Sewer Network Model of a City with a Medium Sized Population

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Summary

1. Introduction
2. Structure of the Sewer Network
3. The Influent
4. Performance Indicators
5. Simulation Results
6. Conclusions

1. Introduction

General OBJECTIVE:

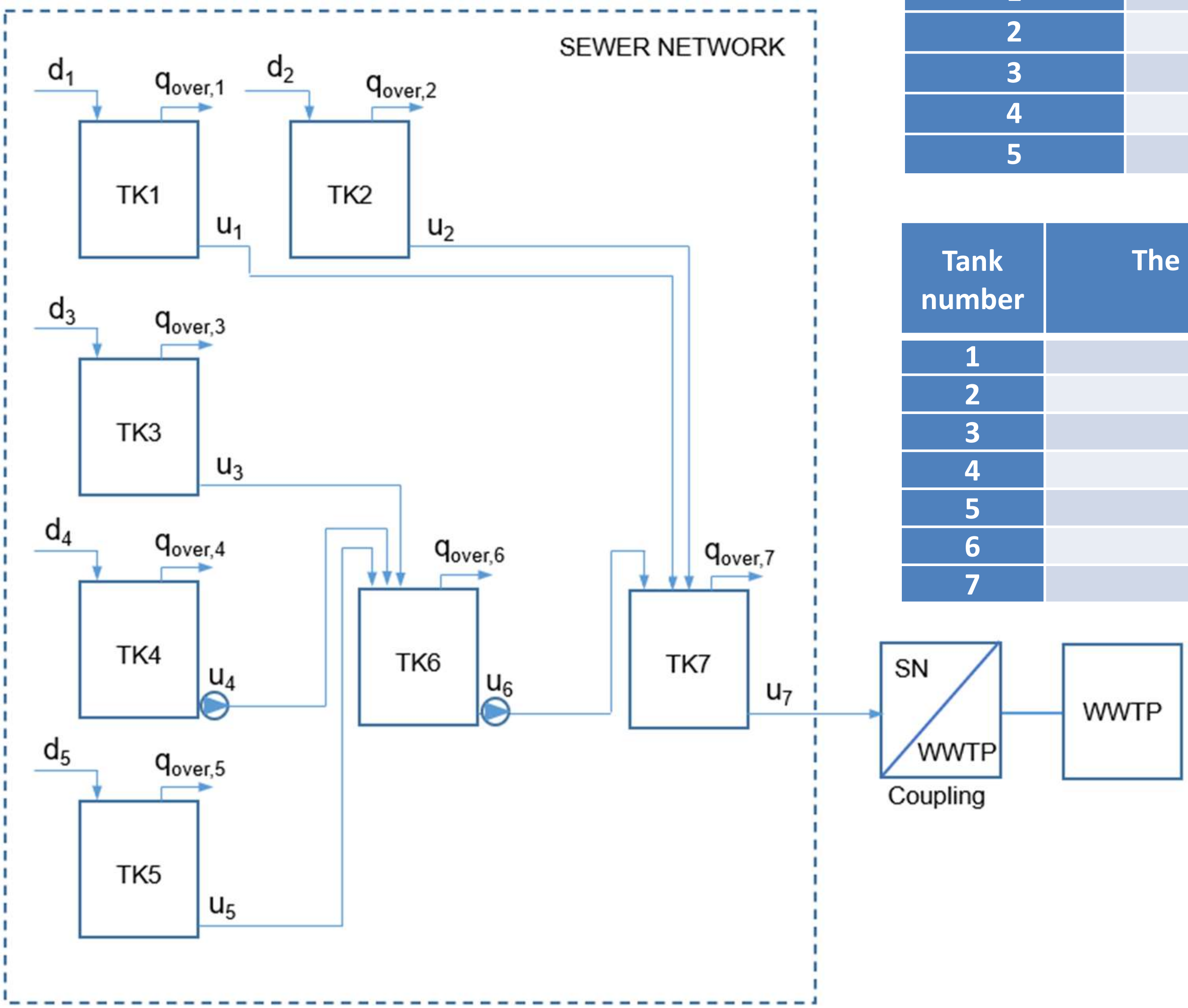
- development of a model of a wastewater system that serves a city with a medium sized population, and which can be used later to optimize the system in terms of volume and quality of discharged water.

The development of this model followed the steps:

- Modeling of the sewer network (SN) - BSM sewer benchmark.
- Defining a 28-days influent
- Simulation of the model in various control scenarios and analyzing the performance indicators

2. Structure of the Sewer Network

The scheme of the sewer network.

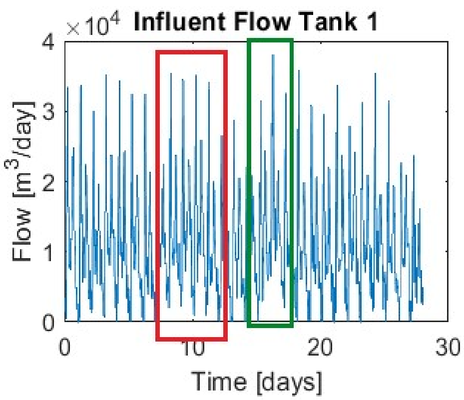


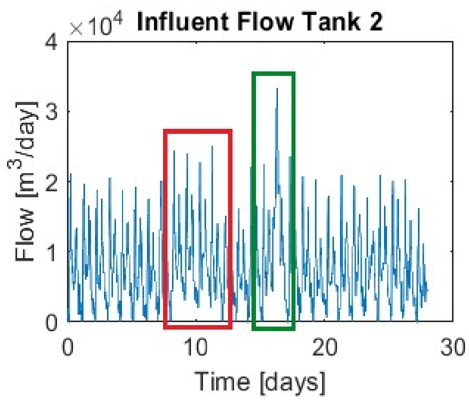
Collecting area number	Collecting area surface [ha]	The population served [number of inhabitants]
1	2500	75000
2	5000	50000
3	6000	40000
4	7500	60000
5	3500	25000

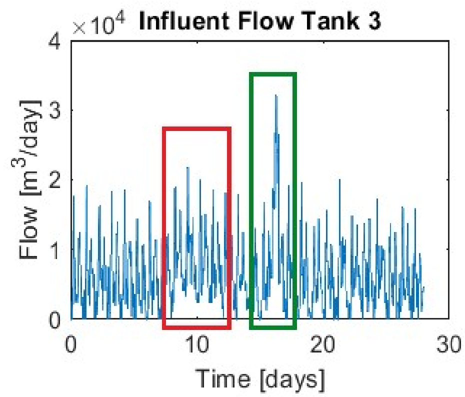
Tank number	The tank volume $[m^3]$	Maximum flow at the tank output $[m^3/day]$
1	3750	33750
2	2500	22500
3	2000	18000
4	3000	15000
5	3750	18750
6	2083	25000
7	2500	112500

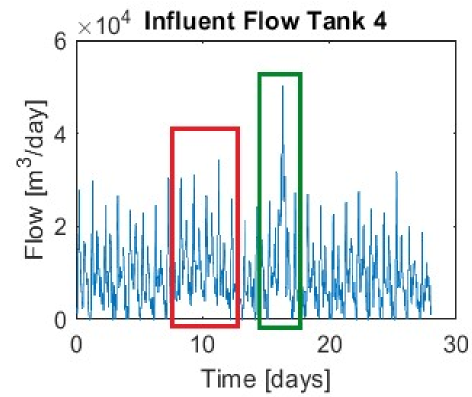
3. The Influent (1)

The influent in SN tanks





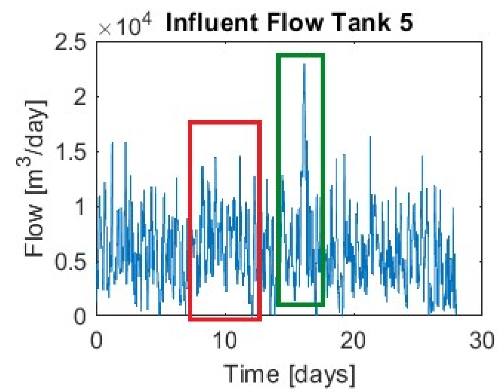




Simulation horizon - 28 days

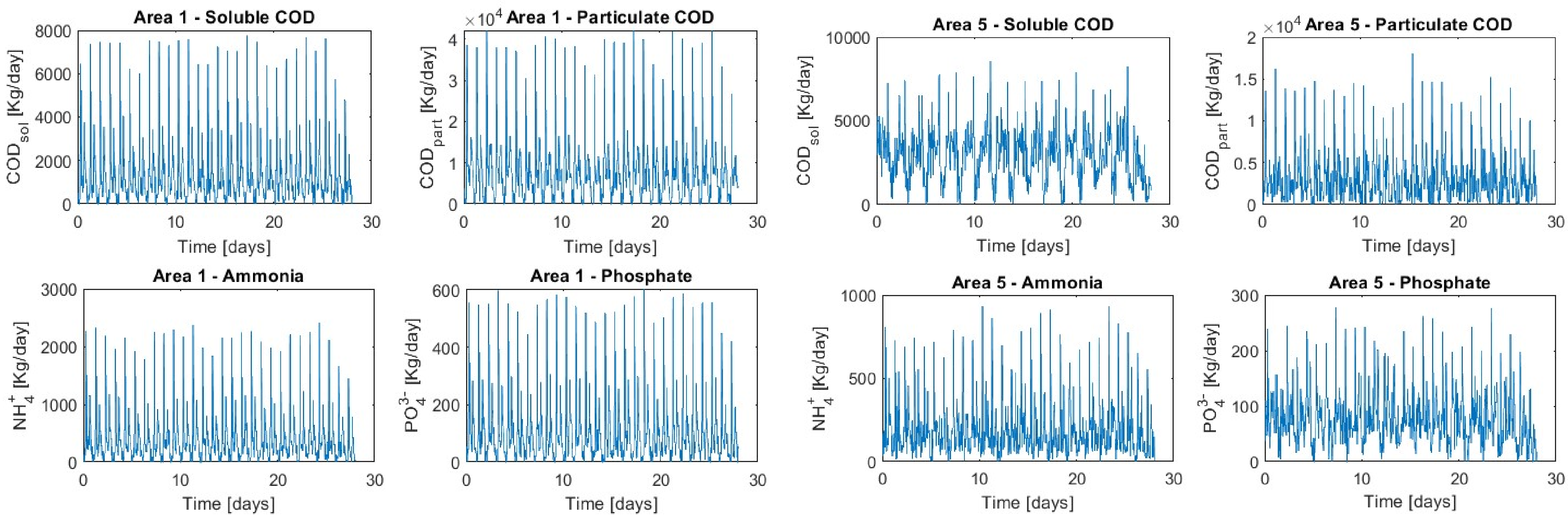
Pluviometric events:

- a rain event - red
- a storm event - green



3. The Influent (2)

The SN influent loads



Area no.	CODsol [kg/day]	CODpart [kg/day]	NH_4+ [kg/day]	PO_4^{3-} [kg/day]	Flow [m³/day]
1	720.71	4607.6	220.84	57.05	7786.2
2	487.97	3104.7	143.80	38.26	5283.0
3	421.18	2693.0	121.91	30.95	4400.5
4	589.17	3789.9	182.30	44.36	6369.4
5	2742.60	2051.3	132.67	61.22	4771.9

Area no.	CODsol [g/m³]	CODpart [g/m³]	NH_4+ [g/m³]	PO_4^{3-} [g/m³]
1	92.57	591.78	28.67	7.33
2	92.37	587.68	27.22	7.25
3	93.67	611.97	27.71	7.04
4	92.50	595.03	28.62	6.97
5	574.74	429.87	27.81	12.83

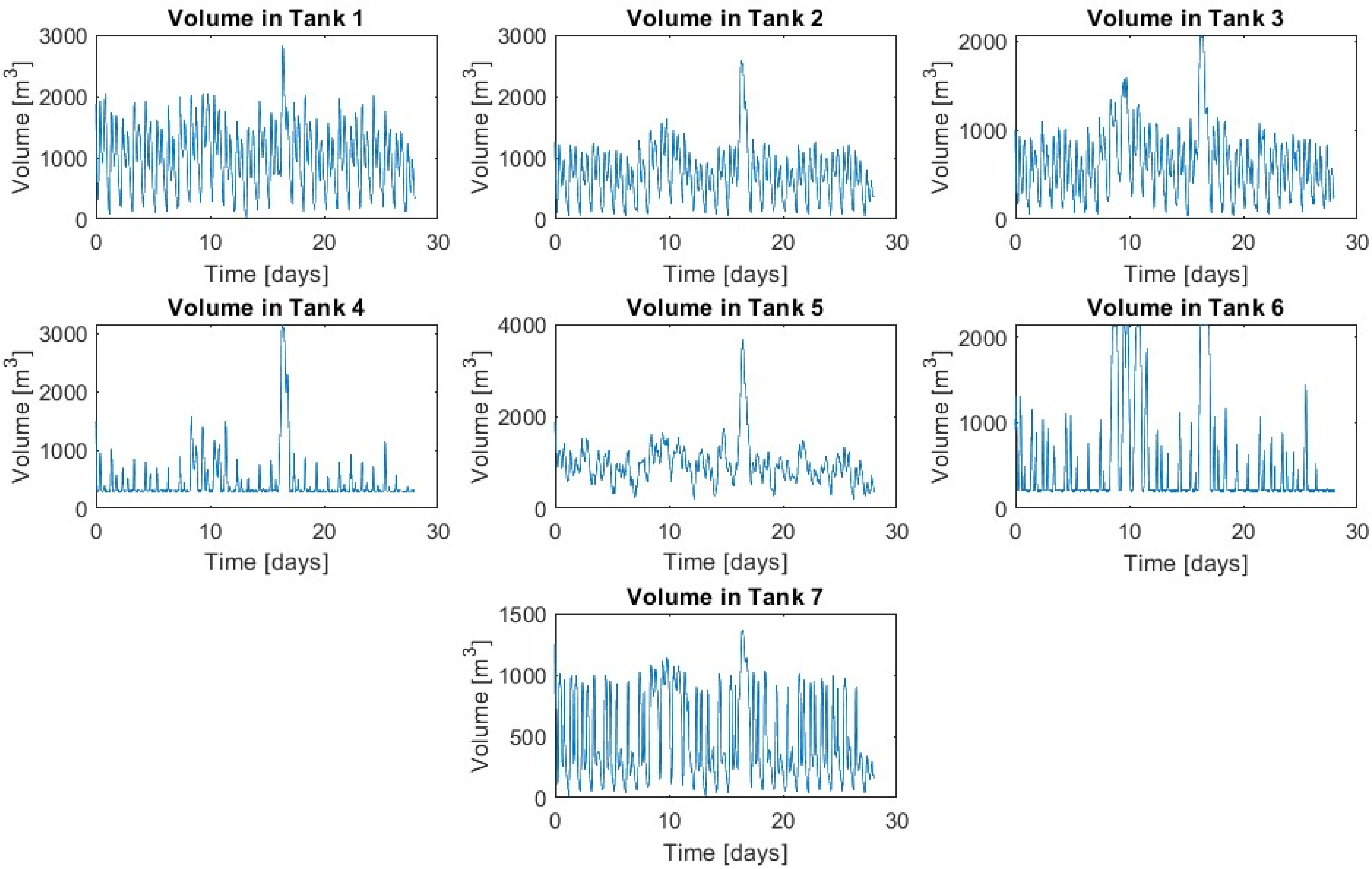
4. Performance Indicators

The analyzed performance indicators

Indicator	Unit	Description
N_{ovf}	1 / year	Frequency of discharges
T_{ovf}	days / year	Duration of discharges
V_{ovf}	m^3 / year	Volume of discharges
OQI	kg-polluting units / day	Discharge Quality Index
$C_{max,TSS}$	gCOD / m^3	Maximum concentration of TSS / hour
$C_{max,TKN}$	gN / m^3	Maximum concentration of TKN / hour
$C_{max,PO4}$	gP / m^3	Maximum concentration of PO_4 / hour
$T_{exc,TSS}$	days / year	Annual duration of exceedances for TSS
$T_{exc,TKN}$	days / year	Annual duration of exceedances for TKN
$T_{exc,PO4}$	days / year	Annual duration of exceedances for PO_4

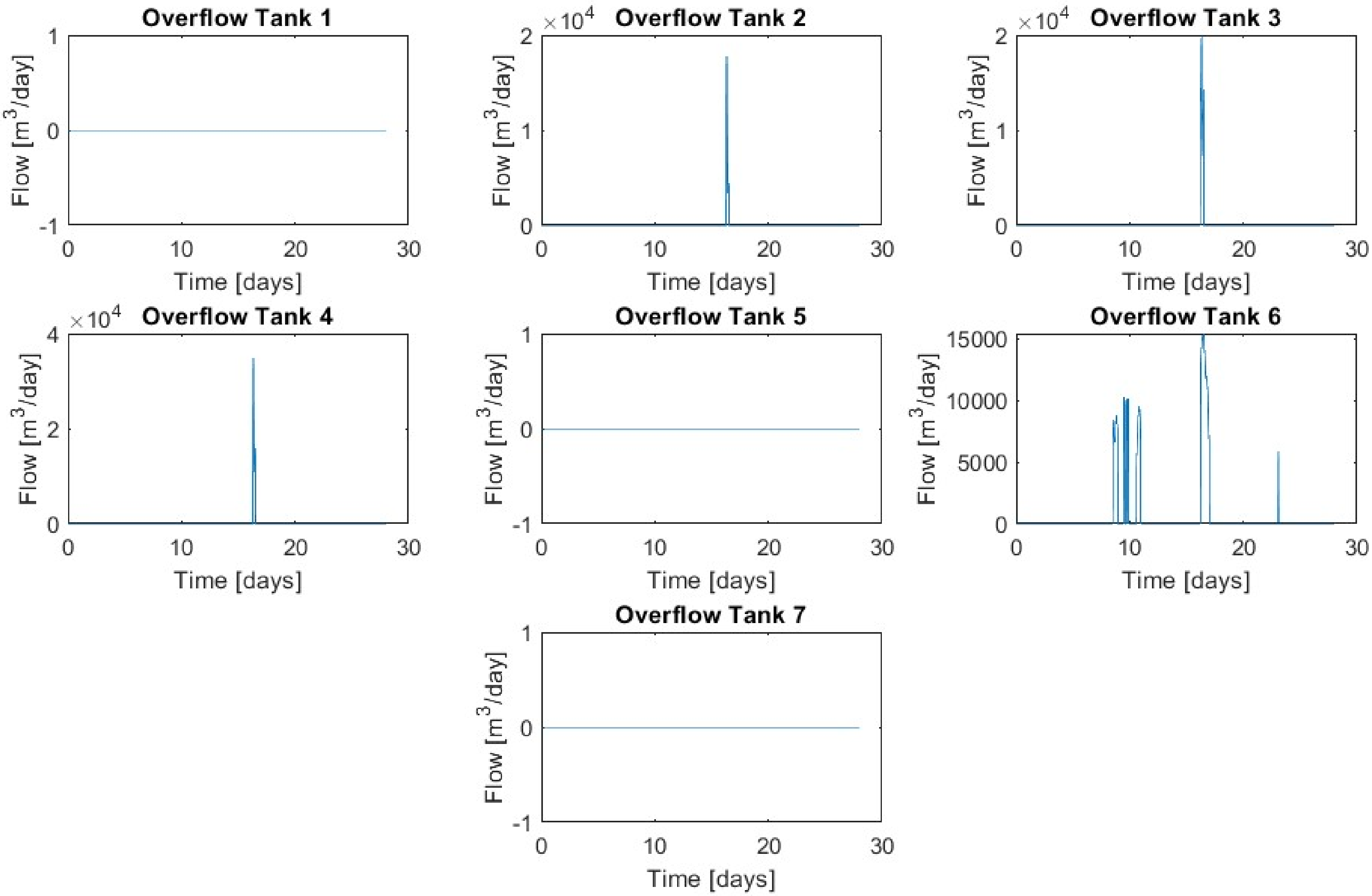
5. Simulation results (1)

Wastewater volumes evolution in SN tanks – no control applied



5. Simulation results (2)

SN tanks overflows – no control applied



5. Simulation results (3)

SN tanks performance indicators – no control applied

Tank no.	N_{ovf} [/year]	T_{ovf} [days/year]	V_{ovf} [m³/year]	OQI	$C_{max,TSS}$ [gCOD/m³]	$C_{max,TKN}$ [gN/m³]	$C_{max,PO4}$ [gP/m³]	$T_{exc,TSS}$ [days/year]	$T_{exc,TKN}$ [days/year]	$T_{exc,PO4}$ [days/year]
1	0	0	0	0	0	0	0	0	0	0
2	13	3	22729	192	402.1	46.7	6.7	2.9	3	3
3	13	4	50202	743	1082	79.5	6.1	3.7	4.1	3.3
4	13	3	55134	1365	1450	97.8	6	2.9	3	3
5	0	0	0	0	0	0	0	0	0	0
6	65	29	241600	3830	1143.5	77.9	10.8	28.2	28.5	28.5
7	0	0	0	0	0	0	0	0	0	0
Global	65	29	369665	6131	1450	97.8	10.8	28.7	29.1	28.5

5. Simulation results (3)

SN tanks performance indicators – TK3 outlet valve at 70%

Tank no.	N_{ovf} [/year]	T_{ovf} [days/year]	V_{ovf} [m³/year]	OQI	$C_{max,TSS}$ [gCOD/m³]	$C_{max,TKN}$ [gN/m³]	$C_{max,PO4}$ [gP/m³]	$T_{exc,TSS}$ [days/year]	$T_{exc,TKN}$ [days/year]	$T_{exc,PO4}$ [days/year]
1	0	0	0	0	0	0	0	0	0	0
2	13	3	22730	192	402.1	46.7	6.7	2.9	3	3
3	78	14	63193	878	1086.8	80.1	8.9	12.2	12.2	12.2
4	13	3	55138	1365	1450	97.8	6	2.9	3	3
5	0	0	0	0	0	0	0	0	0	0
6	78	27	217910	3469	1145.5	78.2	10.5	27.2	27.4	27.4
7	0	0	0	0	0	0	0	0	0	0
Global	91	30	358970	5905	1450	97.8	10.5	30.3	30.3	30.3

5. Simulation results (3)

SN tanks performance indicators – TK3 outlet valve at 70% and TK4 outlet pump running at 70%

Tank no.	N_{ovf} [/year]	T_{ovf} [days/year]	V_{ovf} [m³/year]	OQI	$C_{max,TSS}$ [gCOD/m³]	$C_{max,TKN}$ [gN/m³]	$C_{max,PO4}$ [gP/m³]	$T_{exc,TSS}$ [days/year]	$T_{exc,TKN}$ [days/year]	$T_{exc,PO4}$ [days/year]
1	0	0	0	0	0	0	0	0	0	0
2	13	3	22737	192	402.1	46.7	6.7	2.9	3	3
3	78	14	63454	875	1086.8	80.1	8.9	12.2	12.2	12.2
4	117	17	101664	1748	1455	98.2	9.9	14.4	15.6	15.6
5	0	0	0	0	0	0	0	0	0	0
6	39	25	136648	2364	1149.7	78.7	9.1	24.6	24.6	24.6
7	0	0	0	0	0	0	0	0	0	0
Global	104	33	324502	5180	1455	98.2	9.9	32.7	32.7	32.7

6. Final conclusions.

The paper proposes a model of a sewer network containing 7 storage tanks designed to collect the wastewater from a medium sized city with a population of 250,000 inhabitants and a total surface of about 250 km^2.

The city contains 5 collecting areas with specific flow and loads. One of the collecting areas is serving the industrial part of the city.

The model was simulated in three situations (no control, TK3 outlet valve at 70% and TK3 outlet valve at 70% & TK4 outlet pump running at 70%) and for each situation series of ten performance indicators were calculated and analyzed.

This leads to the conclusion that there are combinations of commands of the outlet valves and pumps that would provide better results than if they were fully opened or running at 100%, resulting the need for an optimization of the operating regime of the sewer network in terms of volume and quality of discharged water.

The objective of the subsequent researches is to use the proposed model of the sewer network for the development of control algorithms (optimization) to achieve an efficient operation.

Thank you for your attention !