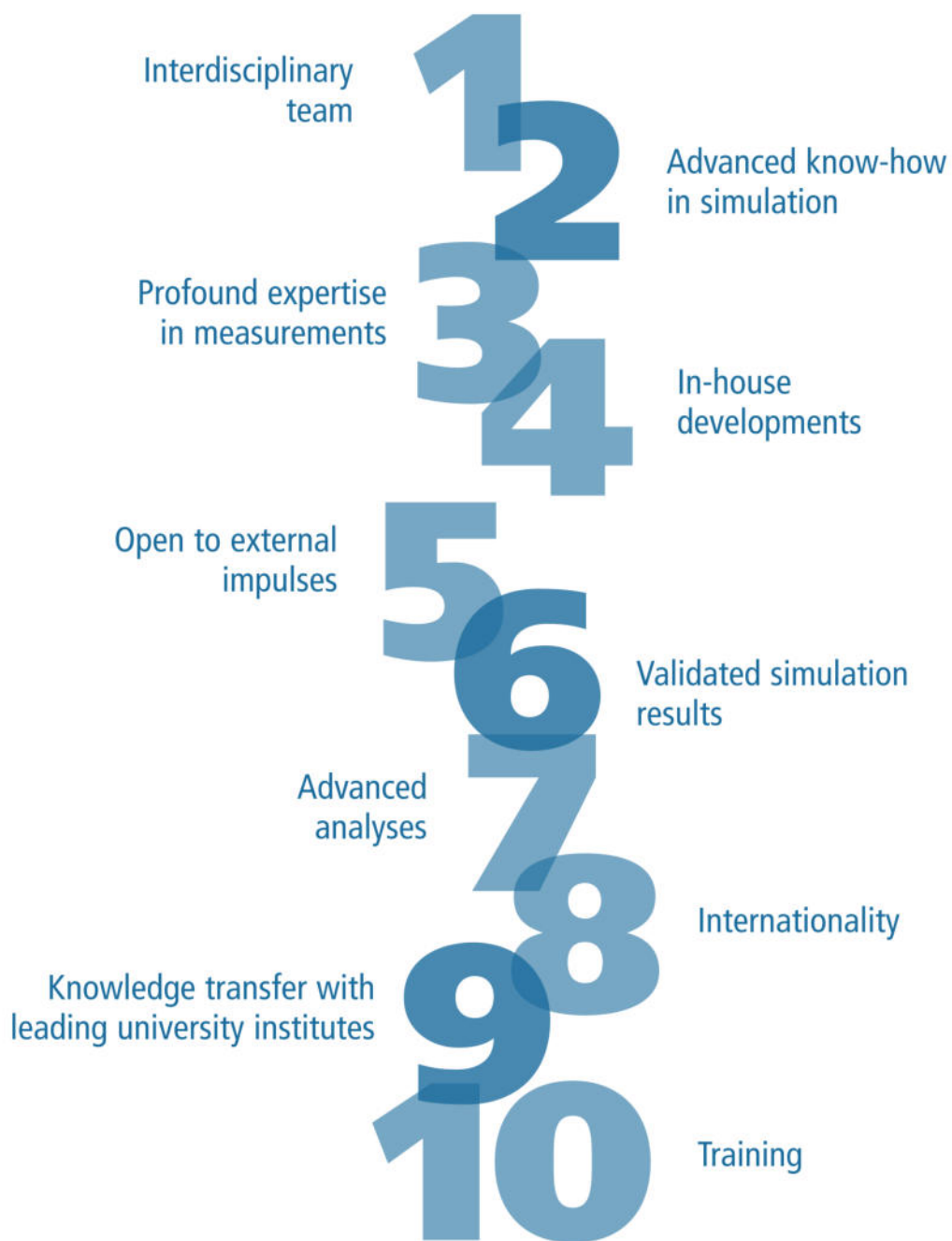


Computational Fluid Dynamics and Optimization

Measurement, Simulation, Evaluation, Solution

Ten good reasons for hydrograv

- 
- 1 Interdisciplinary team
 - 2 Advanced know-how in simulation
 - 3 Profound expertise in measurements
 - 4 In-house developments
 - 5 Open to external impulses
 - 6 Validated simulation results
 - 7 Advanced analyses
 - 8 Internationality
 - 9 Knowledge transfer with leading university institutes
 - 10 Training

Good reasons for hydrograv

Interdisciplinary team

For CFD simulations in urban water management it is important to combine the knowledge of flow engineers with the know-how of municipal water management engineers and other experts. Therefore, experts from many disciplines work at hydrograv, such as hydrologists, mathematicians, civil engineers or mechanical engineers.

Advanced know-how in simulation

Our simulations are based on more than 35 years of experience in the field of CFD simulations in wastewater technology. Our roots lie in the CFD team of the Institute for Hydromechanics of Karlsruhe Institute of Technology (KIT) that was a pioneer of wastewater relevant simulations. Its first paper about the modeling and simulation of clarifiers was already published in 1981. Since then we have continued developing and improving CFD models.

Profound expertise in measurements

For more than three decades, we have been testing and, if necessary, improving our model approaches based on measured data. This includes external data and our own measurements in the laboratory, in nature and of course in sewage treatment plants and gives us the practical experience we need to perform and interpret simulations practice oriented.

In-house developments

After decades of development work, the quality of our simulations is very high and acknowledged by our customers. But there is no time to rest. Our approaches are still subject to our own critical examination and further development. In the meantime, hydrograv has developed a number of innovative model approaches, for example the modelling of sludge rheology, reaction kinetics in ozone reactors or the oxygen transfer in aeration tanks ($k_L a$, SOTE, SSOTR), e.g. according to the German design guideline DWA-M 209.

Open to external impulses

Quite a few of our models were developed to meet customer requests with particular hydraulic problems. Our mission is that these developments always have to meet scientific requirements. Do you have maybe a particular hydraulic question?

Validated simulation results

hydrograv is convinced that regular measurement is necessary for responsible handling of simulations. Therefore we offer you measurements and simulations from a single source. Before simulating your system we recommend to carry out measurements in your facility. Without measurements we can make use of a huge data base of previous measurements from which reliable calibrated model approaches have been arisen. Basically, with measured data, we critically assess how accurately the simulation reflects the flow patterns or settling processes in each particular case. This provides confidence, deepens process understanding and motivates model improvements.

Advanced analyses

With our data mining tools we process and analyze large amounts of data of a plant. We apply statistical methods systematically and goal-oriented to solve technical problems. For this reason, every flow simulation involves a variety of deterministic analyses. These analyses together with visualizations of flow processes improve the understanding of the actual causes and lead to efficient and targeted solutions. These analyses reveal, for example separation rates in percent, potential deposition areas, residence time curves, variant-dependent oxygen transfer rates ($k_L a$, SOTE, SSOTR) or hydraulic pressures and torques.

Good reasons for hydrograv

Internationality

Time and again we have cooperated with institutions in several European and non-European countries, e.g. in United Kingdom, Spain and Netherlands. We also work successfully for customers from all over the world.

Knowledge transfer with leading university institutes

We have close contacts to different scientific institutes, such as the Institute of Urban and Industrial Water Management at the Technische Universität Dresden. These contacts provide valuable support and opportunities for our projects.

Training

Our employees are continuously trained to sustain our high quality standard. Additionally, our employees train other professionals.

We deliver verified, comprehensible, comparable and interpreted results:

- hydrograv delivers reviewed and verified simulations. Therefore we regularly perform measurements to validate our simulation results and ensure that our simulation models are applied within valid system constraints.
- Sensitivity analyses are carried out regularly to archive a better understanding of system behavior, to interpret the simulation results in a targeted manner and to verify the plausibility of the simulations.
- Operating data of several years will be extensively analyzed and evaluated statistically. These statistical analyses are the basis for the simulations which are agreed with the customer.
- hydrograv delivers extensive and comprehensible analyses and technically targeted interpretations of the results, for example as comparable key indicators.

Why a computer-based simulation?

- Cost saving in construction and operation due to early identification of weak points, often with possible performance increases of 20 % and more
- complex tasks cannot be solved with analytical methods in most cases
- extensive variation of building geometries are possible easily and quickly
- simple and fast analyses of variants including dynamic processes
- cost-efficient testing ground
- verification of special solutions which do not correspond to the state of the art or are outside the validity of design guidelines

We deliver:

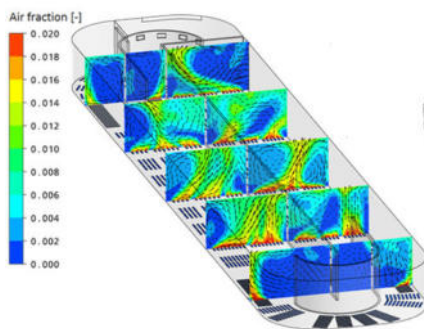
- proof of functionality
- facility dimensioning
- verification of safety reserves
- performance limits
- avoidance of weak points and bottlenecks
- development and validation of emergency strategies
- effects of changes in requirements and accidents
- process logic/control criteria

Activated Sludge Tanks

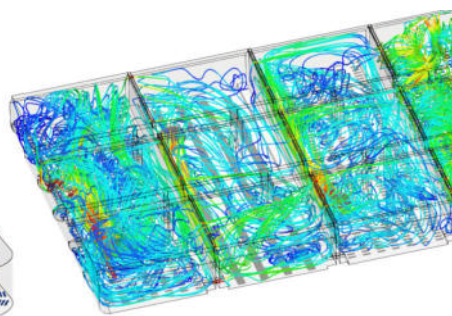
Enhanced biodegradation

Your benefits

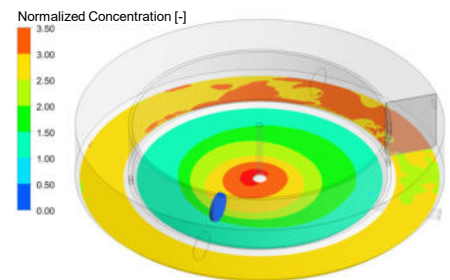
- Optimal operational conditions
- Cost reduction due to energy and investment savings
- Optimization of position, performance and the number of stirrers
- Prevention of depositions
- Increased oxygen transfer



Optimization of aerators arrangement



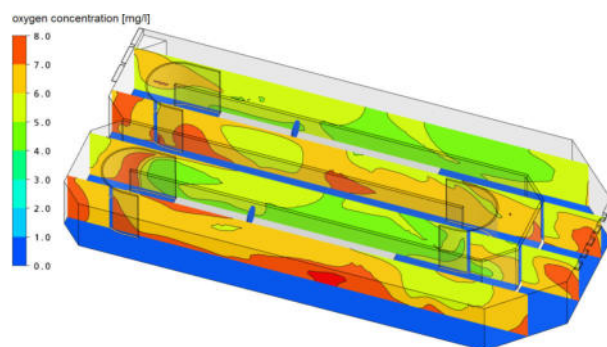
Optimization of agitators



Analysis of depositions

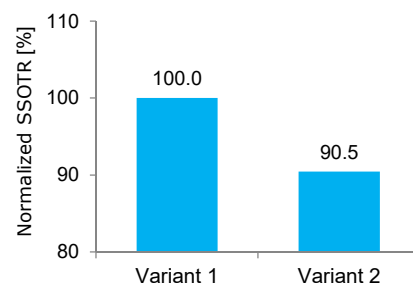
Virtual oxygen transfer experiments

- Optimization of aerator arrangement by virtual oxygen transfer experiment
- Realistic determination of SSOTR, SOTE and $k_L a$



SSOTR +23 %

Simulation of oxygen transfer



SSOTR - comparison of variants

Professional CFD analyses – based on leading expertise!

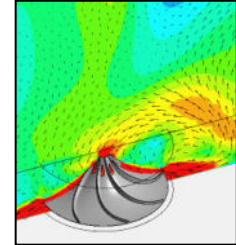
Measurement · Deterministic analyses · Optimization

Activated Sludge Tanks

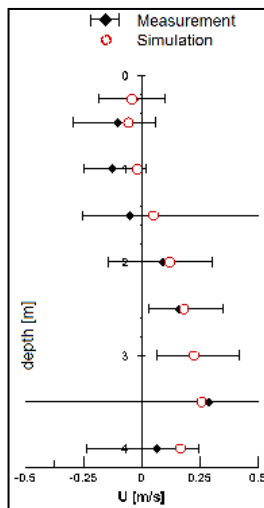
Enhanced biodegradation

Methods

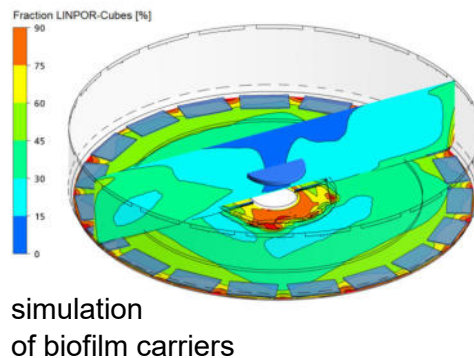
- three-dimensional, multiphase flow simulation incl. aeration
- modeling activated sludge or floating biofilm carriers
- agitators as impulse source or real geometries
- virtual oxygen transfer experiments
- velocity measurement for the validation of modeling approaches



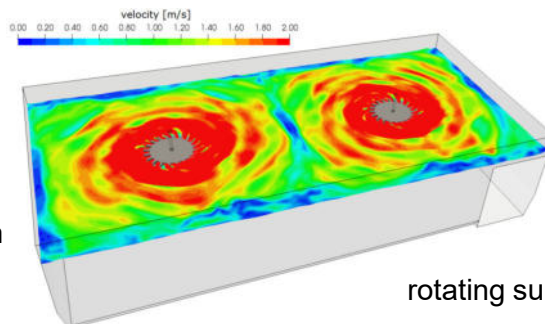
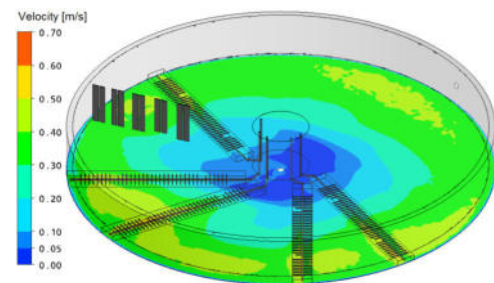
rotating agitators
used for mixing



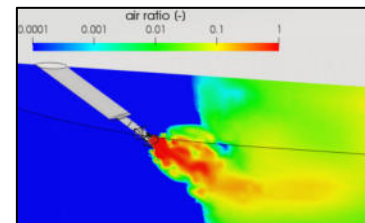
Comparison
Measurement - Simulation



simulation
of biofilm carriers



rotating surface aerators



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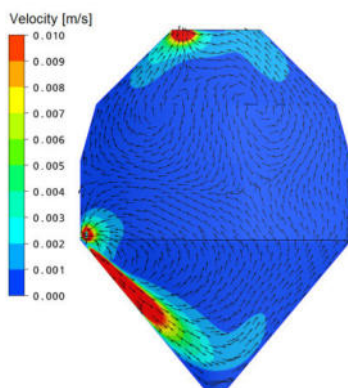


Anaerobic Digesters

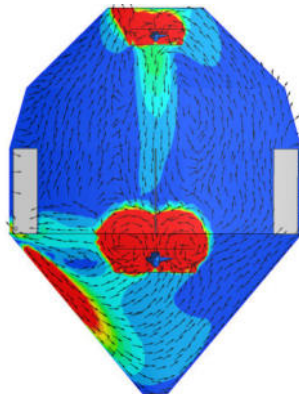
Optimal mixing

Your benefits

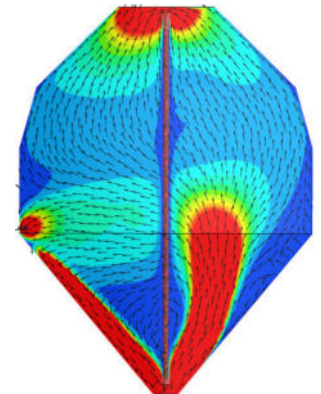
- mixing verification and optimization.
- comparison of various mixing systems like pumps, screw pumps, stirrers or gas injection
- increased predictive reliability through measurements of sludge rheology



External mixing by pumps



Central agitator

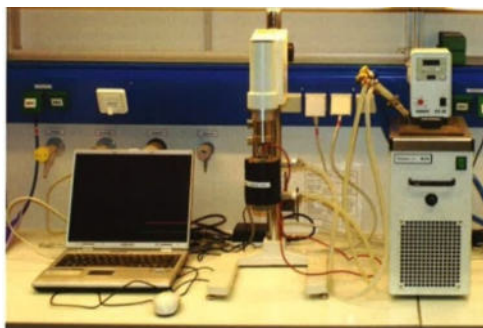


Central screw pump

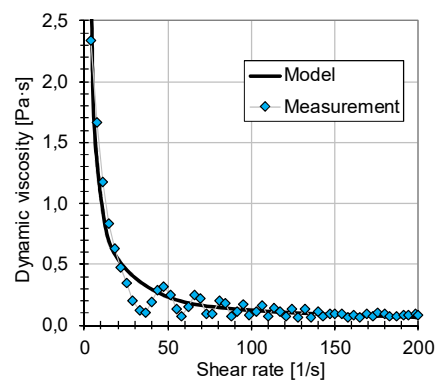
Comparison of various mixing systems

Methods

- three-dimensional multiphase flow simulations
- implementation of gas formation
- application of rheological models
- measurement of sludge viscosity



Measurement of the sludge viscosity

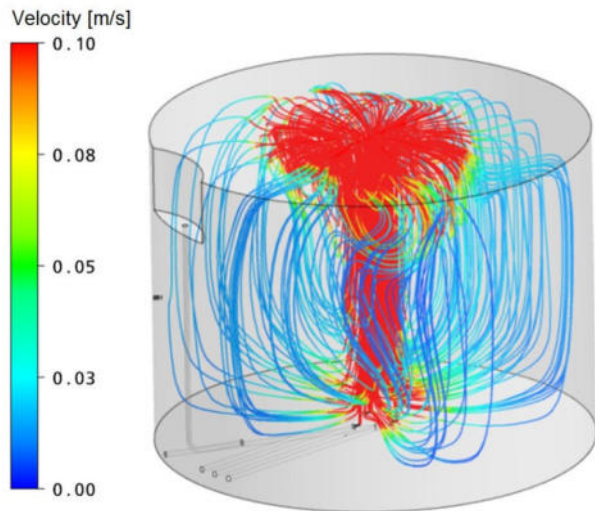


Professional CFD analyses – based on leading expertise!

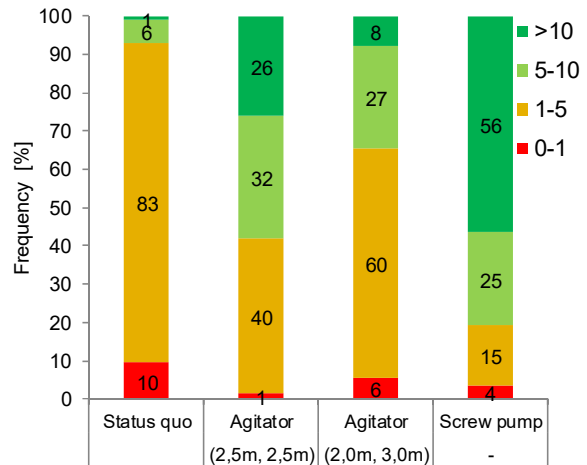
Measurement · Deterministic analyses · Optimization

Anaerobic Digesters

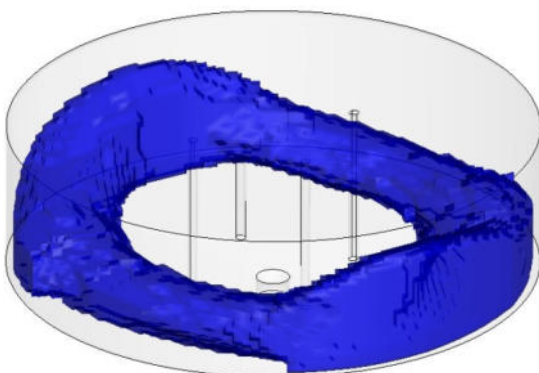
Optimal mixing



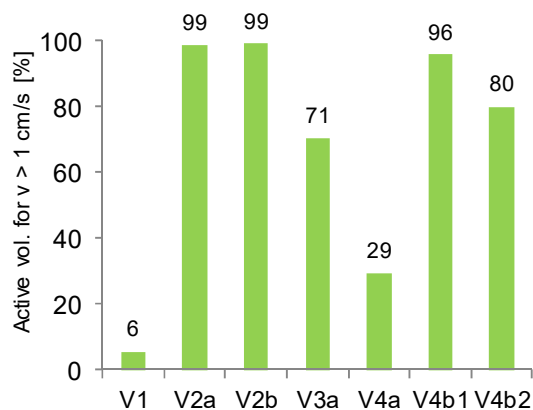
Anaerobic digester with gas injection



Analysis of the mixing rate



Areas with active volume



Analysis of the active volume

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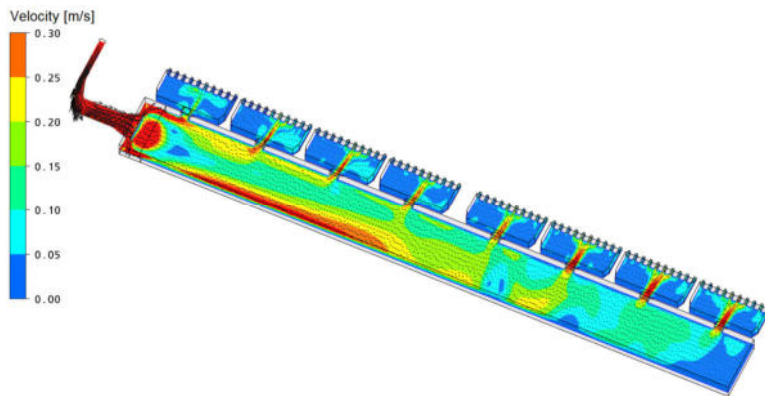


Distribution Structures

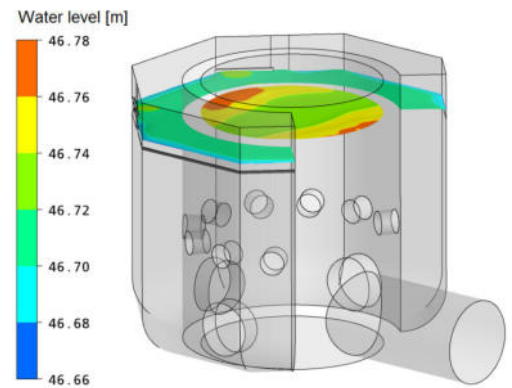
Optimal hydraulic and material distribution

Your benefits

- optimization of hydraulic and material distribution
- prevention of deposits
- analysis of water levels and hydraulic losses



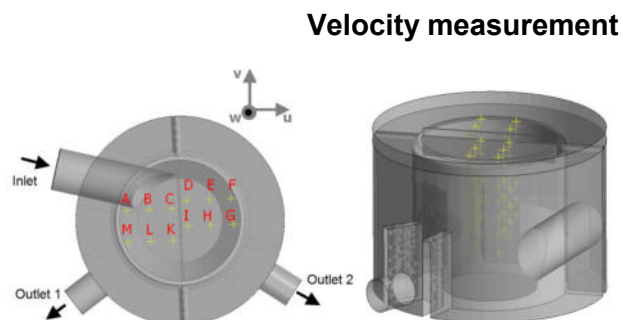
Optimization of the hydraulic distribution



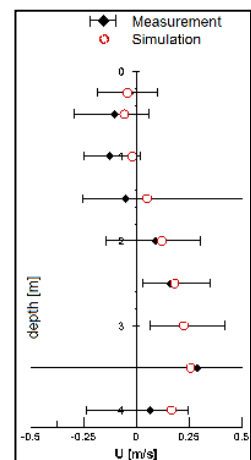
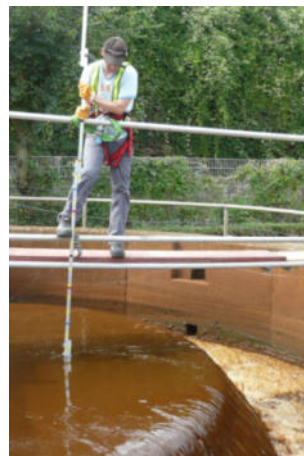
Analysis of hydraulic losses

Methods

- three-dimensional multiphase flow simulations
- free surface flow simulation
- particle and/or activated sludge modelling
- model validation through on-site velocity measurements



Velocity measurement

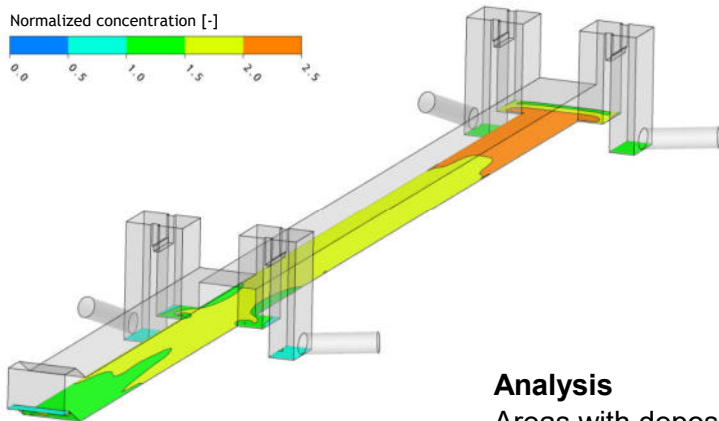



Professional CFD Analyses – Based on Leading Expertise!
Measurement · Deterministic analyses · Optimization

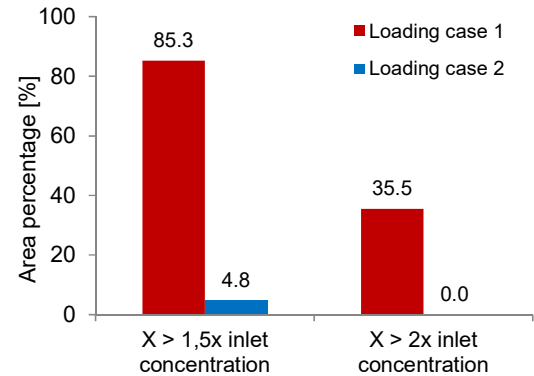
Distribution Structures

Optimal hydraulic and material distribution

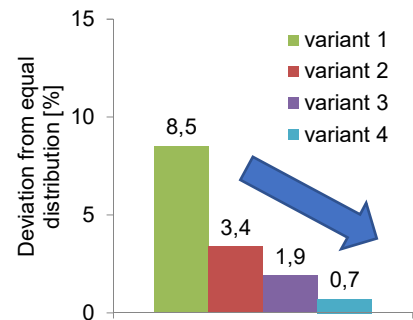
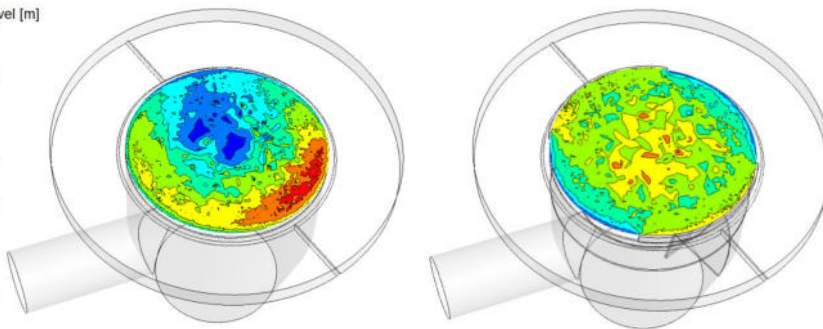
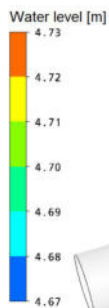
Normalized concentration [-]



Analysis
Areas with deposition



Water level [m]



Optimization
of the hydraulic distribution

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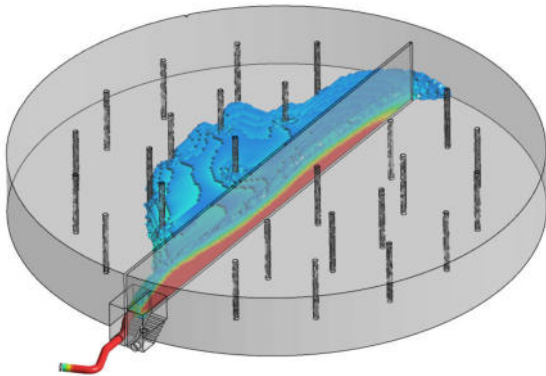


Drinking Water Supply

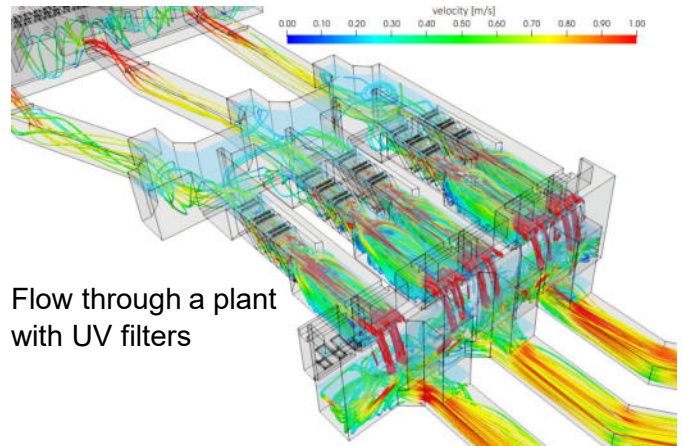
Enhanced water quality

Your benefits

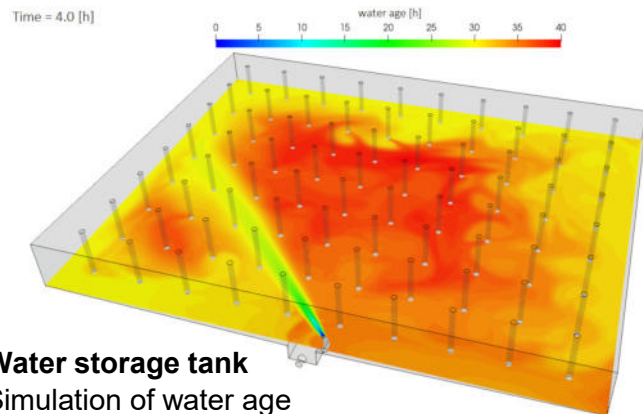
- increased reliability in planning
- enhanced drinking water quality
- improved process knowledge



Water storage tank
Tracer distribution



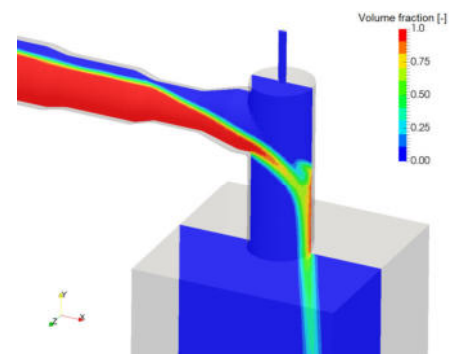
Flow through a plant
with UV filters



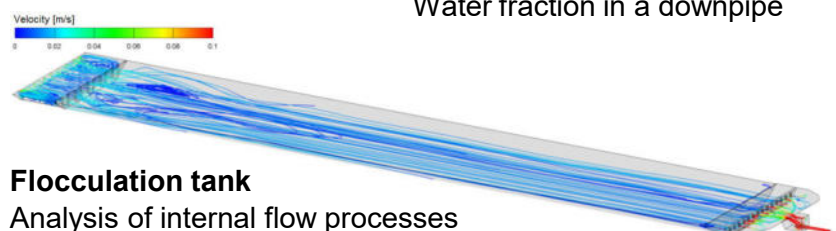
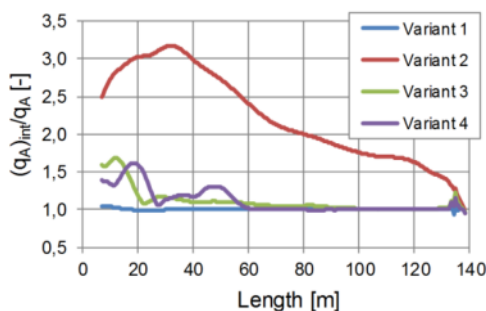
Water storage tank
Simulation of water age

Applications

- water storage tanks
- valves
- flocculation tanks



Valve in a waterworks
Water fraction in a downpipe



Flocculation tank
Analysis of internal flow processes

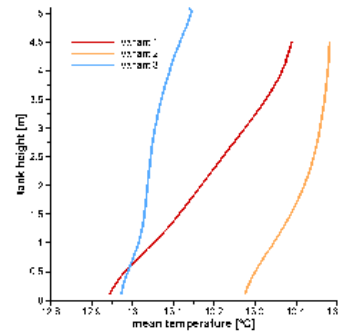
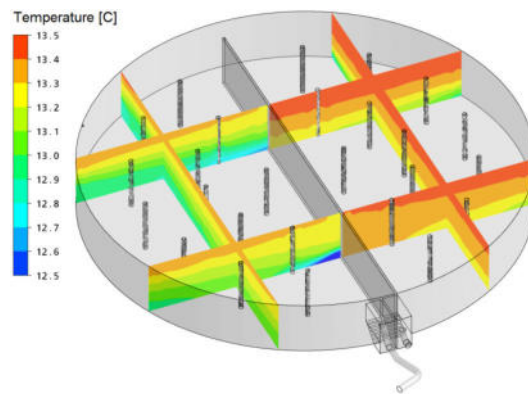
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Drinking Water Supply

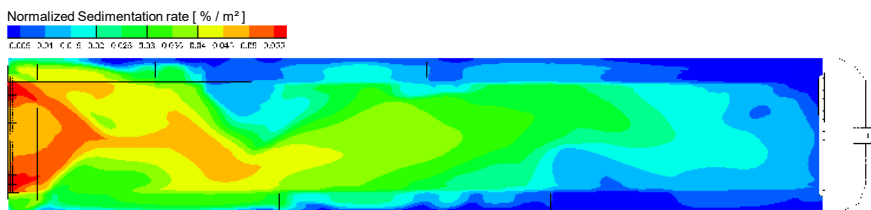
Enhanced water quality

Methods

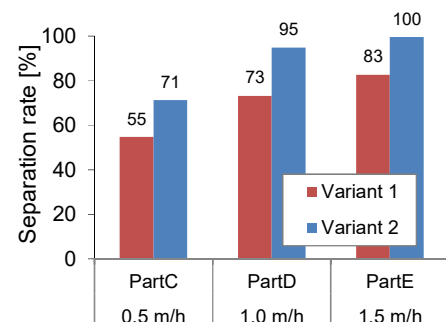
- three-dimensional simulations
- simulation of tracers to verify residence time
- determination of water age
- consideration of temperature gradients
- simulation of particles in flocculation tanks



Water storage tank
Distribution of temperature



Flocculation tank
Analysis of particle removal



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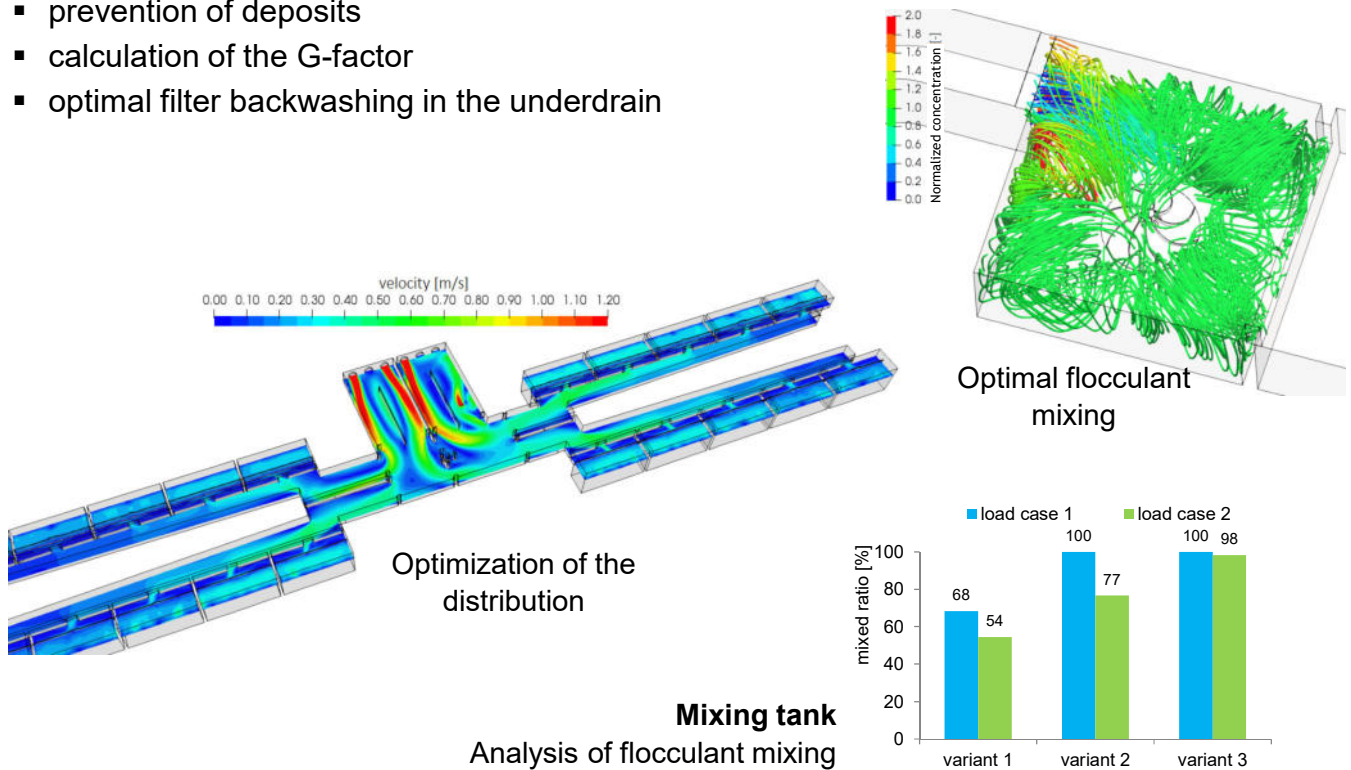


Flocculation Filtration

Optimal mixing, distribution and filter inflow

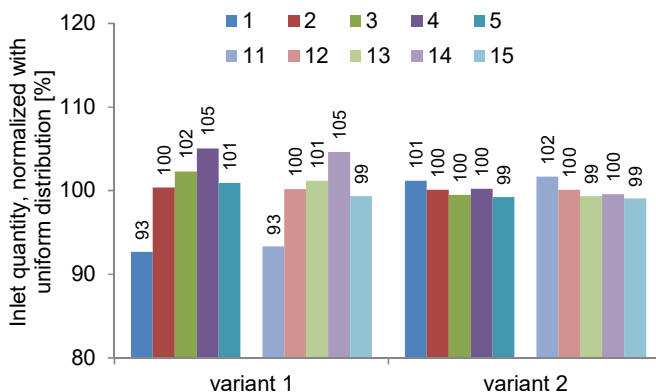
Your benefits

- optimal mixing of activated carbon, coagulants and flocculants
- optimization of the hydraulic and particle distribution in the filter chambers
- prevention of deposits
- calculation of the G-factor
- optimal filter backwashing in the underdrain



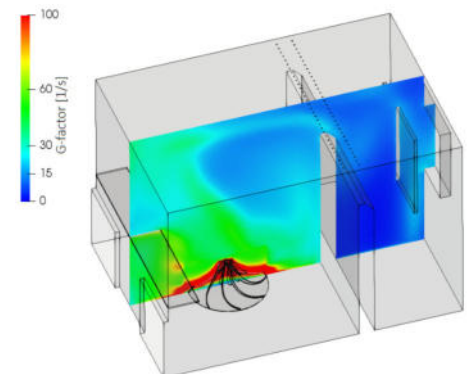
Methods

- three-dimensional multiphase flow simulation
- with free water surface
- incl. modeling of particles, activated carbon, coagulants and flocculants



Filter chambers

Analysis of the distribution to the filter chambers

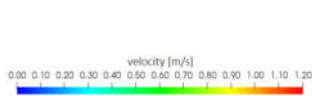


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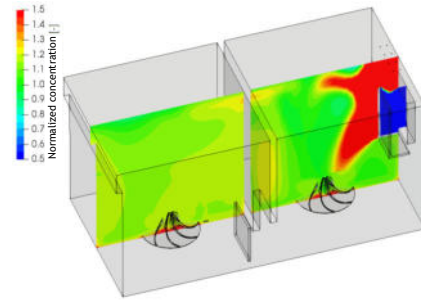
Measurement · Deterministic analyses · Optimization

Flocculation Filtration

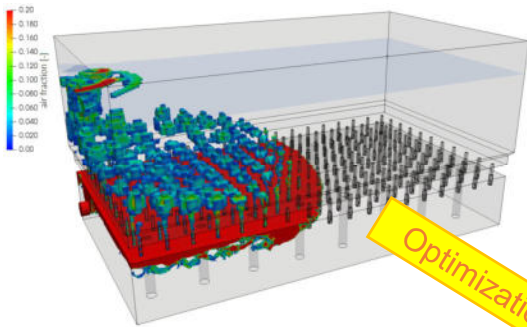
Optimal mixing, distribution and filter inflow



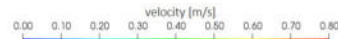
Mixing tank
Optimal flocculant mixing



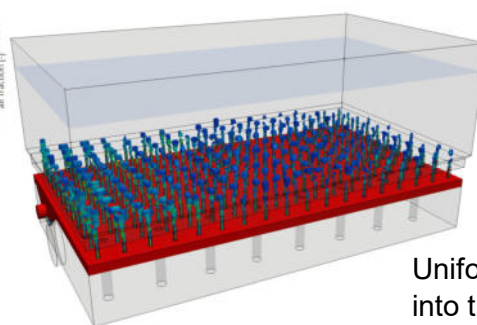
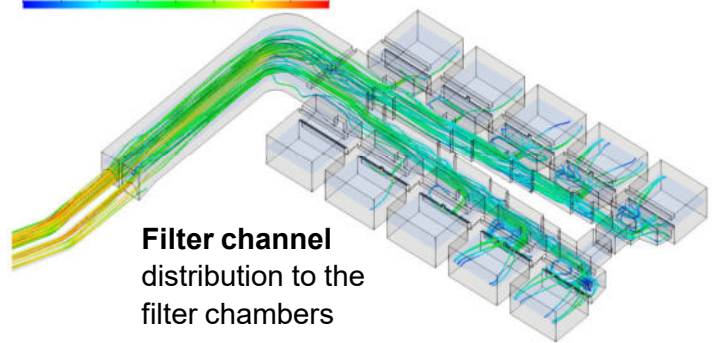
Filter underdrain



Early air introduction into the filter bed



Filter channel
distribution to the
filter chambers



Uniform air introduction
into the filter bed

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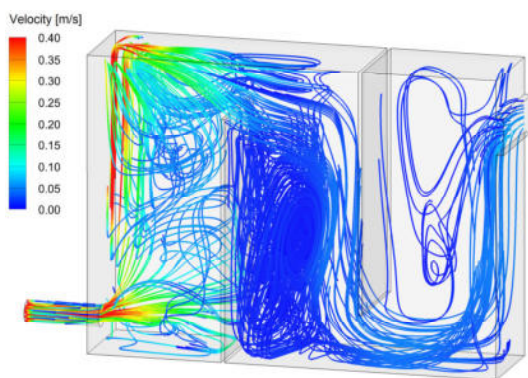
Micropollutant Removal

Increased degradation of micropollutants

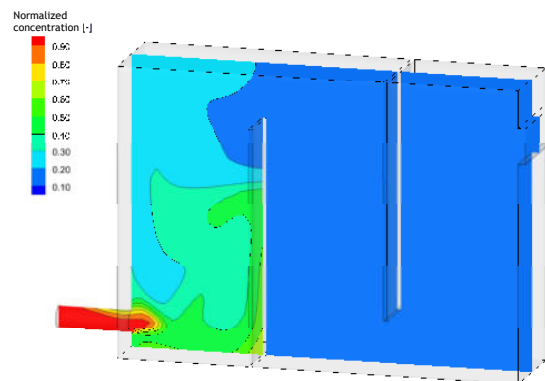
Ozone Reactor

Your benefits

- calculation of micropollutants degradation rates
- optimized hydraulics for efficient degradation
- cost savings due to the reduction of required treatment volume
- detection of micropollutant concentration in off-gas and effluent flow



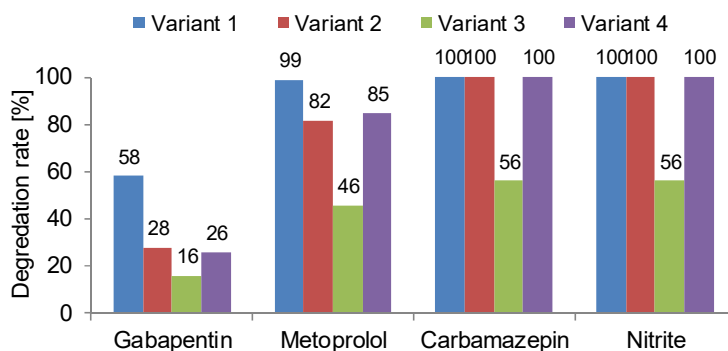
Streamlines



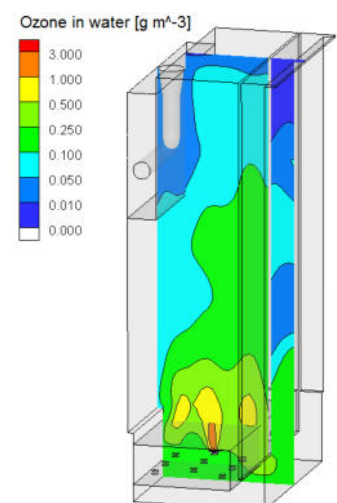
Concentration of the micropollutant Metoprolol

Methods

- three-dimensional multiphase flow simulations
- mass transfer between ozone-oxygen mixture and water
- decay of ozone rate
- reaction with micropollutants and other substances in water, e.g. Metoprolol and DOC



Analysis of degradation rates for micropollutant and nitrite



Ozone distribution in the reactor

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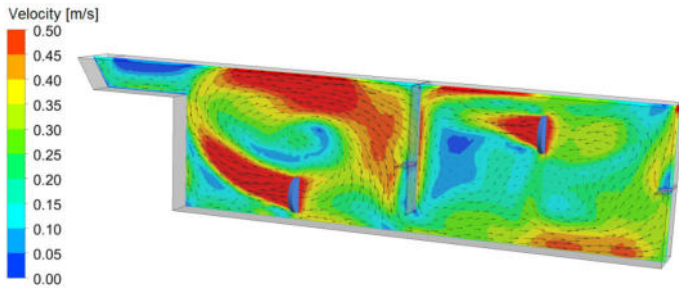
Micropollutant Removal

Increased degradation of micropollutants

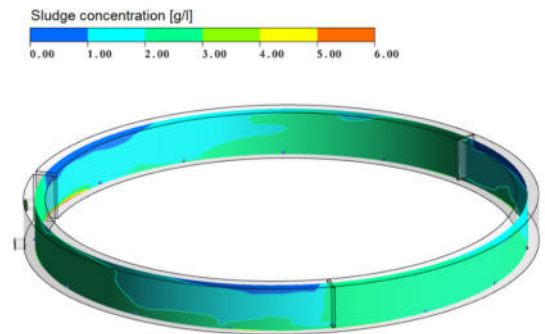
Activated carbon reactor

Your benefits

- optimal mixing in the reaction tank
- maximum separation in the sedimentation tank



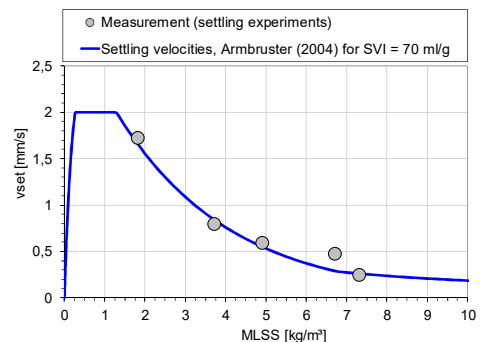
Velocity distribution



Concentration distribution

Methods

- three-dimensional multiphase flow simulations
- modeling of activated carbon particles
- experimental determination of settling velocities



Comparison experiment vs. model

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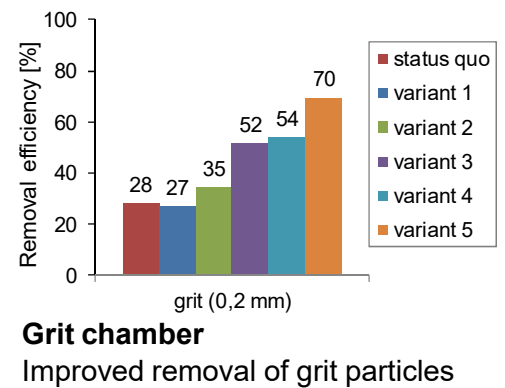
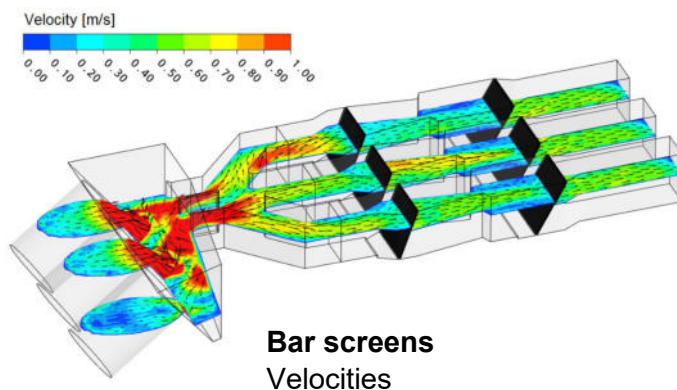


Primary Treatment

Maximum removal efficiency

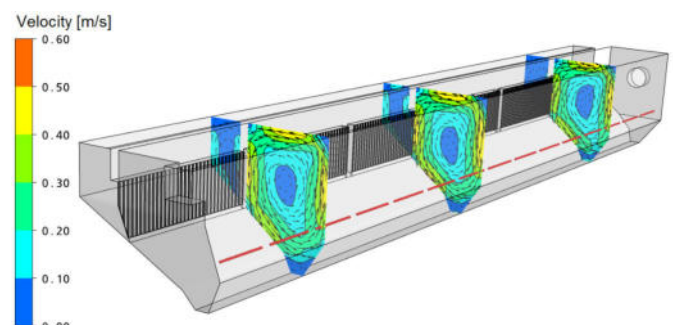
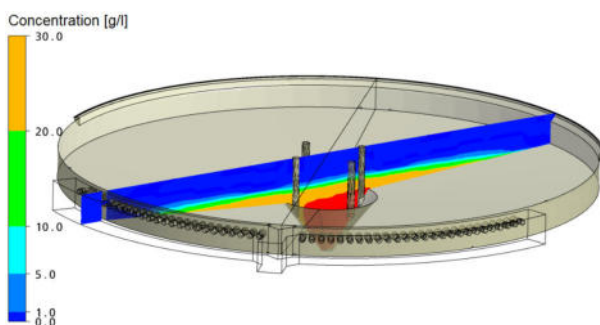
Your benefits

- optimization of hydraulic and material distribution
- maximization of grit removal efficiency
- minimization of energy usage for aeration in grit chambers
- comparison of variants, e.g. types of bar screens
- verification of hydraulic losses



Methods

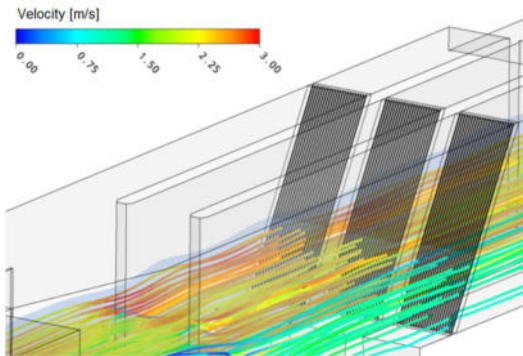
- three-dimensional multiphase flow simulation
- for each treatment step specific modeling approaches:
 - free surface in channels
 - aeration in grit chambers
 - simulation of different wastewater substances: sand, organic particles, grease, primary sludge



Professional CFD analyses – based on leading expertise!
Measurement · Deterministic analyses · Optimization

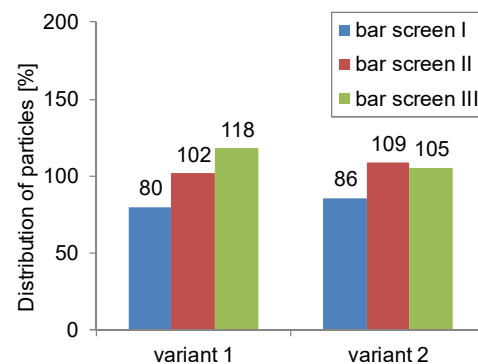
Primary Treatment

Maximum removal efficiency



Bar screens

Realistic modeling by calibration



Deterministic analysis

Distribution of particles at bar screens

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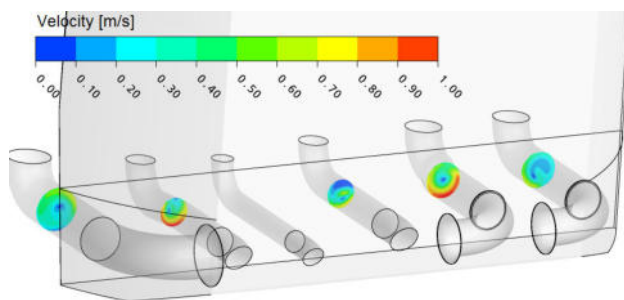


Pumping Stations and Agitators

Optimal flow conditions

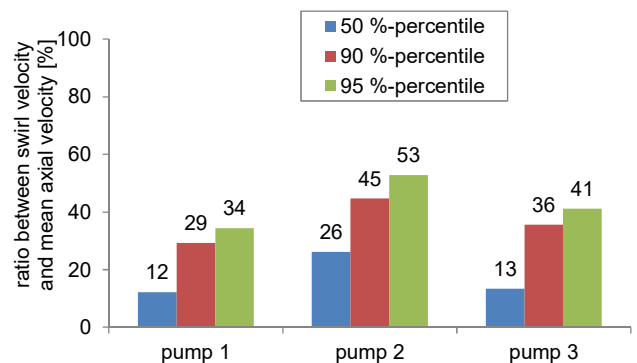
Your benefits

- influent optimization
- reduction of life cycle costs
- assessment during planning
- R&D-support, e.g. for pump manufacturer
- evaluation of hydraulic losses



Pumping station

Analysis of inflow velocity



Deterministic analysis

Proof of swirl absence

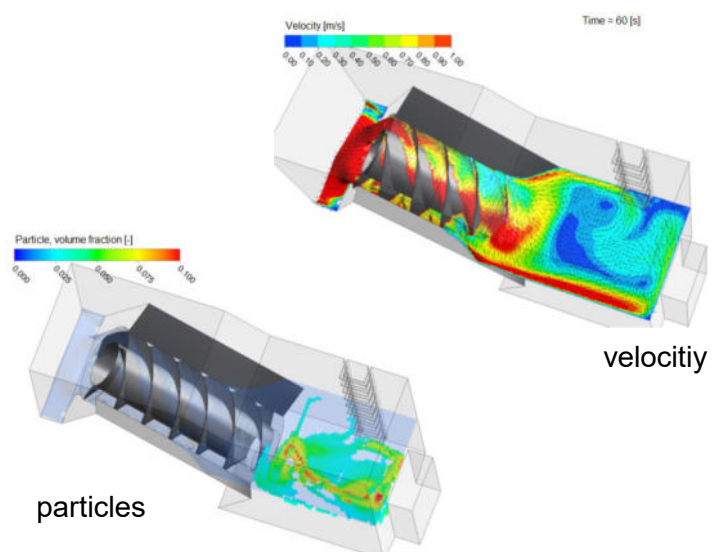
Methods

- three-dimensional, multiphase flow simulations
- free surface flow simulation
- including particles, e.g. floating or settling particles



Screw pump

Simulation incl. floating sludge



particles

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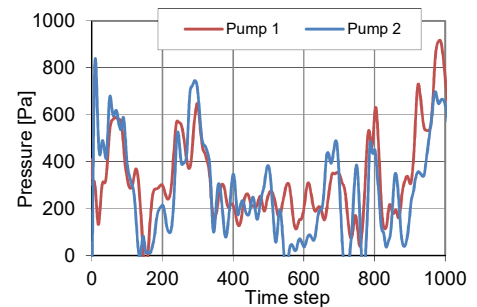
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Pumping Stations and Agitators

Optimal flow conditions

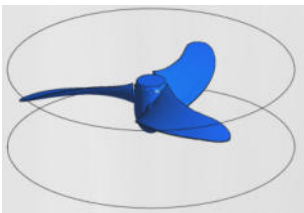
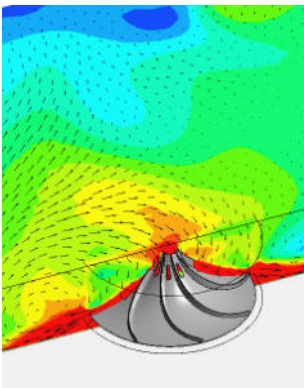
Analysis

- pressure losses and fluctuations
- swirl freedom and axial velocities in the intake manifold
- deposit areas



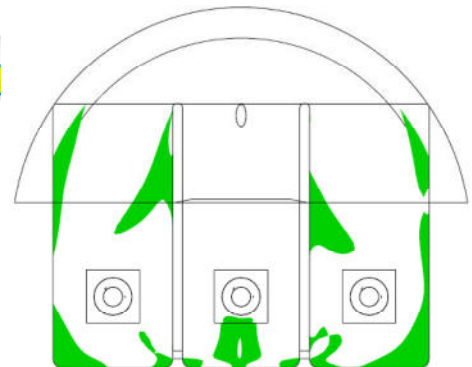
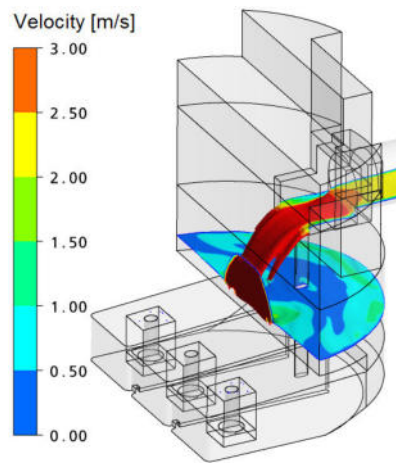
Pumping station

Analysis of pressure fluctuations



Agitators

Modeling of real geometries



Pumping station

Analysis of potential deposit areas

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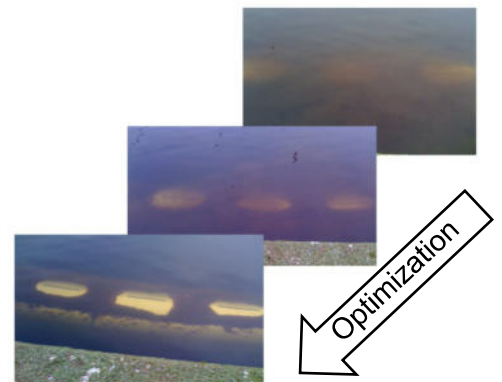
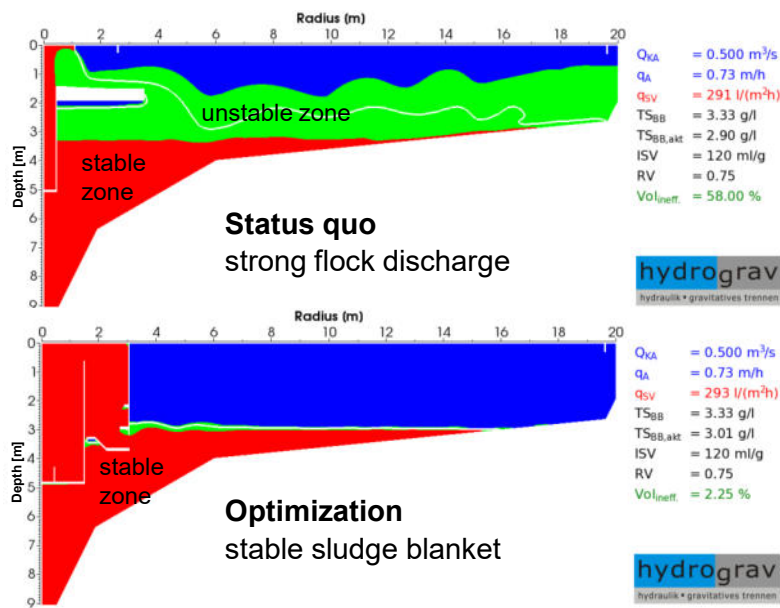


Secondary Clarifiers

Highest effluent quality and maximum capacity

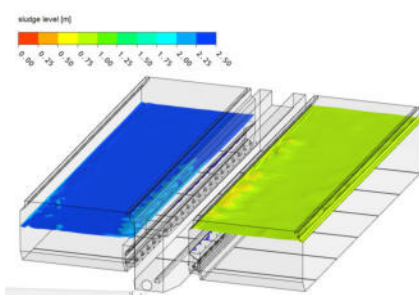
Your benefits

- maximum safety in terms of sludge overflow and flock discharge
- optimization of operating strategies, e.g. optimal return sludge flow
- variant comparison already in the planning phase
- proof of performance limits even beyond design guidelines
- determination of the flocculation potential

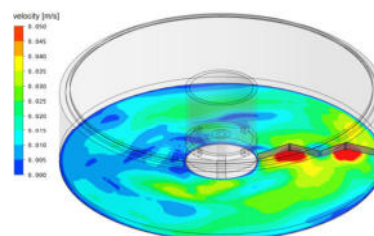


Methods

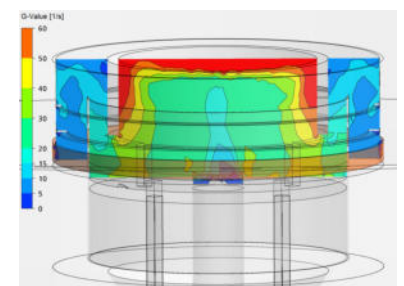
- two- and three-dimensional simulations
- realistic modeling of the settling and flow characteristics of activated sludge
- consideration of sludge displacement into the clarifiers
- realistic modeling of scraper systems



Rectangular Tank:
Sludge Level



Circular Tank:
Velocities above the Floor



G-Value Determination

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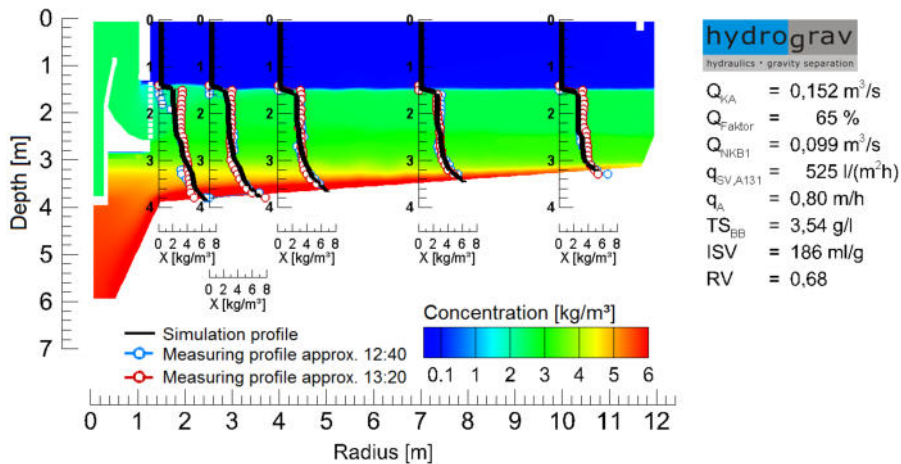
Measurement · Deterministic analyses · Optimization

Secondary Clarifiers

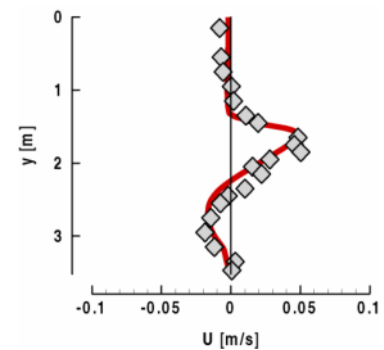
Highest effluent quality and maximum capacity

Measurement

- calibration of modeling approaches by measurement of
 - sludge concentration,
 - settling velocities and
 - flow velocities.



Calibration using measurement of sludge concentration



Velocity measurement

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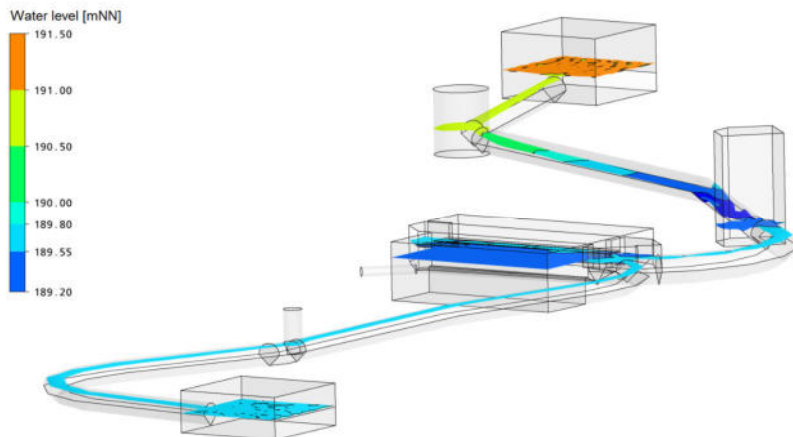


Sewers and separating systems

Optimal hydraulic and material distribution

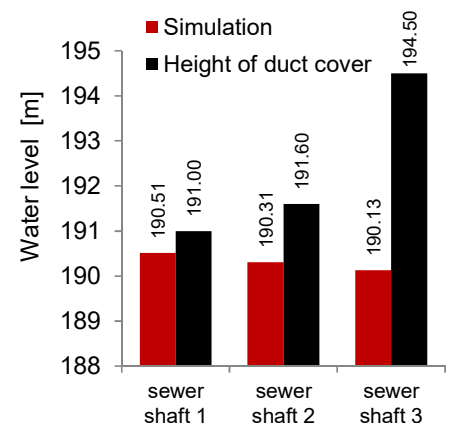
Your benefits

- verification and optimization of stormwater tanks, separation structures and sewer systems
- realistic determination of hydraulic losses
- distribution of water streams
- determination of the separation efficiency, e.g. according to DWA-A-102 (AFS63)



Separation structure with sewers and sewer shafts

Water level

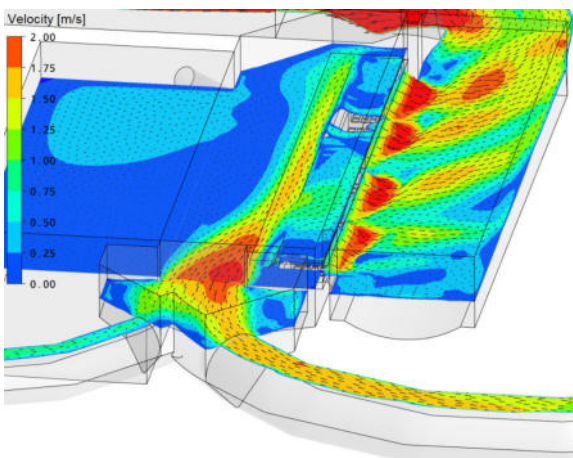


Deterministic analysis

Hydraulic losses

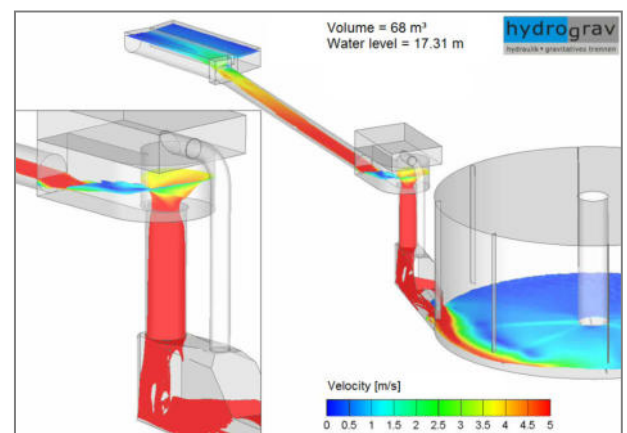
Methods

- three-dimensional multiphase flow simulation
- free surface simulation
- including particles



Separation structure

Optimization of hydraulic and material distribution



Transient processes

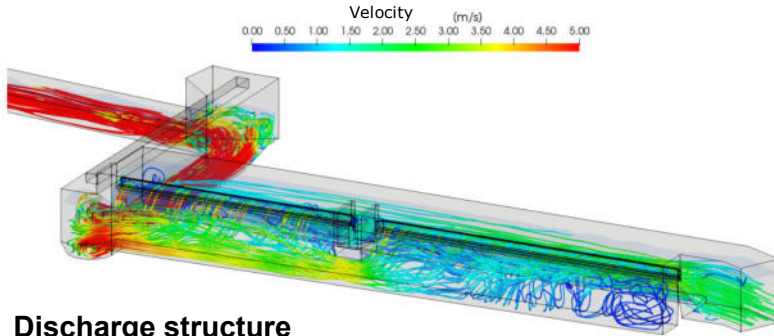
Verification of a stormwater tank
with vortex drop shaft

Professional CFD analyses – based on leading expertise!

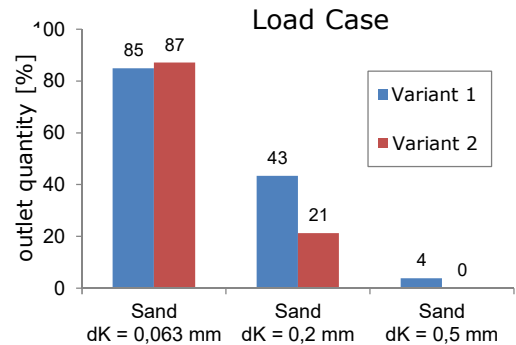
Measurement · Deterministic analyses · Optimization

Sewers and separating systems

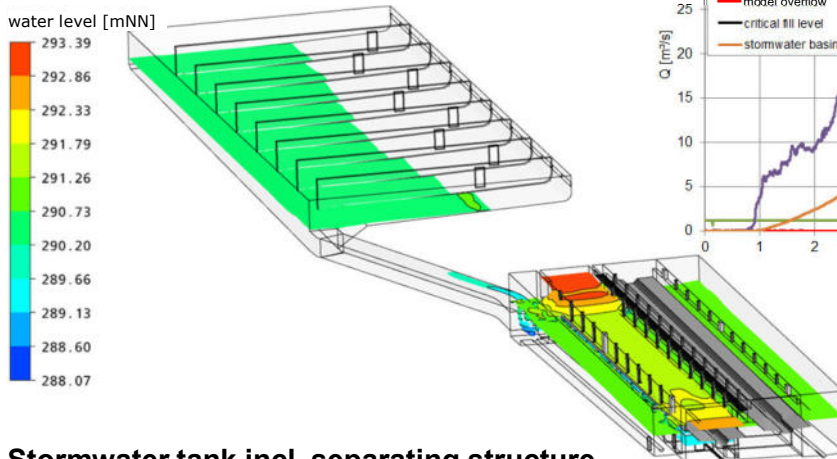
Optimal hydraulic and material distribution



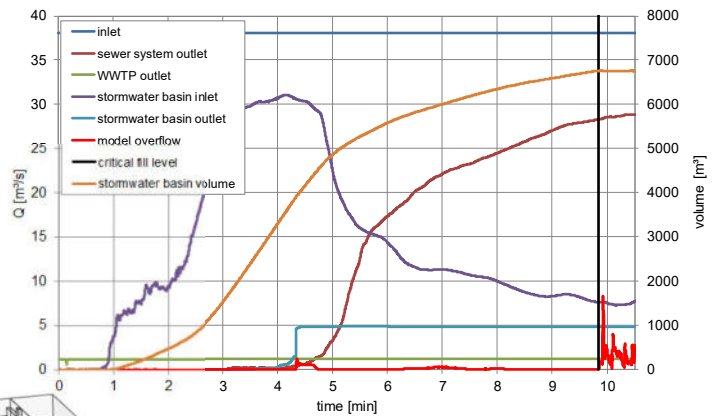
Discharge structure
Streamlines



Analysis of particle retention



Stormwater tank incl. separating structure
Filling



Analysis of the filling
Time course of the inflow quantities and basin volumes

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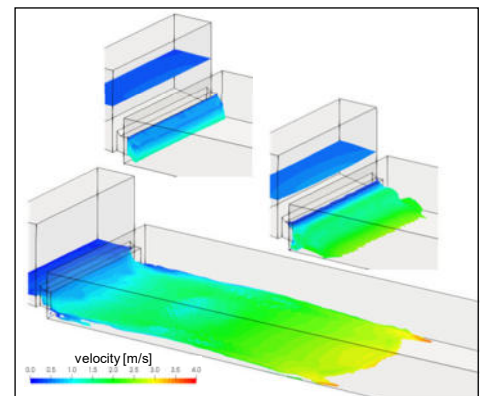
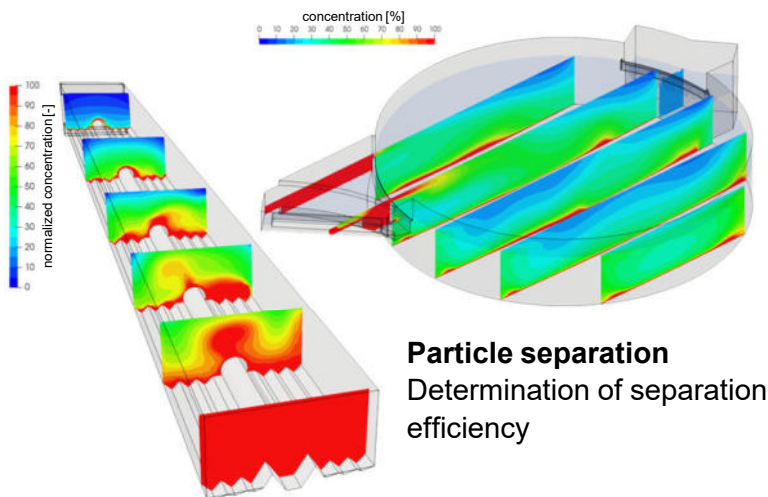


Stormwater treatment

Maximum separation performance

Your benefits

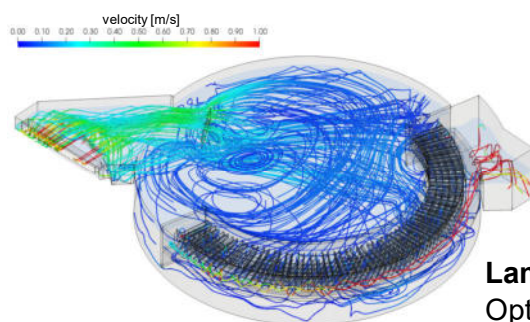
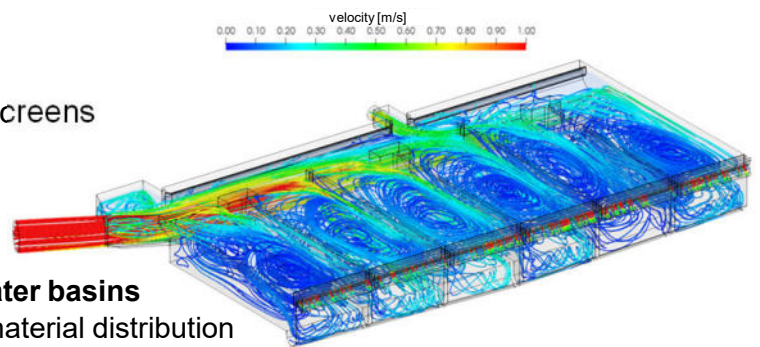
- verification and optimization of stormwater overflow, retention and clarification basins.
- determination of the separation efficiency, according to DWA-A-102 (AFS63)
- testing flushing processes
- realistic determination of hydraulic losses.



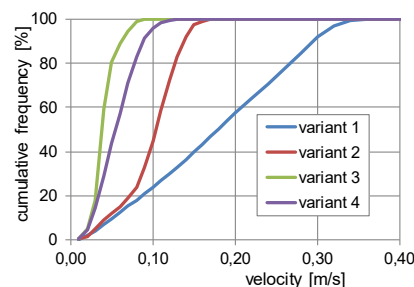
Methods

- three-dimensional multiphase simulation
- if necessary, with free surface
- including particles
- modelling of equipments, e.g. lamellas, screens

System with several stormwater basins
Optimization of hydraulic and material distribution



Lamella separators
Optimization of flow direction and flow through lamellapacks

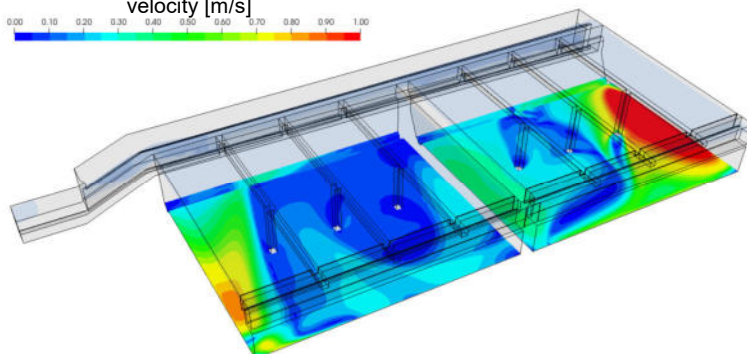


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Stormwater treatment

Maximum separation performance

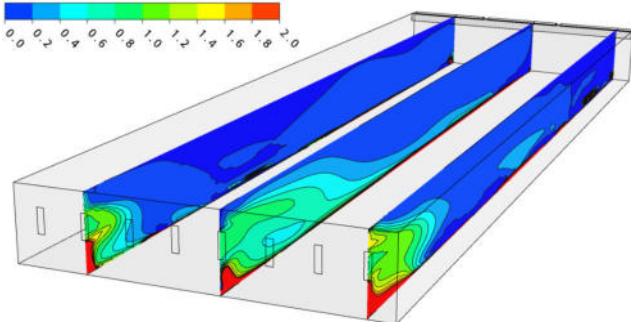
velocity [m/s]



Stormwater tanks

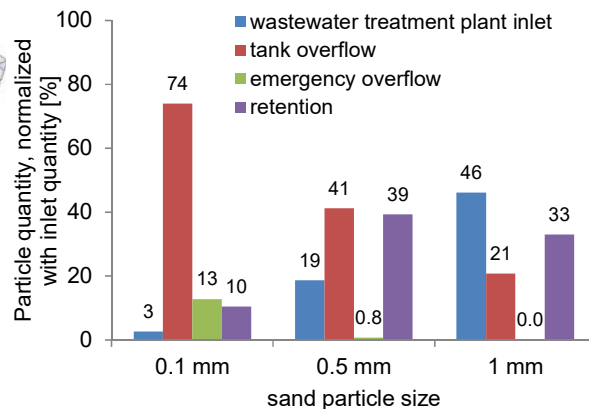
Analysis of velocities near the bottom

normalized concentration [-]

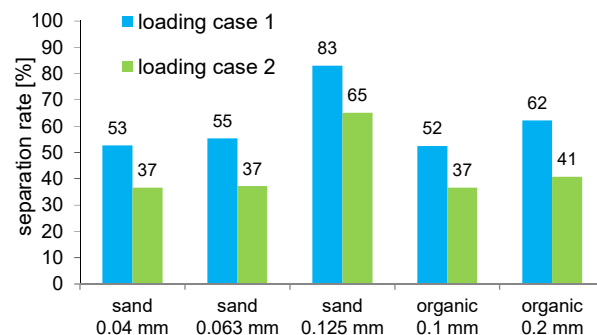


Stormwater tanks

Analysis of potential deposits and separation rate



Analysis of particle distribution



Analysis of the separation rate

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- Activated Sludge Tanks
- Secondary Clarifiers
- Ozone Reactors
- Distribution Structures
- Digesters
- Stormwater Basins
- Sewer Systems
- Water Supply Systems
- Power Plants
- Industrial Facilities