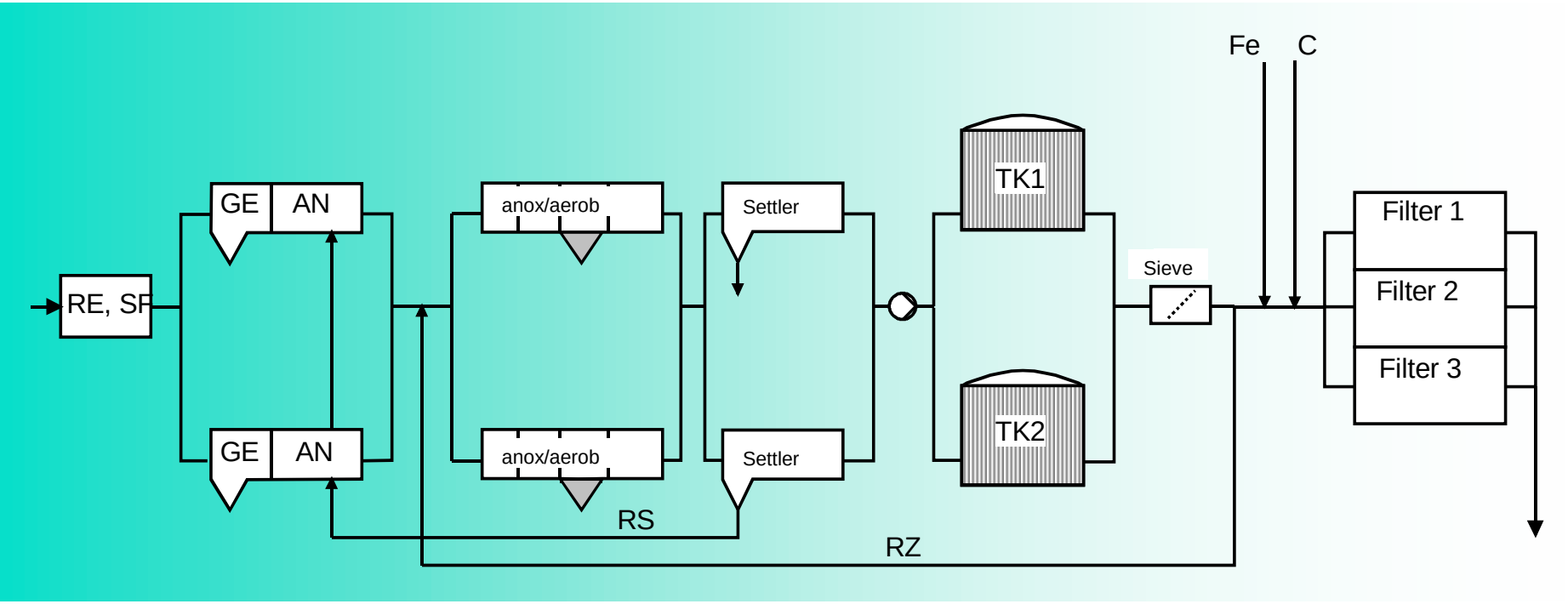
- Capacity 50.000/85.000 PE
- Inlet
  - Screen/gritchamber
- Large primary settler
  - V 1.320 m³
- 2 Tricking filter
  - 4.660 m³ BioNet
- Activated stage
  - V_{BB} 1.060 m³
- Sandfilter
  - A 120 m²; H 2 m

Combination activated sludge/fixed bed reactor

Example WTP Heiligenhafen/Baltic sea

Load: Winter: 50,000 PE
Summer: 85,000 PE

Plant design:



DynaSand-Deni

Example: Final denitrification in summer

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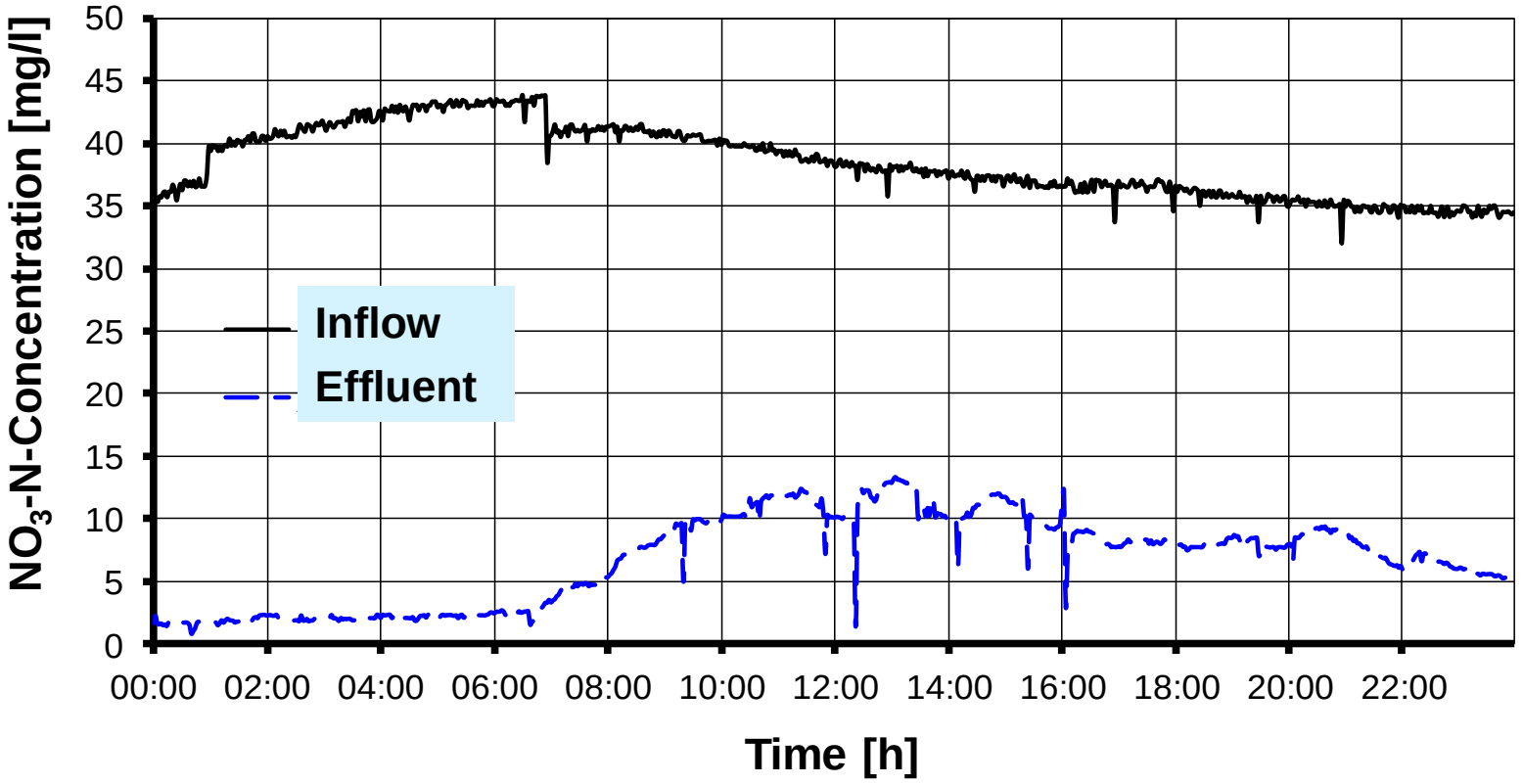
Dosage of carbon source

DynaSand-Deni

Operation results: summer time

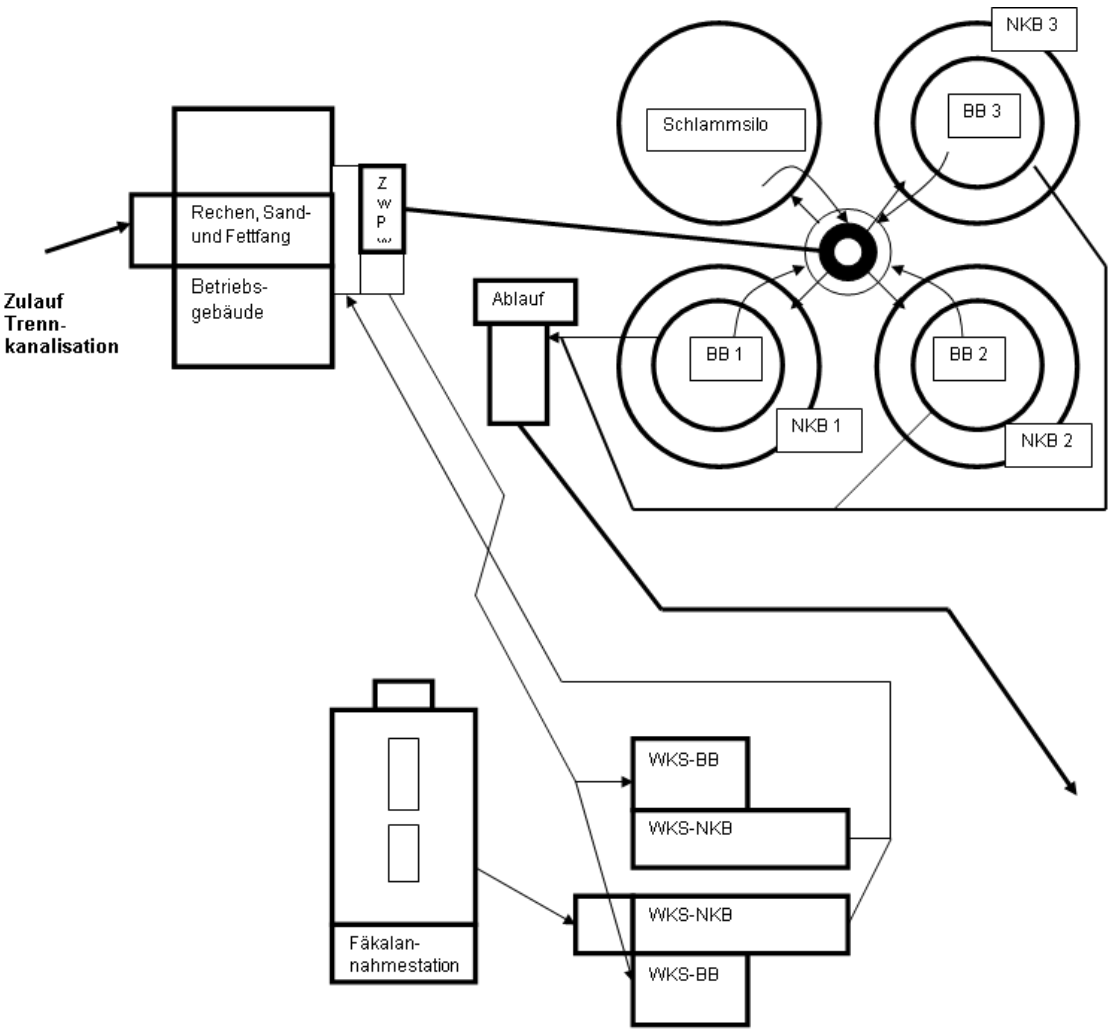


Example WTTP Zingst

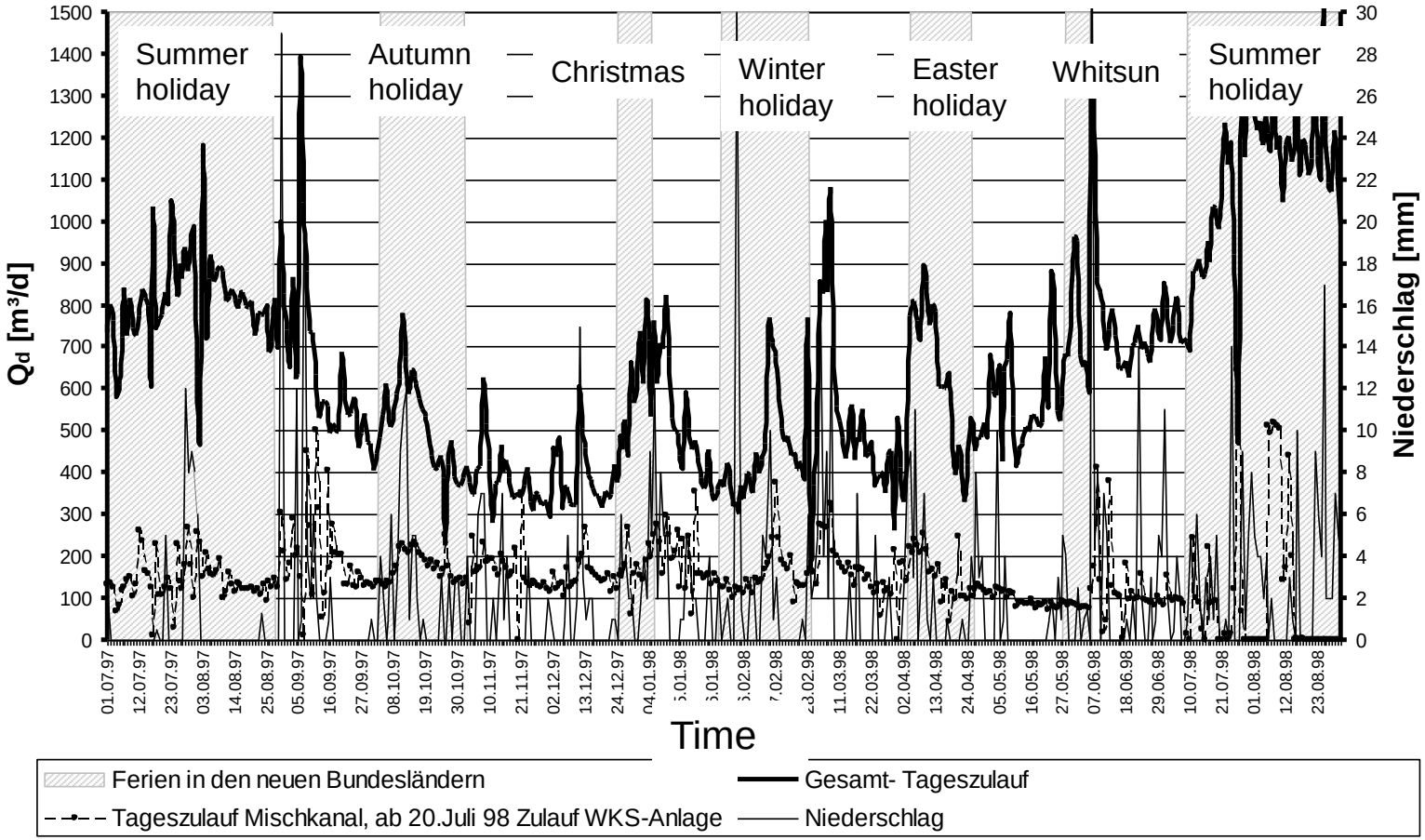
- Average Load ca. 9.200 PE; peak load: upto 14.000 PE
- Basic treatment performance
  - very good COD, BOD_5 efficiency (> 90%)
  - N-elimination liegt mit über 70%
  - Drift of suspended solids in the season
  - High loads appear in a short period (ca. 2 month)
- Challenges
  - Unclear capacity of the WTTP
    - –No expansion of settlement allowed by water authority
    - –No future development of tourism
    - –Summer house park connection was forbidden
  - No sufficient oxygen supply in the season
  - Bulking sludge ; drift of sludge

WTTP Zingst

Year of 1999

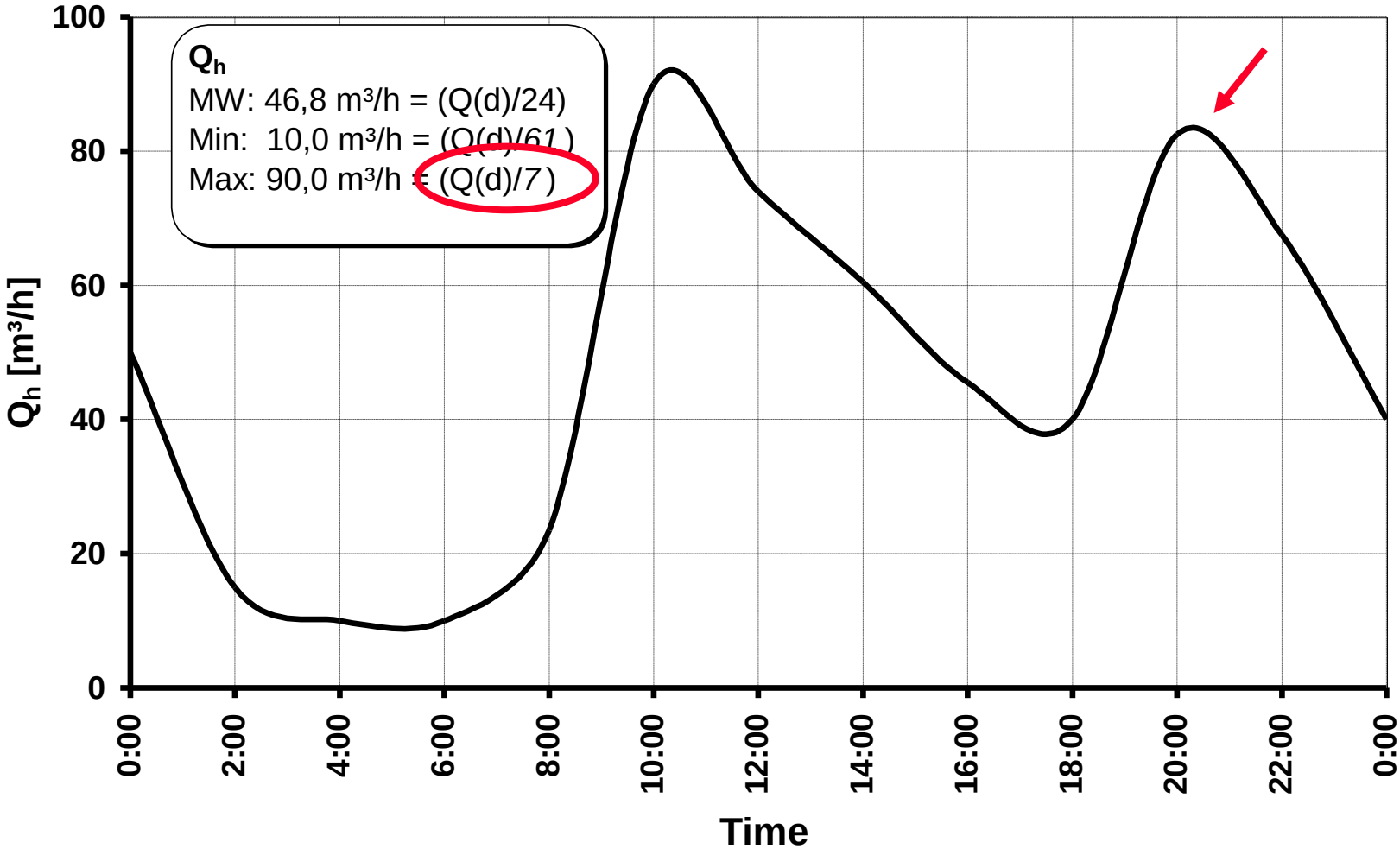


Daily wastewater flow over the year

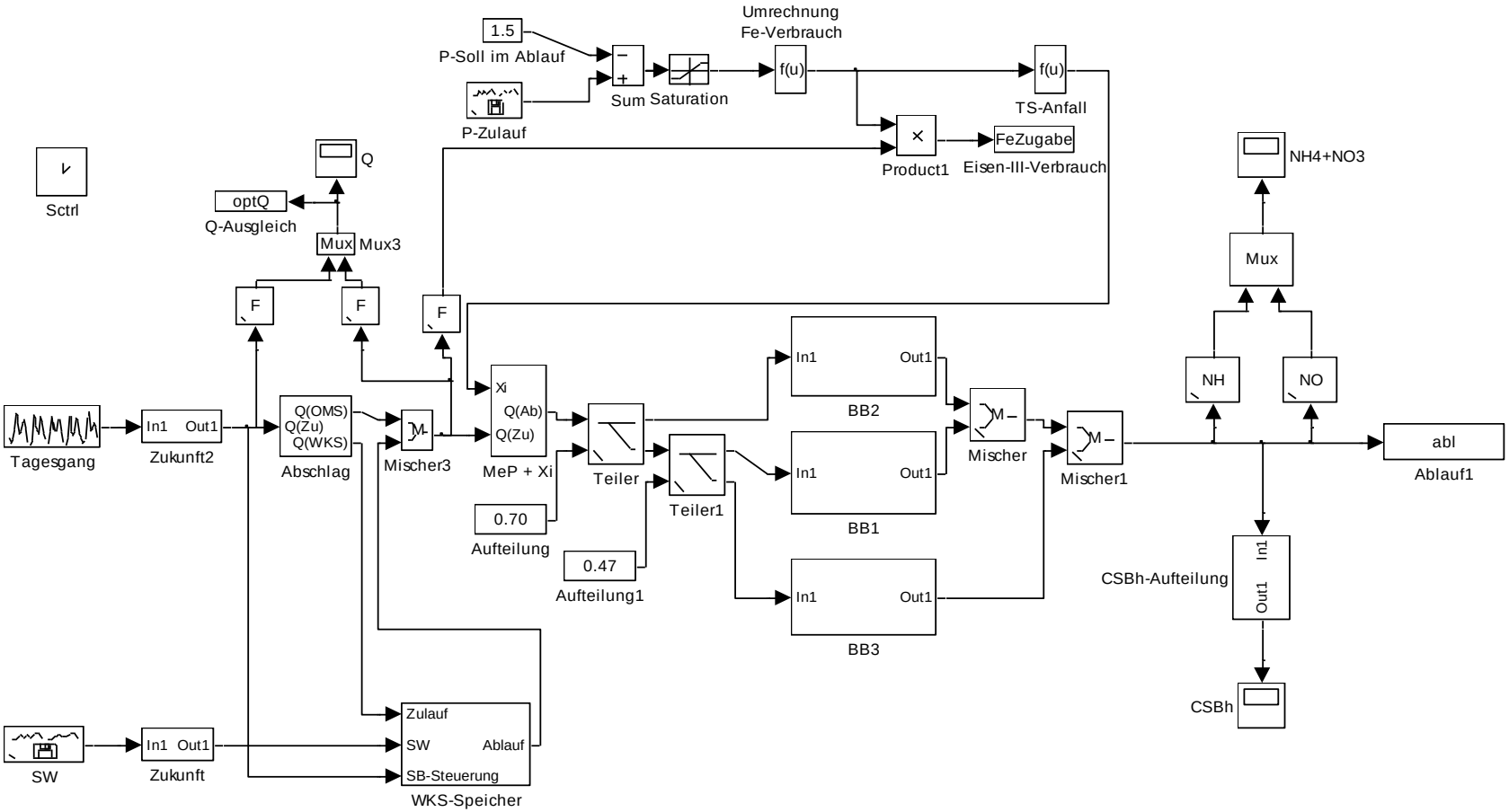


Curve of daily flow (high season)

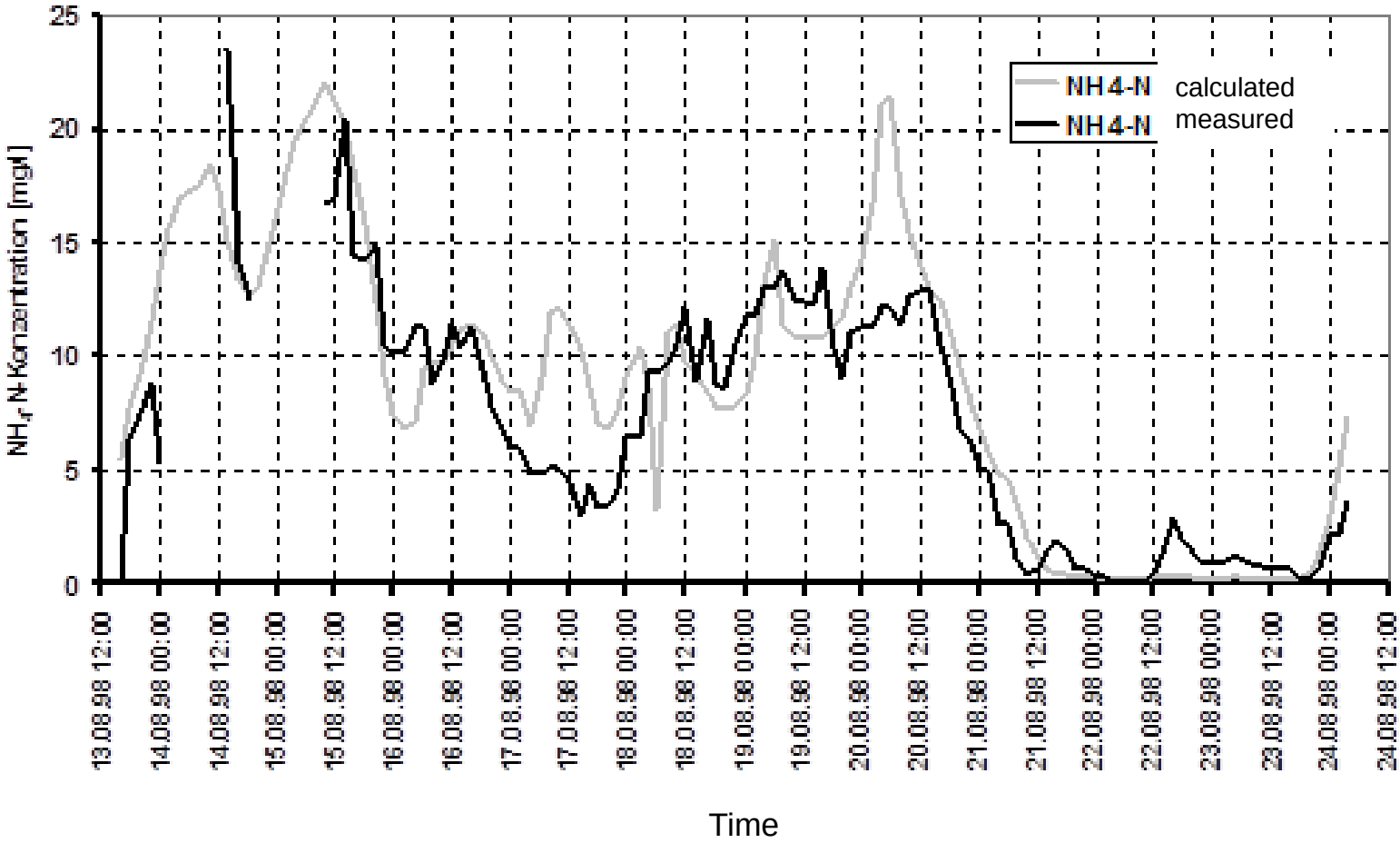
Example WTP Zingst/Darss



Modell of the activated sludge system



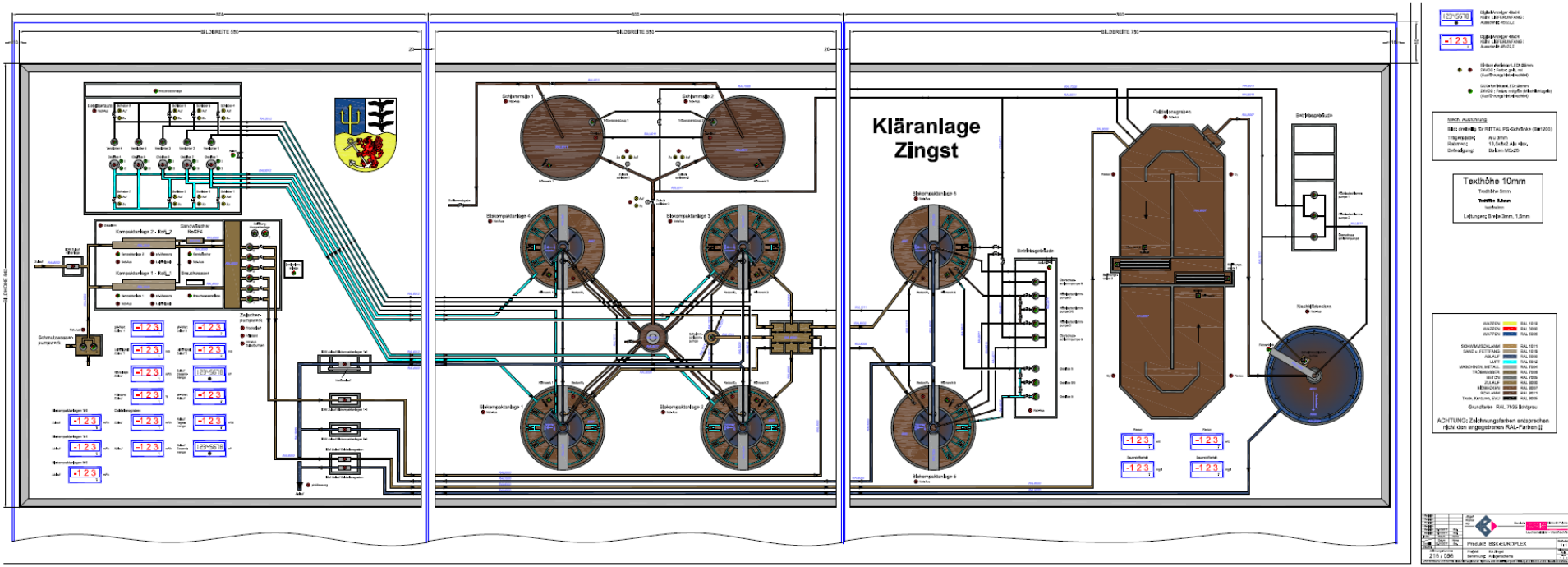
Evaluation of the NH_4-N effluent curve



Results and recommendations

- The rotation disc plant should be only used as a buffer
  - ➡ Enlargement of the capacity by 1.600 PE
- Existing seasonal load can be covered by improved aeration system
- Buffer and improved aeration covers a load of 11.000 PE
- Short term load increase of 1.800 E can be provided
  - ➡ No limitation of short term touristic development
- For future loads the plants has to be rehabilitated

WTTP Zingst Today



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Determination of the treatment capacity WTTP Körkwitz using dynamic simulation

Introduction

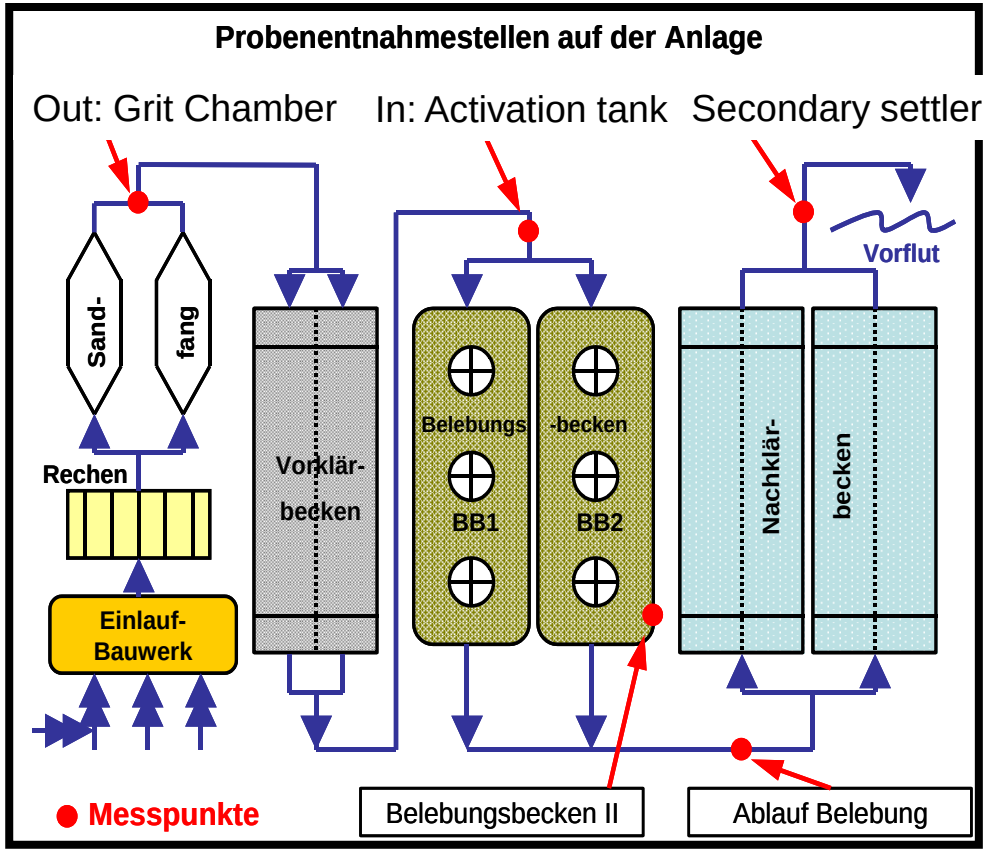
- Capacity of the WTTP Körkwitz according water law permission from 1987 was 187.000 PE
  - ➡ COD was limited to 200 mg/l; BOD_5 to 130 mg/l
  - ➡ In future COD: 90 mg/l, N: 18 mg/l, P: 2 mg/l
- Changed conditions through the collapse of the main industry (fibreboard factory (IKEA))
  - ➡ No exact classification for the size of the WTTP to the objectives of treatment was possible
  - ➡ Water authorities had forbidden to build up new residential sites of hotels without a proof of capacity
- Investigation of the actual capacity of the WTTP was necessary
- Tool: measurement campaign and dynamic simulation

Determination of the input data for the simulation Measurement programme (July)

Objective:

Determination of the inlet and outlet parameters

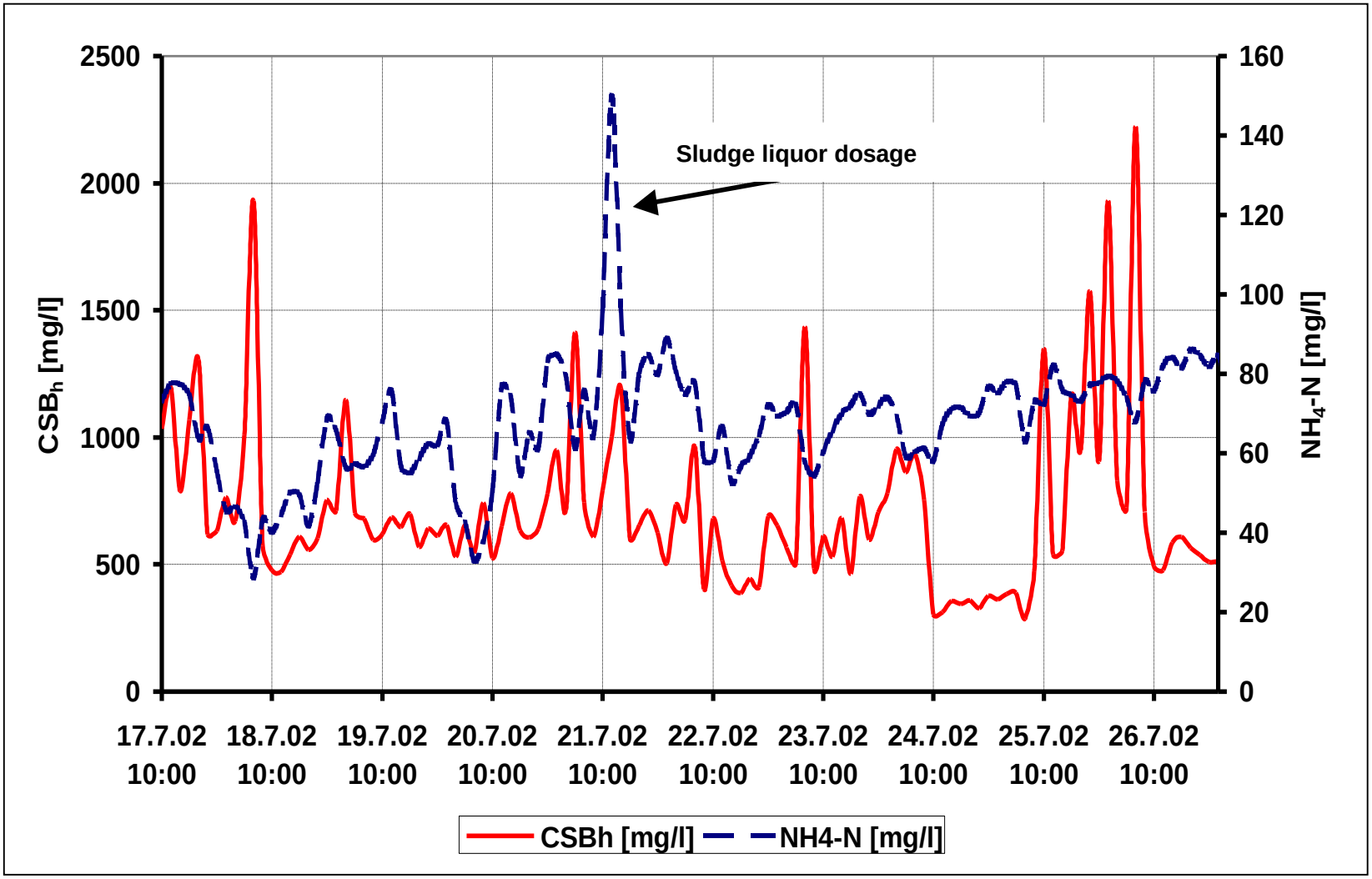
Sketch of the plant



Location of samples during the measure campaign

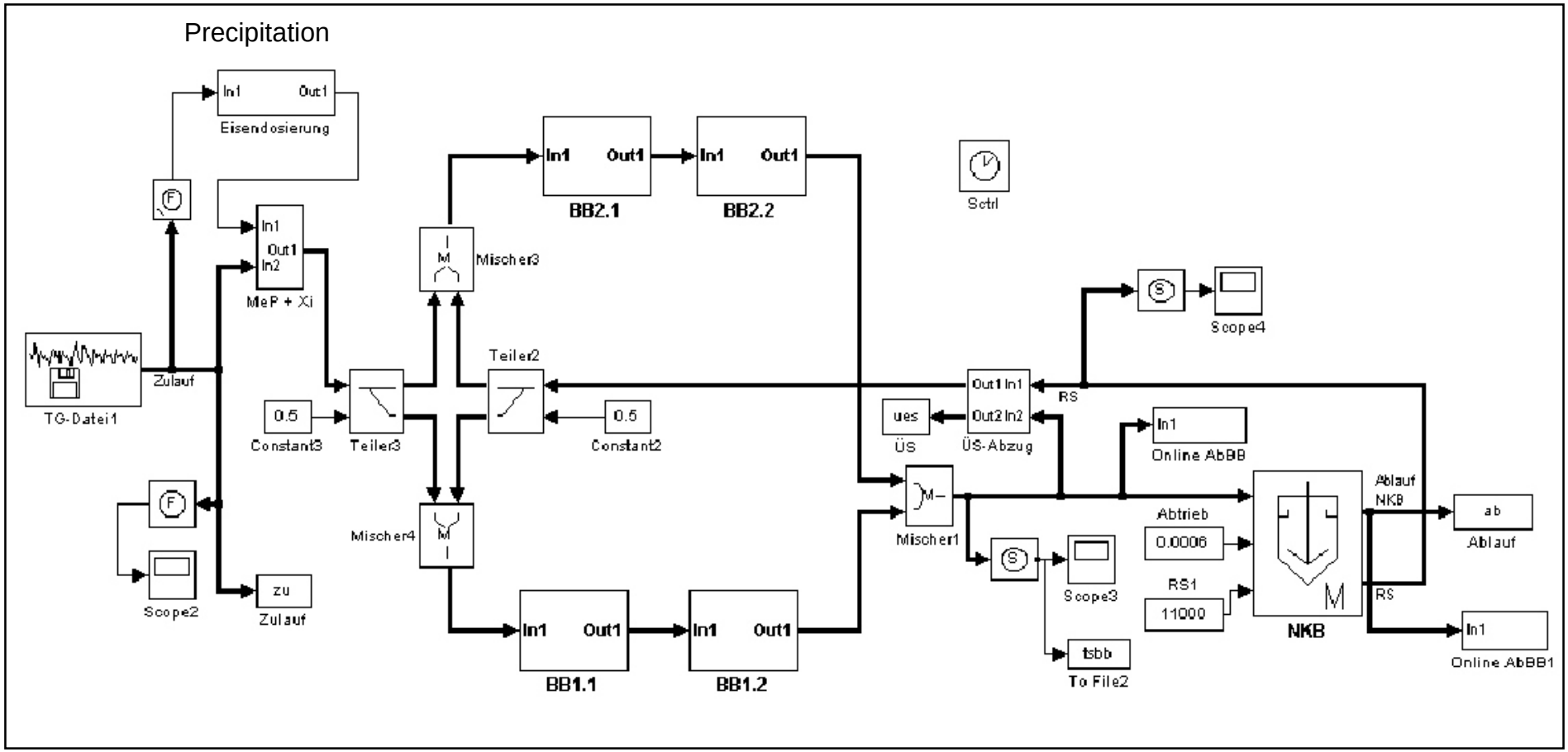
Determination of the input data for the model

Concentration graph (2-h) in the inlet of the activated tank



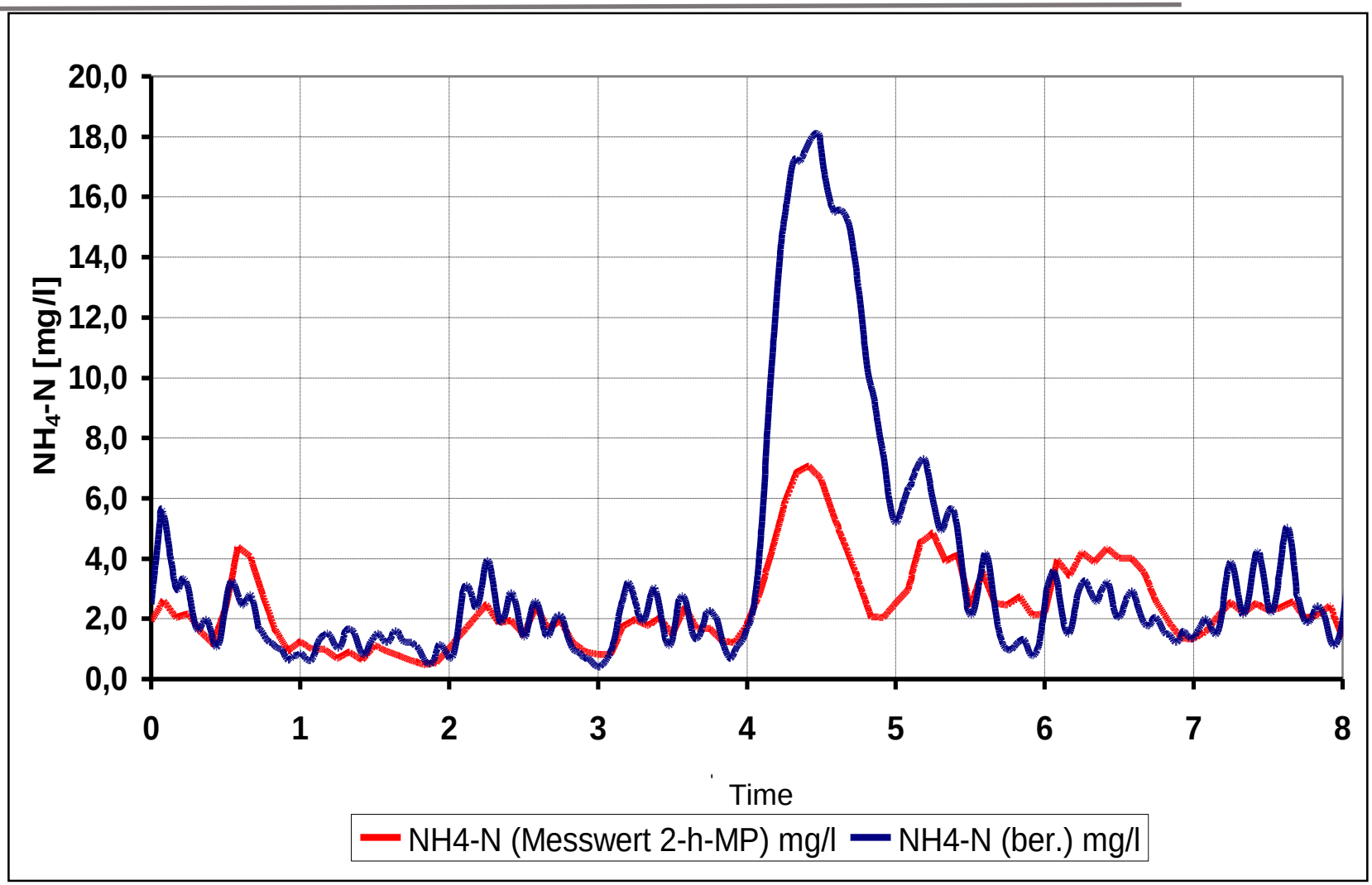
Execution of the simulation

Model of the WTTP Körkwitz made with SIMBA®



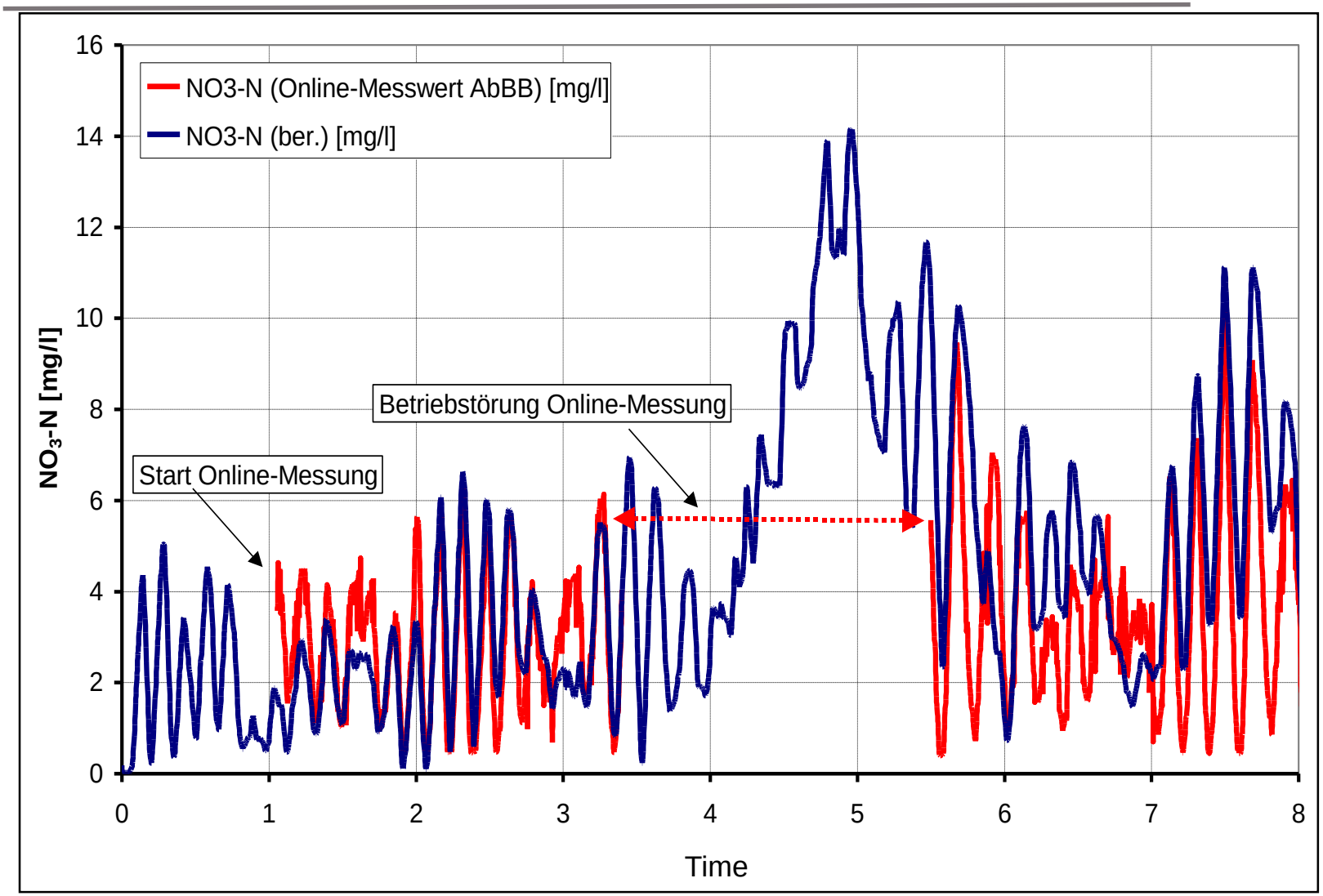
Execution of the simulation

Results of the calibration (NH_4-N-out)



Execution of the simulation

Results of the calibration (NO_3-N-out)



Procedure of the simulation

Case studies

- Objectives of the simulation studies:
  - Determination of the capacity limitation of the WTTP Körkwitz with different loading situations
- Increasing the inlet load step by step (5.000 PE) starting on the load of the measurement period (42.200 PE)
- Case of loading, which have been considered:
  - 42.200 PE, 15°C
  - …..
  - 52.000 PE, 15°C
  - 41.500 PE, 10°C
  - **55.000 PE 15°C; buffering tank in the inlet**

Summary

- Changes in amount and quality
  - Seasonal fluctuation
  - Sudden peaks
- Dimensioning of the treatment plants
  - Case study of loadings
  - Dimensioning of plant with dynamical simulation and additional pilot-plat investigations
  - Adapted treatment technology (“breathing” plant)
- Other specialities
  - Sewer system (sediments, max. flow, odour and corrosion)
  - Wastewater disinfection (UV- Irradiation)
  - Chemical toilets
  - Alkalinity

Objectives for modelling a WTTP

- Optimized design of the plant
  - Minimising the tank volume
  - Comparison of different variations of process technologies
  - Creating and adapting the control strategy
  - Combination with existing technologies
  - Design of mechanical and electrical equipment
- Estimations of future loading scenarios
  - Connection of new industries
  - New residual areas
  - Variation of load scenarios
- Determination of the capacity of exiting WTTP
- Optimizing the operating of the plant
  - Energy optimisation
  - Effect on the operation performance
  - Integrated Simulation
- Education of the operation personal

Variable parameters of models