Real-Time Control Strategies of the Outflow from Stormwater Basins from a River's Perspective

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1996 – 2001	**Academic study** in civil engineering, Technische Universität Darmstadt, Germany
2001 – 2006	**Research associate** at Technische Universität Darmstadt, Germany
2006 – 2008	**Lecturer** at Technische Universität Darmstadt, Germany
Since 2007	**Teaching assignment** at Graz University of Technology, Austria
Since 2008	**Postdoctoral Researcher** of the Canada Research Chair in Water Quality Modelling, Université Laval, Québec

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Overview

- Idea
- Test case
- Model
- Control strategies
- Results
- Conclusion and outlook

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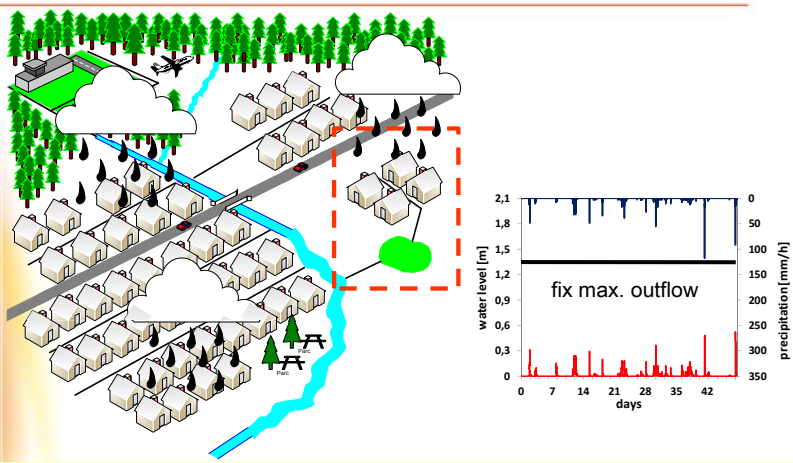
Idea
General



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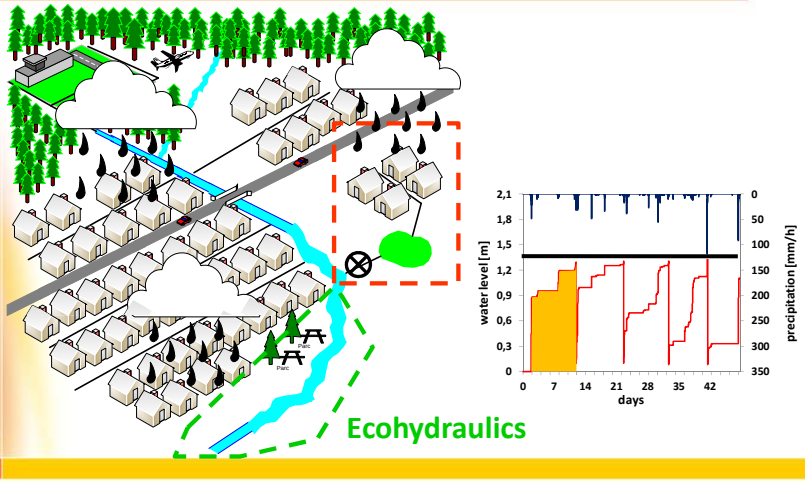
Idea
General



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Idea
General

- Improve Eco-hydraulic:

Reduce hydraulic stress

and

Reduce effects on the quality (pathogens, heavy metals...)

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Idea
Focus TSS and contaminants

- **60-80% P** and **Pb**, **50-60% N**, and **30-40% Zn** are associated with **particles**
- **Higher concentrations** of pollutants (e.g. heavy metals) are associated with the **smaller particle size fractions** of urban dust and dirt
- **Silt and clay** account for less than **10 % of TSS** but contain **> 50% of P and > 25% of other pollutants**

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Idea
Focus TSS and contaminants

Control outlet of basin to

- Extend the hydraulic retention time
- Increase the removal efficiency for TSS and agglomerated contaminants

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Test case
Stormwater Basin Chauveau - overview

- Separate System
- Stormwater part designed as dual drainage system
- Residential area
- ~15 ha
- Degree of imperviousness ~30 %
- ~900 inhabitants

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Test case
Stormwater Basin Chauveau - overview

- 3300 m^3
- Max. water level 1.4 m
- Max. outflow ~350 l/s

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Model

- SWMM5
- Build-up and wash-off
- TSS model stormwater basin based on 6 particle size fractions / settling velocity classes

$$\frac{dC_{TSS,i}}{dt} = -\frac{v_{s,i}}{h(t)} \cdot C_{TSS,i}$$

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Model

Fraction i	Settling velocity class (m/h)	Average settling velocity of particles in size fraction i, $V_{s,i}$ (m/h)	Fraction of total mass contained in settling velocity fraction i (%)
1	< 0.019	0	31
2	0.019 - 0.062	0.019	11
3	0.062 - 0.140	0.062	10
4	0.140 - 0.262	0.140	8
5	0.262 - 0.568	0.262	9
6	> 0.568	0.568	31

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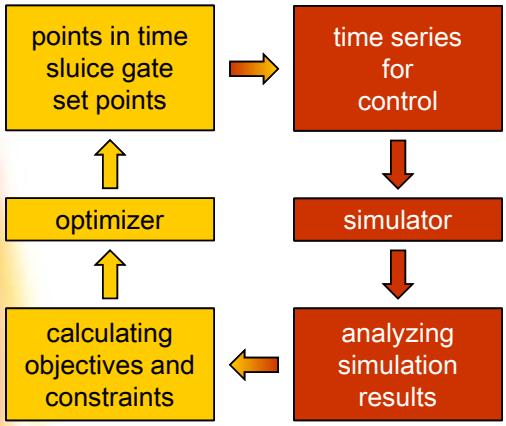
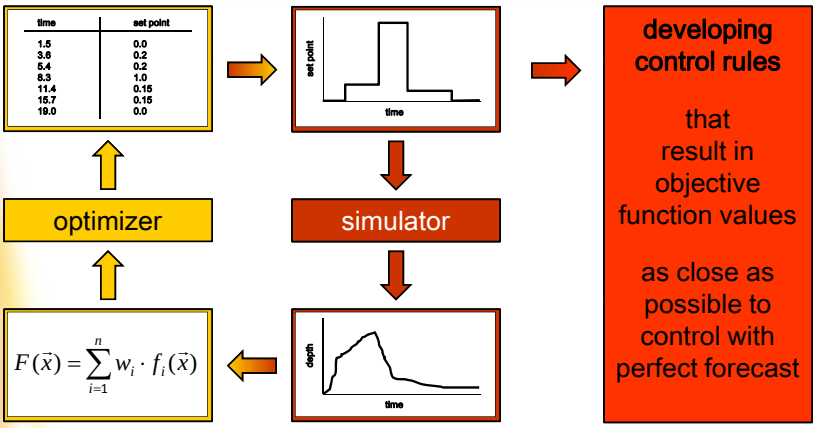
Control strategies
Objectives

- Decrease loads of TSS
  and agglomerated contaminants
  by increasing time for sedimentation
- Decrease hydraulic peaks
  by limiting maximum outflow
- Avoid overflows

Control strategies
Optimization with perfect forecast



Control strategies
Optimization with perfect forecast



developing control rules

that result in objective function values

as close as possible to control with perfect forecast

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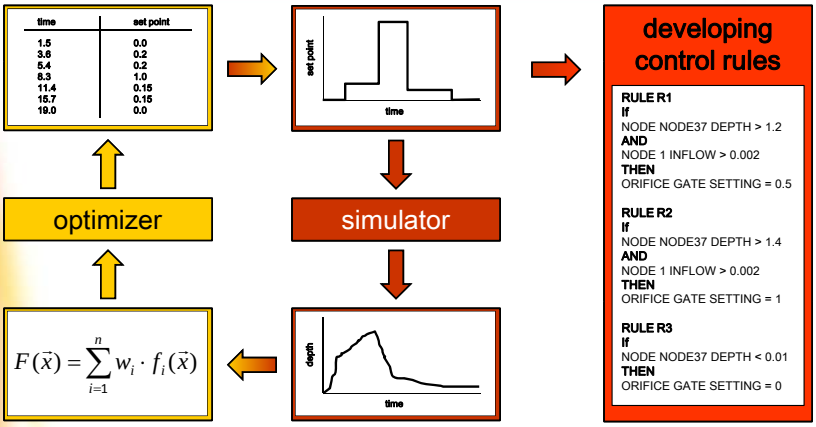
Control strategies
Optimization with perfect forecast



developing control rules

RULE R1
If
NODE NODE37 DEPTH > 1.2
AND
NODE 1 INFLOW > 0.002
THEN
ORIFICE GATE SETTING = 0.5

RULE R2
If
NODE NODE37 DEPTH > 1.4
AND
NODE 1 INFLOW > 0.002
THEN
ORIFICE GATE SETTING = 1

RULE R3
If
NODE NODE37 DEPTH < 0.01
THEN
ORIFICE GATE SETTING = 0

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Control strategies
Derived rules

- Static control
  - Fixed maximum outflow between 15 and 150 l/s (~3 l/(s*ha) and ~33 l/(s*ha)
- Dynamic Control (basic set)
  - **If** runoff **then** close outlet
  - **If** runoff and defined water levels are reached **then** open outlet to a defined percentage
  - **If** defined maximum water level is reached **then** open outlet completely

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Control strategies
Derived rules

Dynamic Control (updated)

- Volume free-up control
  - Basic set
  - **If** stormwater is stored longer than time span needed to settle finest particles **then** open outlet to a defined percentage

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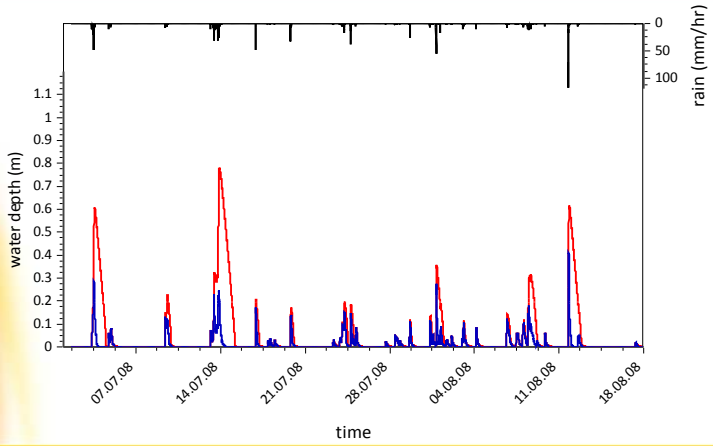
Results
Hydraulic behavior stormwater basin



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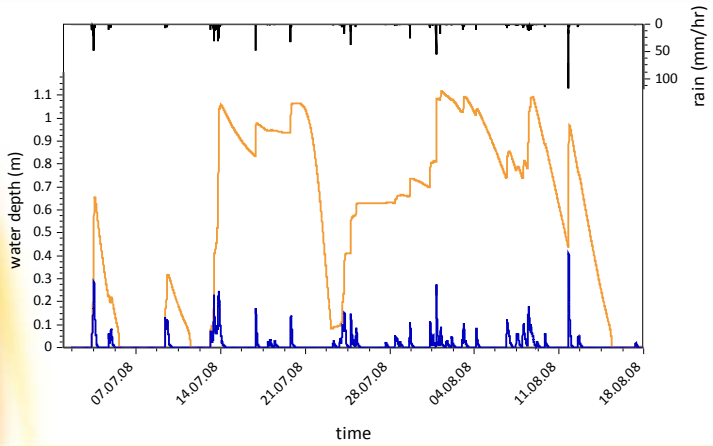
Results
Hydraulic behavior stormwater basin



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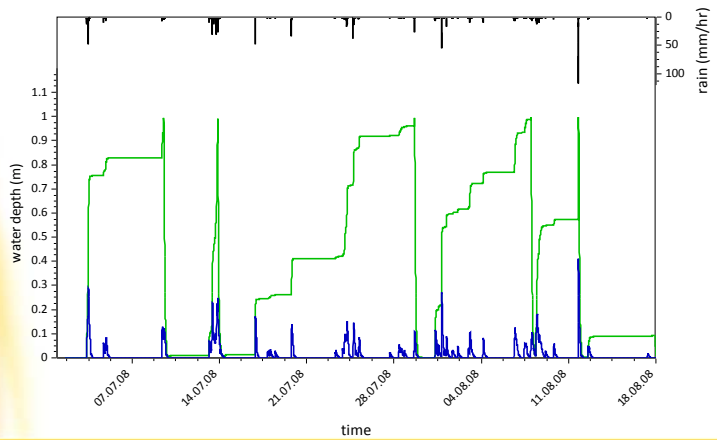
Results
Hydraulic behavior stormwater basin



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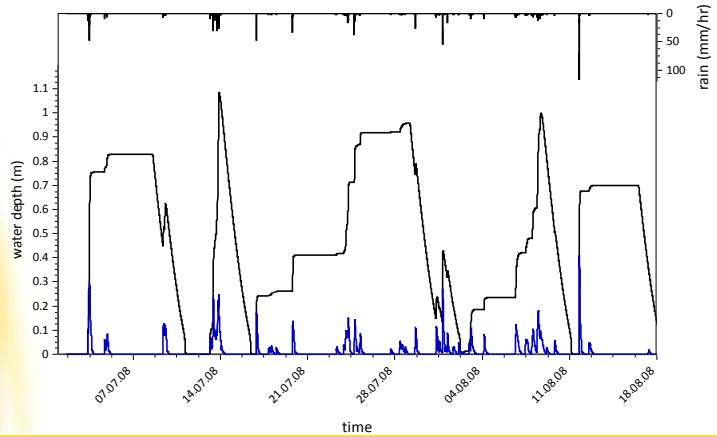
Results
Hydraulic behavior stormwater basin



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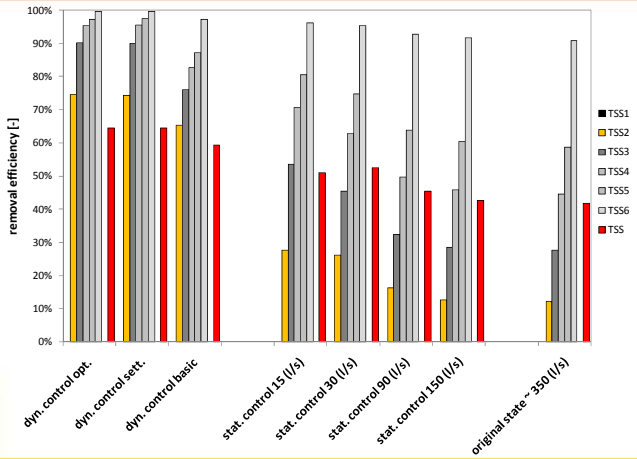
Results
TSS removal efficiency



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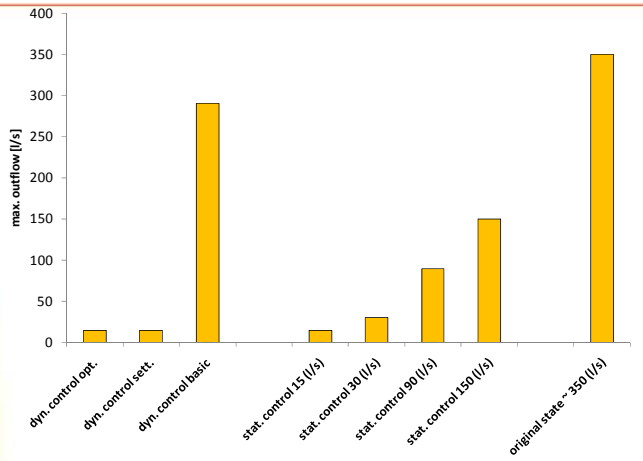
Results
Max. outflow



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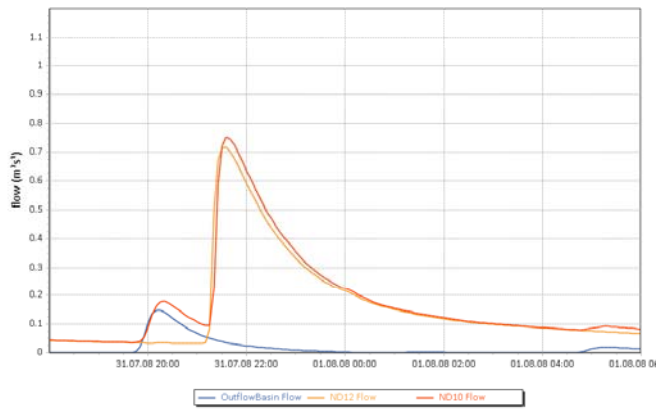
Results
Hydraulic impact – current state



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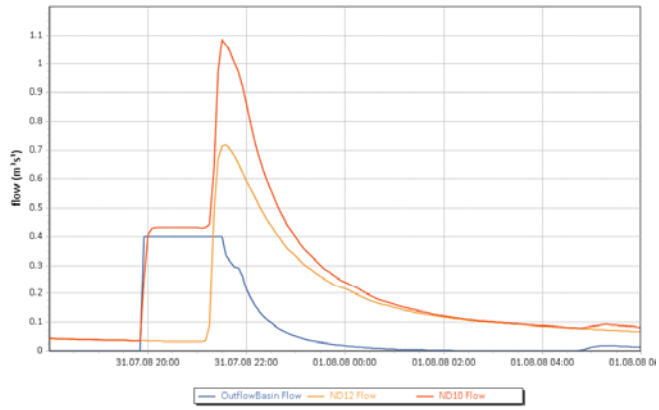
Results
Hydraulic impact – dyn. control basic



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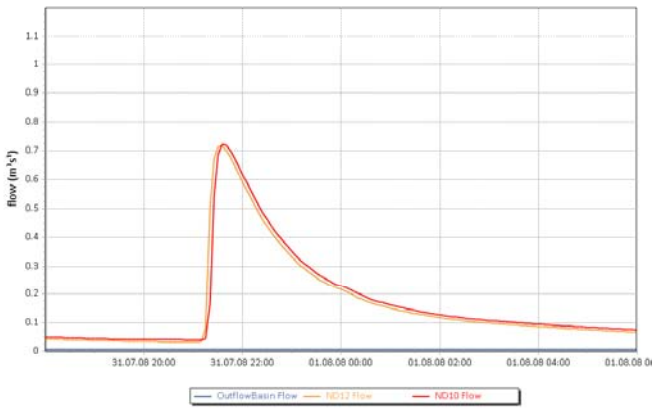
Results

Hydraulic impact – dyn. control sett.



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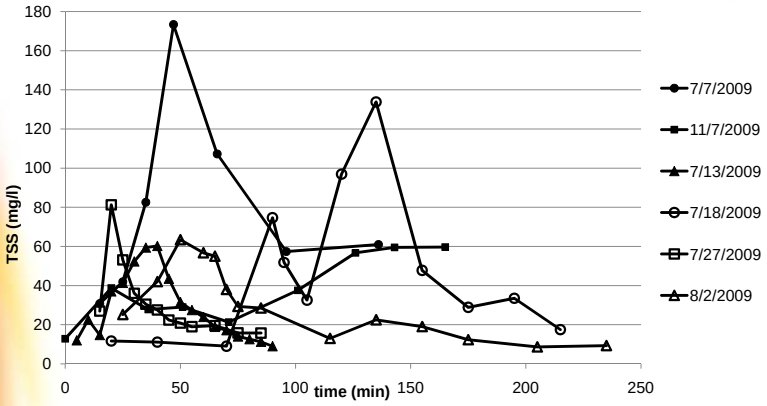
Conclusion

Measurement results TSS outlet



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Conclusion
Measurement results TSS outlet

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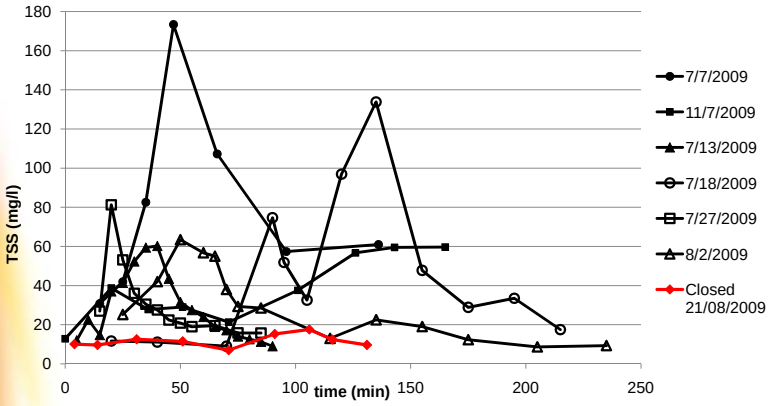
Conclusion
Measurement results TSS outlet



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Conclusion and outlook

- RTC of stormwater basins is an effective solution for reducing the suspended solids discharge
- Dynamic control enables removal efficiencies for fine particles and associated contaminants much higher than the current state
- At the same time hydraulic peaks can be reduced
- Incorporating of rainfall forecast ensembles in control rules

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