Sewer System Hydraulic Performance in Networks with Defects and Deteriorating Assets

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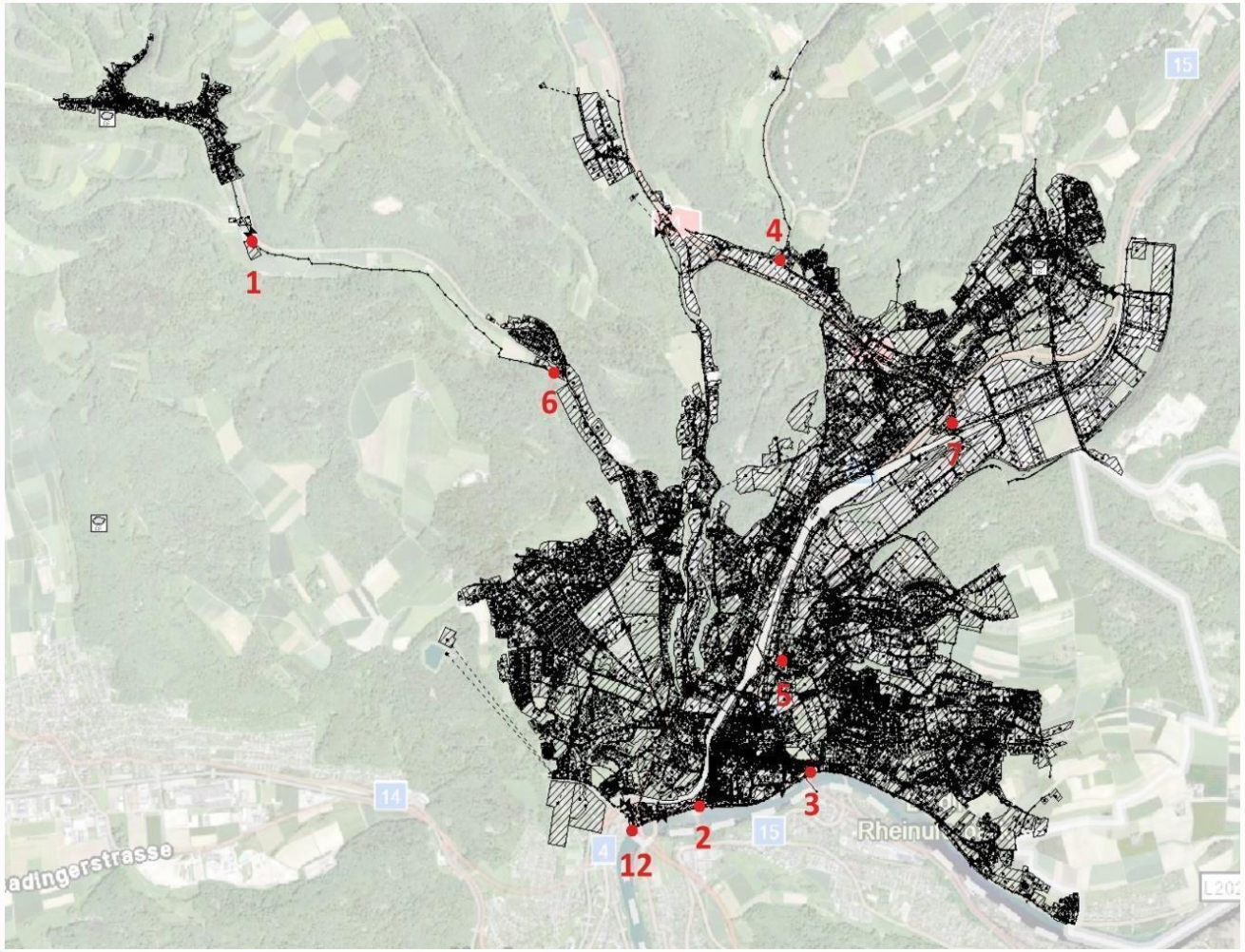
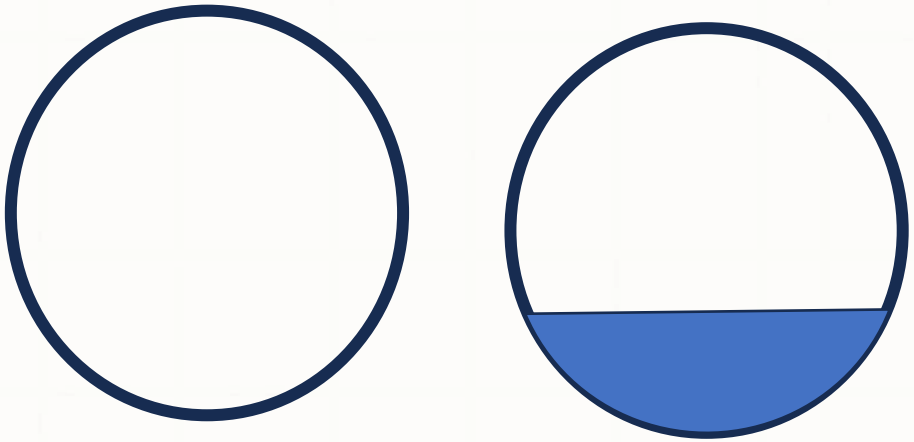
Co-UDlabs

Introduction

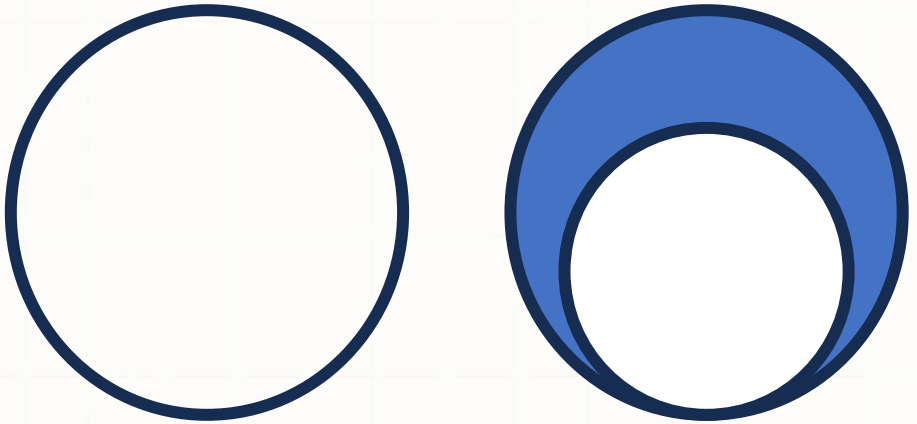


- Analysing sewer system hydraulic performance under influence of defect formation and asset condition deterioration.
- Vulnerability of assets to performance impacts caused by defects is examined by analysing the location and volume of flooding caused by the deteriorated pipe.
- Case study is performed with the sewer network at the town of Schaffhausen, which stands on the right bank of the River Rhine.
- Two types of defects are examined:
  - siltation (distributed deterioration)
  - root intrusion in pipes (discrete defects)
- Effect of defects on the overflows is analysed.

Defect simulation

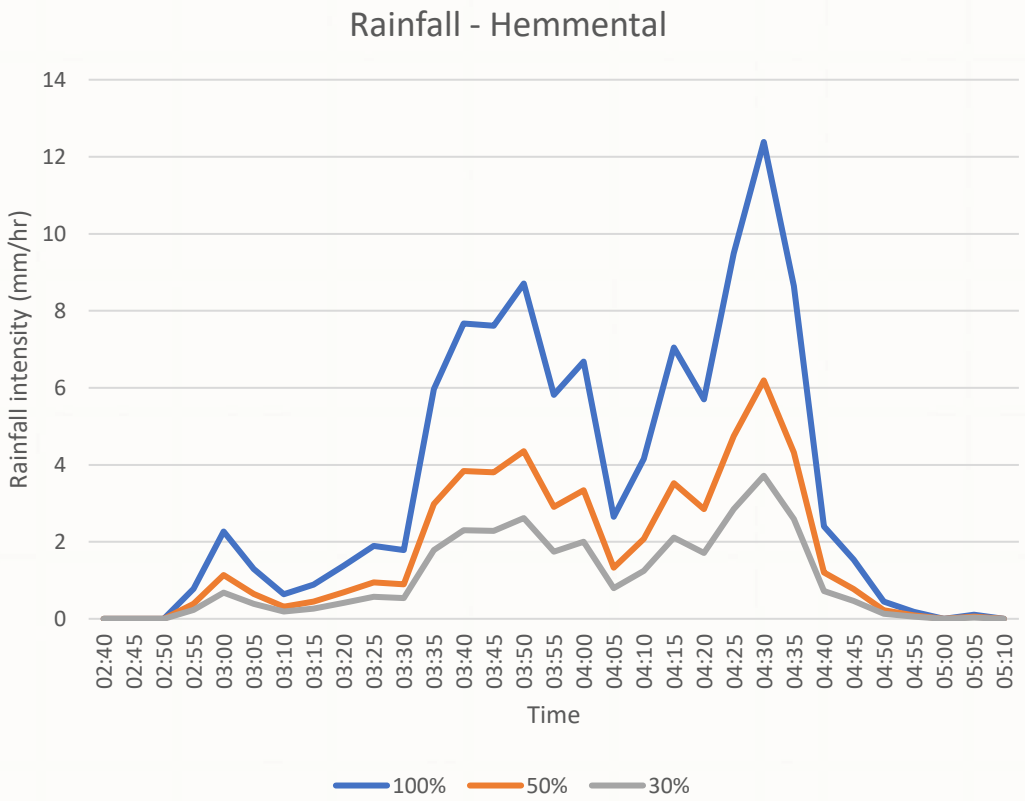


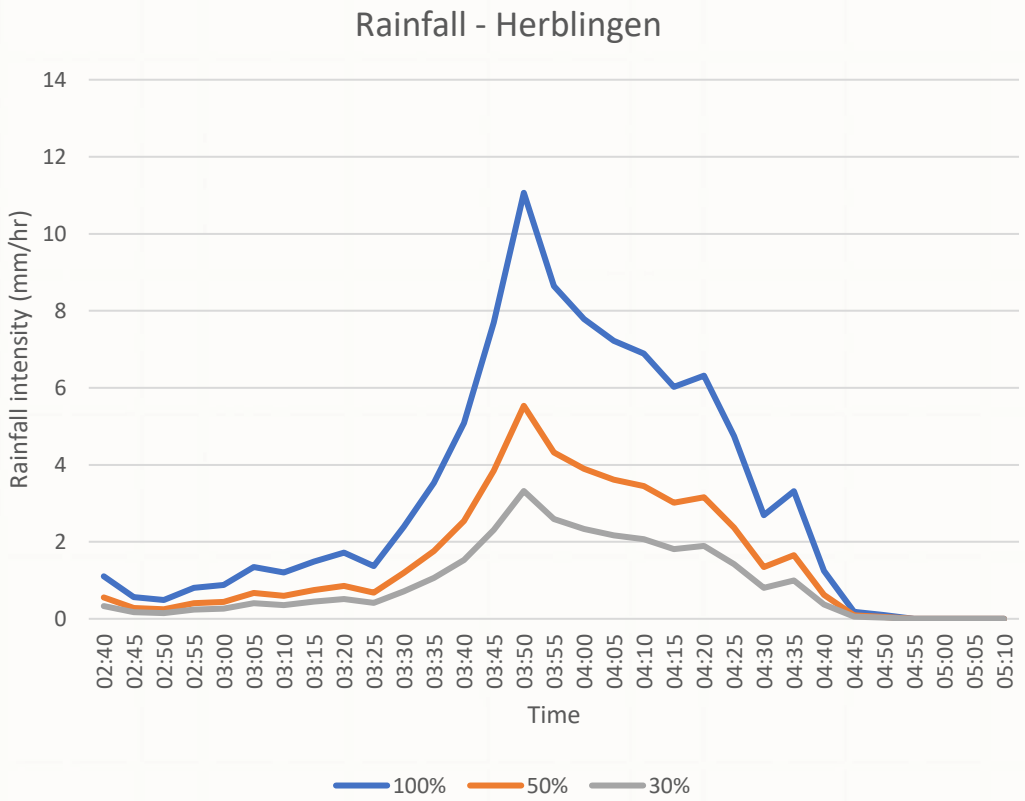
Defect type 1:
Siltation
Filled bottom



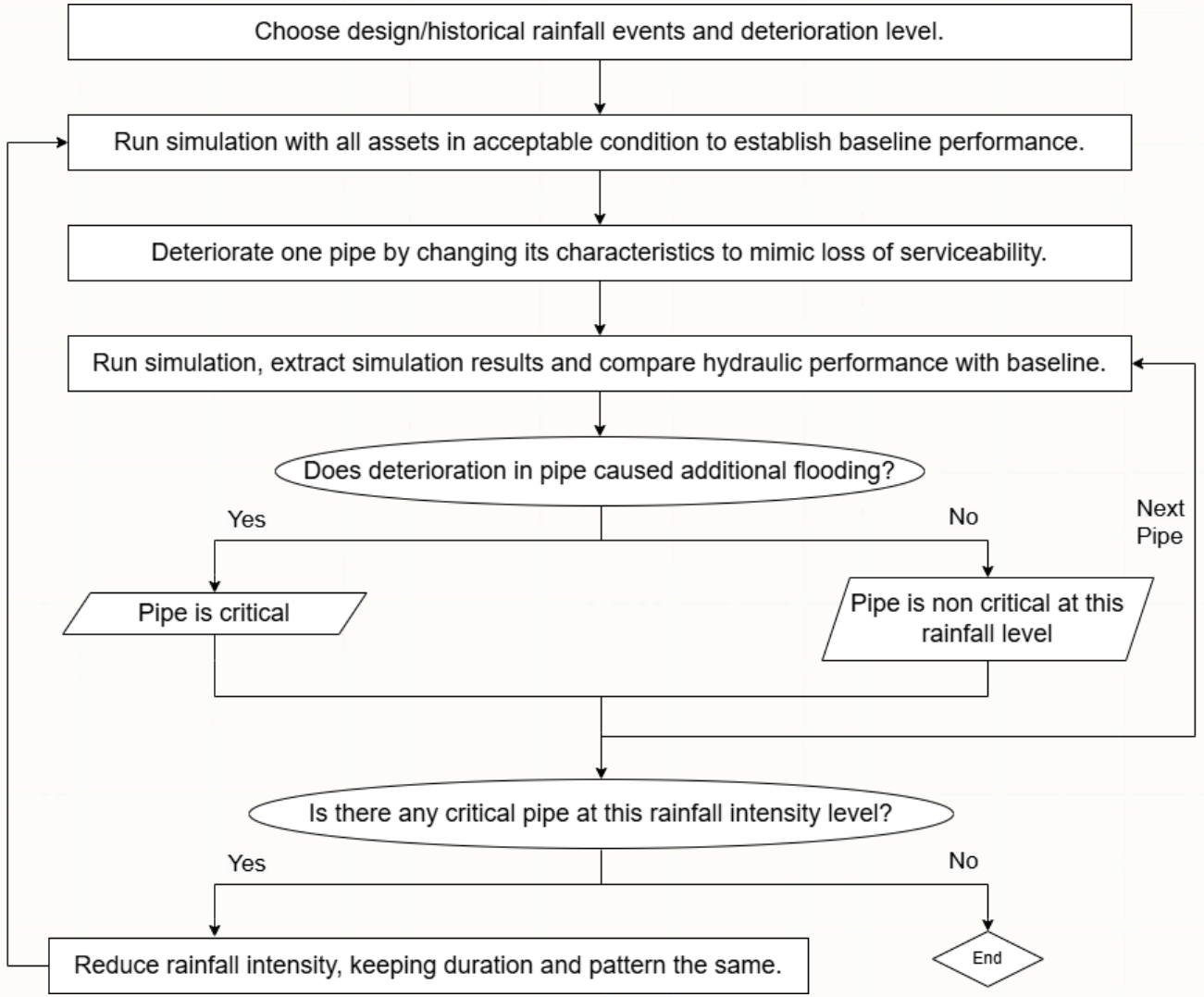
Defect type 2:
Root intrusion
Reduction in diameter

Rainfall


Rainfall - Hemmental
Rainfall intensity (mm/hr)
14
12
10
8
6
4
2
0
02:40
02:45
02:50
02:55
03:00
03:05
03:10
03:15
03:20
03:25
03:30
03:35
03:40
03:45
03:50
03:55
04:00
04:05
04:10
04:15
04:20
04:25
04:30
04:35
04:40
04:45
04:50
04:55
05:00
05:05
05:10
Time
100%
50%
30%


Rainfall - Herblingen
Rainfall intensity (mm/hr)
14
12
10
8
6
4
2
0
02:40
02:45
02:50
02:55
03:00
03:05
03:10
03:15
03:20
03:25
03:30
03:35
03:40
03:45
03:50
03:55
04:00
04:05
04:10
04:15
04:20
04:25
04:30
04:35
04:40
04:45
04:50
04:55
05:00
05:05
05:10
Time
100%
50%
30%

Methodology

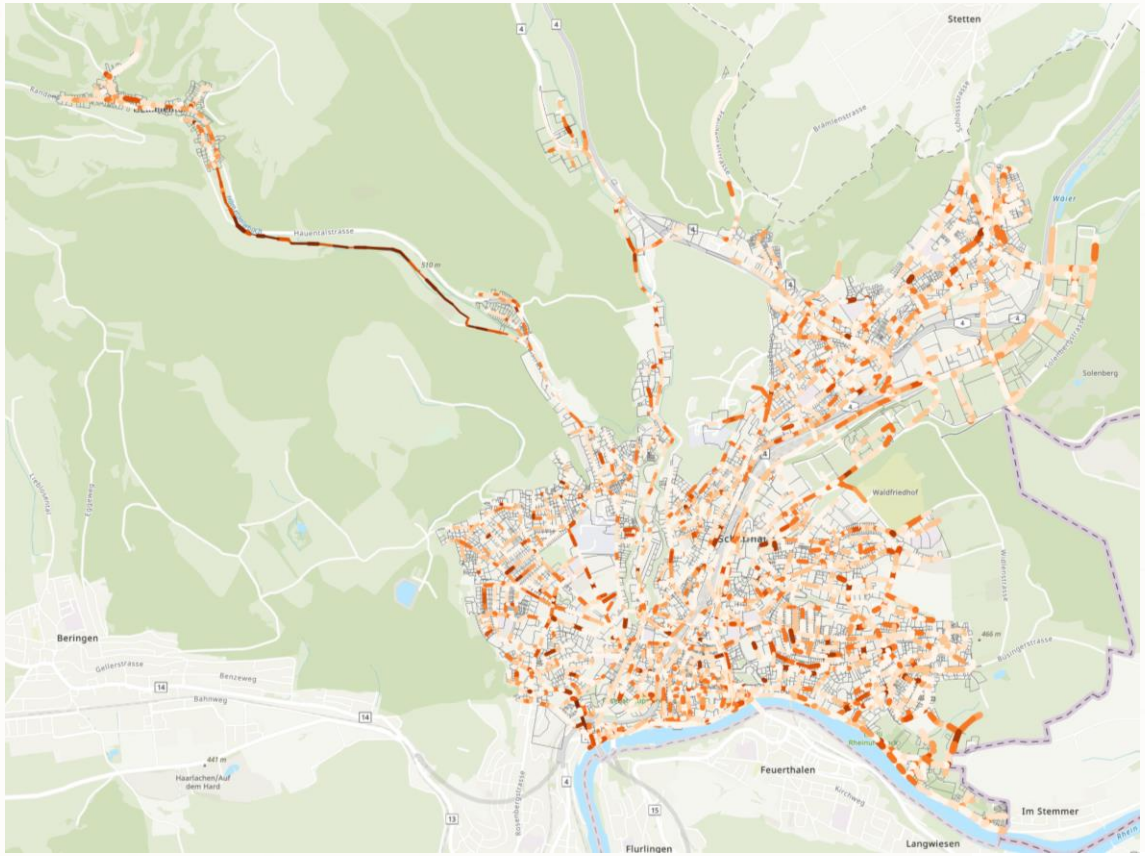


Time of Simulation for one event:

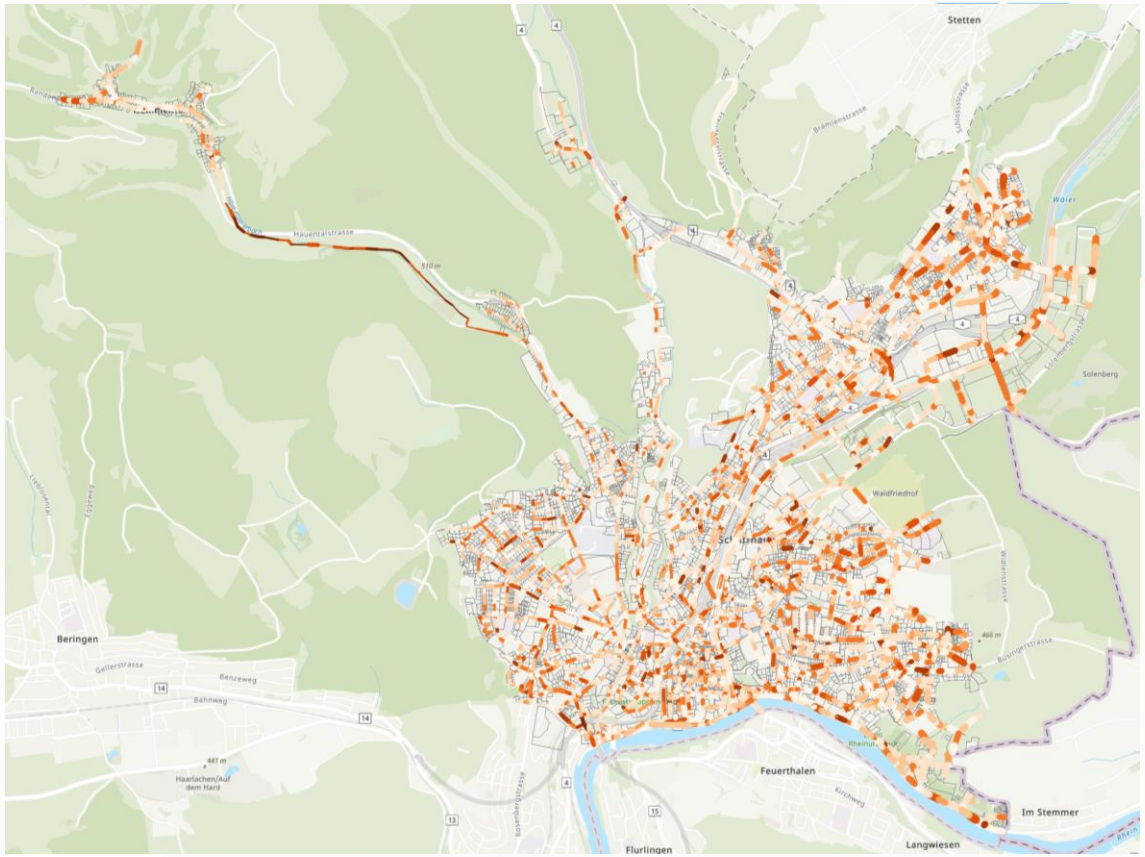
One pipe: 6 min

All pipes (parallel programming) : 36 hours 46 min

Additional Flood Loss - 100% Rainfall



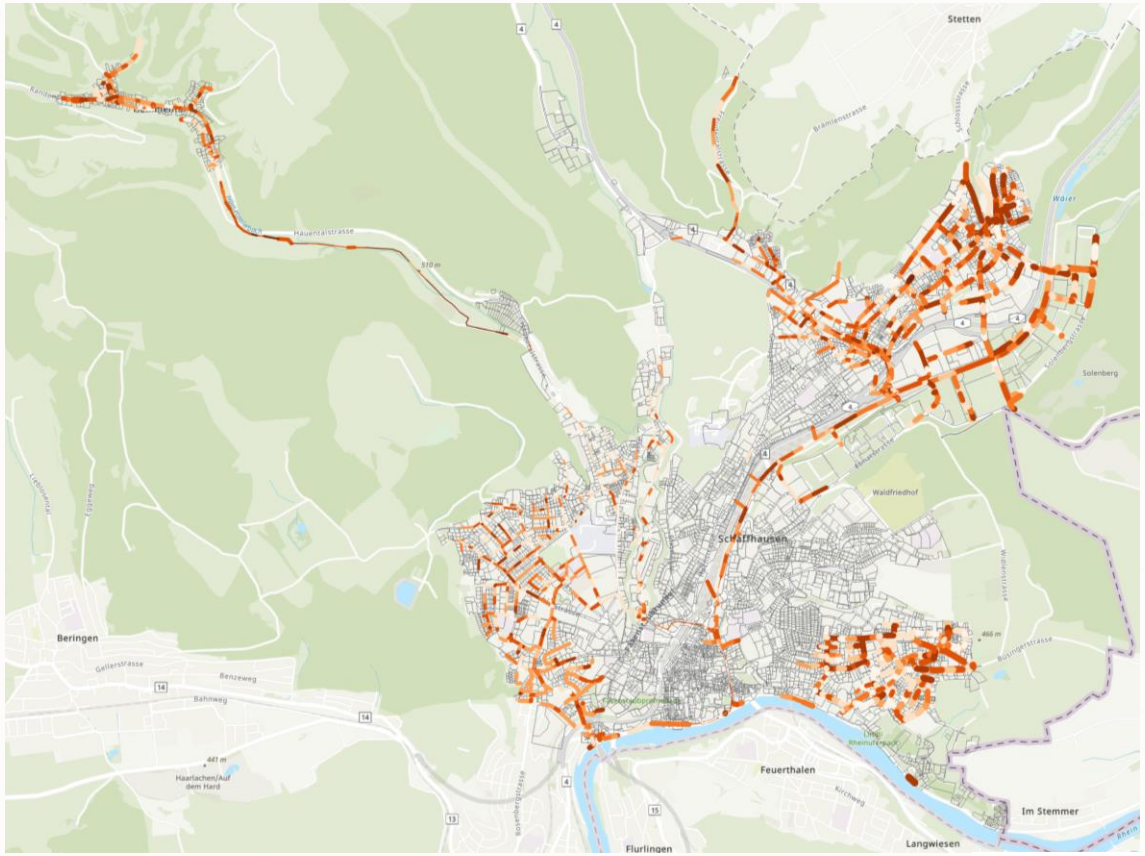
Siltation



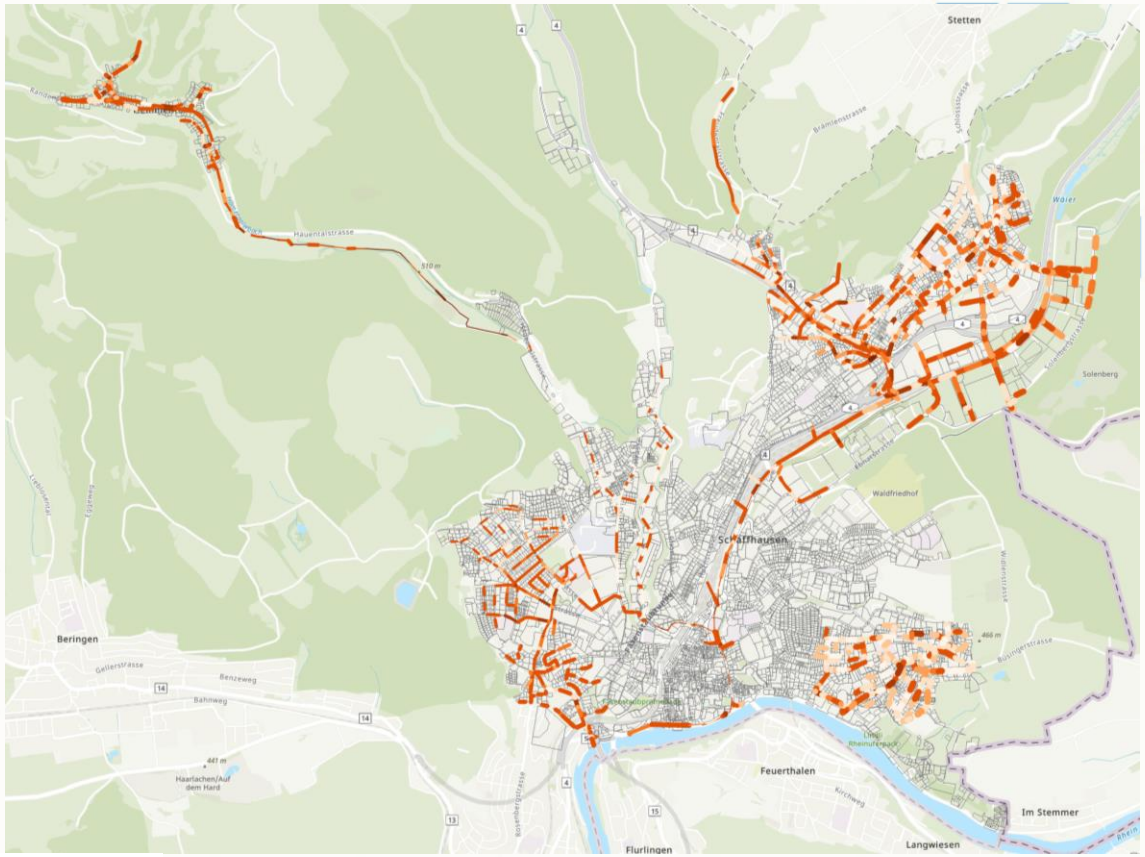
Top Intrusion

Symbol	Label
	0.000% - 0.002%
	0.002% - 0.032%
	0.032% - 0.052%
	0.052% - 0.077%
	0.077% - 0.104%
	0.104% - 0.141%
	0.141% - 0.208%
	0.208% - 0.327%
	0.327% - 6.600%
	6.600% - 100.000%

Additional Flood Loss - 50% Rainfall



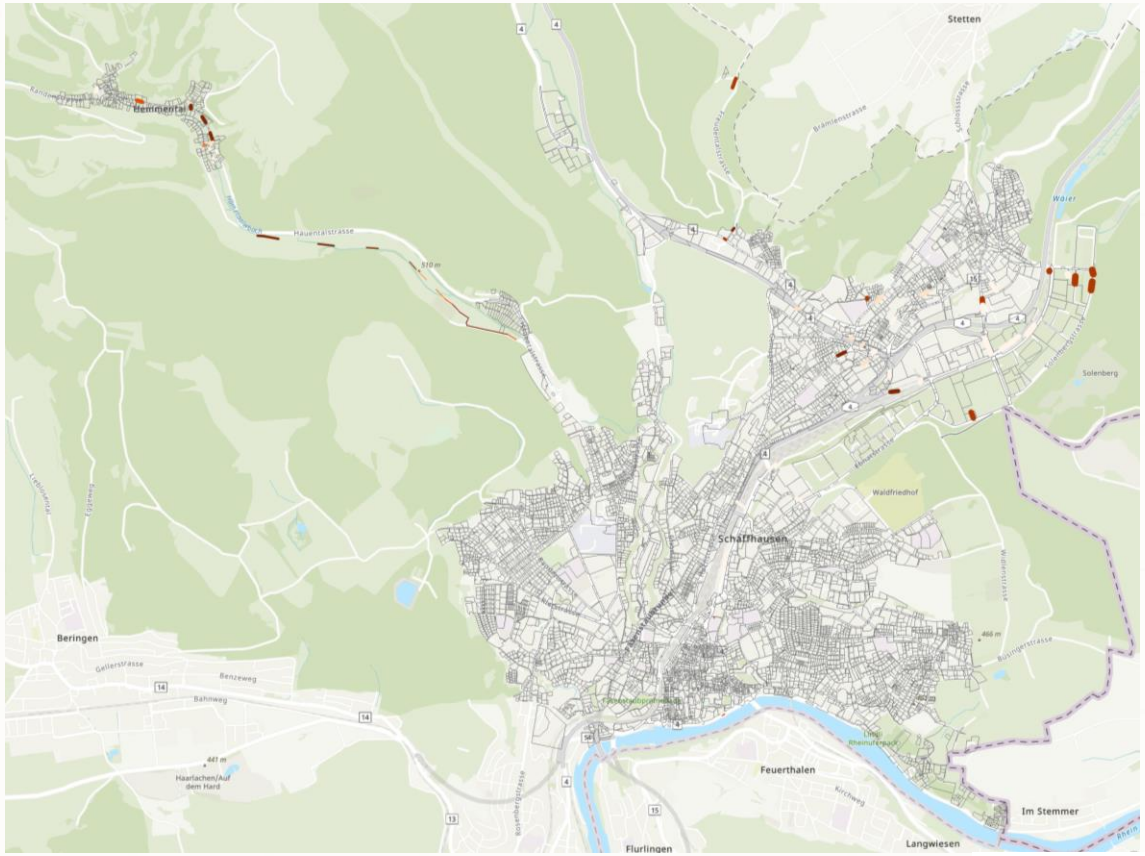
Siltation



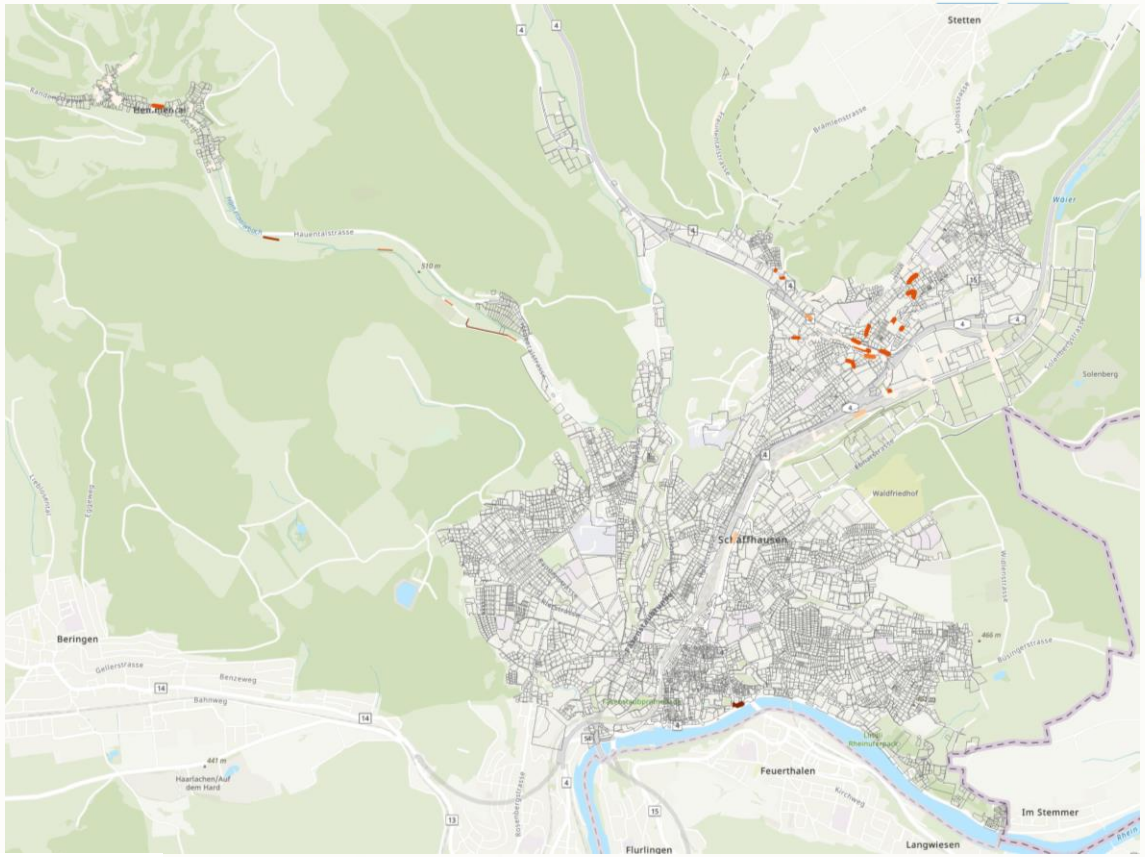
Top Intrusion

Symbol	Label
	0.000% - 0.002%
	0.002% - 0.032%
	0.032% - 0.052%
	0.052% - 0.077%
	0.077% - 0.104%
	0.104% - 0.141%
	0.141% - 0.208%
	0.208% - 0.327%
	0.327% - 6.600%
	6.600% - 100.000%

Additional Flood Loss - 30% Rainfall



Siltation



Top Intrusion

Symbol	Label
	0.000% - 0.002%
	0.002% - 0.032%
	0.032% - 0.052%
	0.052% - 0.077%
	0.077% - 0.104%
	0.104% - 0.141%
	0.141% - 0.208%
	0.208% - 0.327%
	0.327% - 6.600%
	6.600% - 100.000%

Summary

- number of pipes caused additional flooding vs rainfall volume

Rainfall volume ($m^3 \times 10^5$)	Number of pipes caused additional flooding	Percentage of pipes caused additional flooding
73.9 (100%)	4044	91.0%
36.9 (50%)	1799	40.5%
22.2 (30%)	76	1.7%
18.5 (20%)	0	0.0%

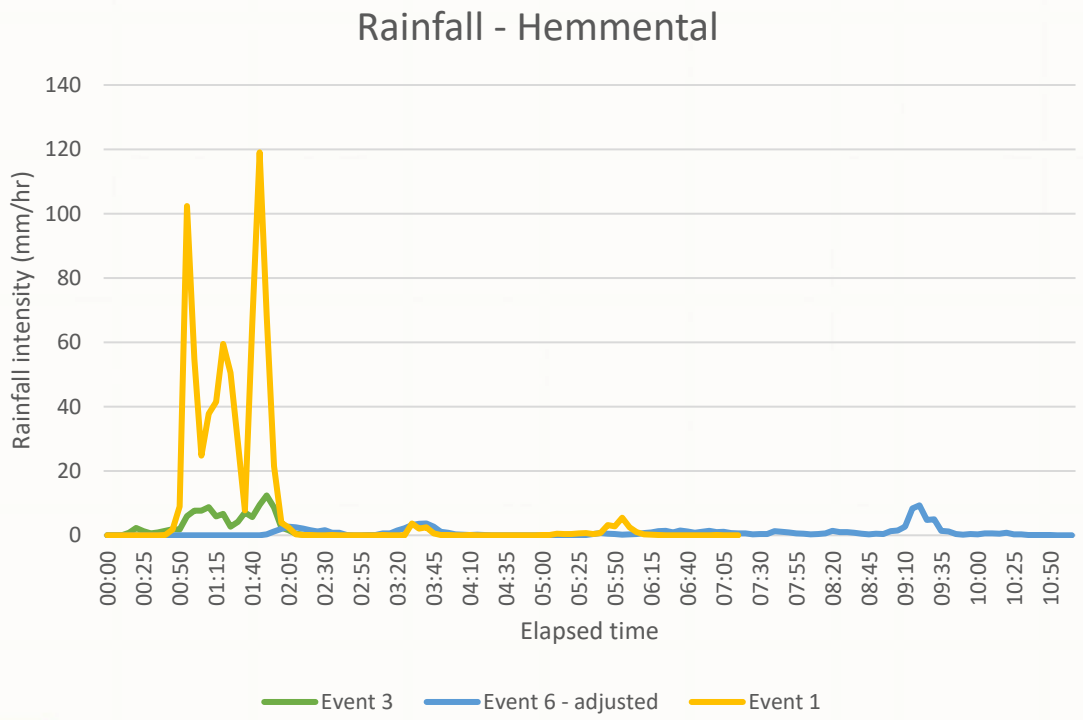
Siltation

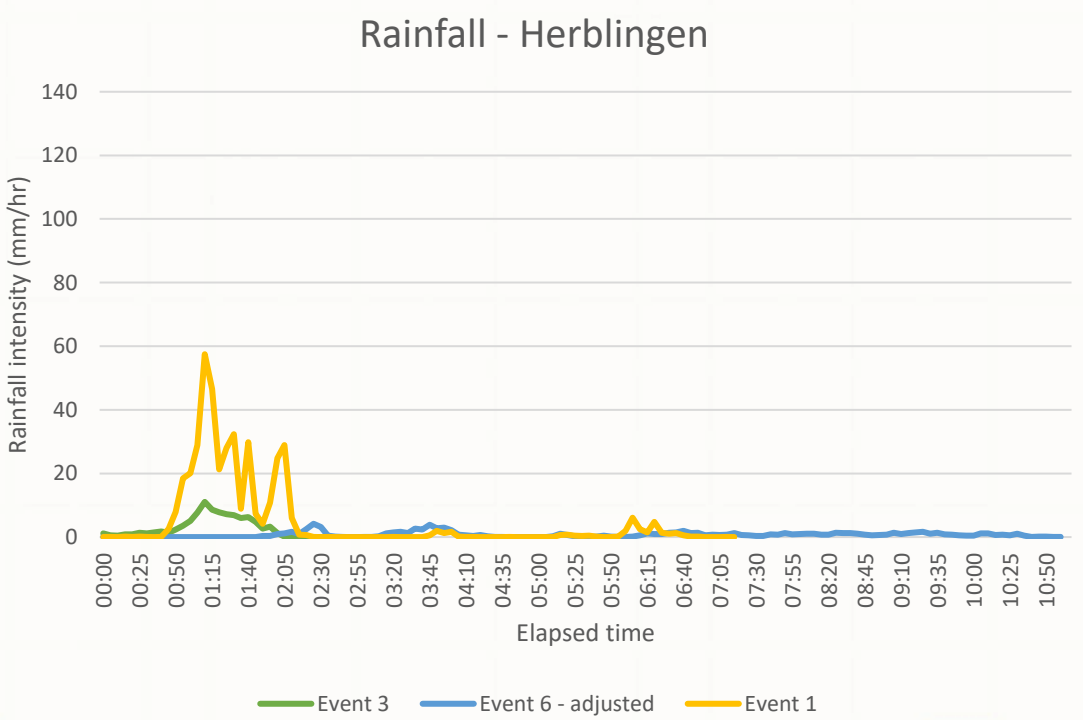
Rainfall volume ($m^3 \times 10^5$)	Number of pipes caused additional flooding	Percentage of pipes caused additional flooding
73.9 (100%)	4039	90.8%
36.9 (50%)	1337	30.1%
22.2 (30%)	125	2.8%
18.5 (20%)	0	0.0%

Top Intrusion

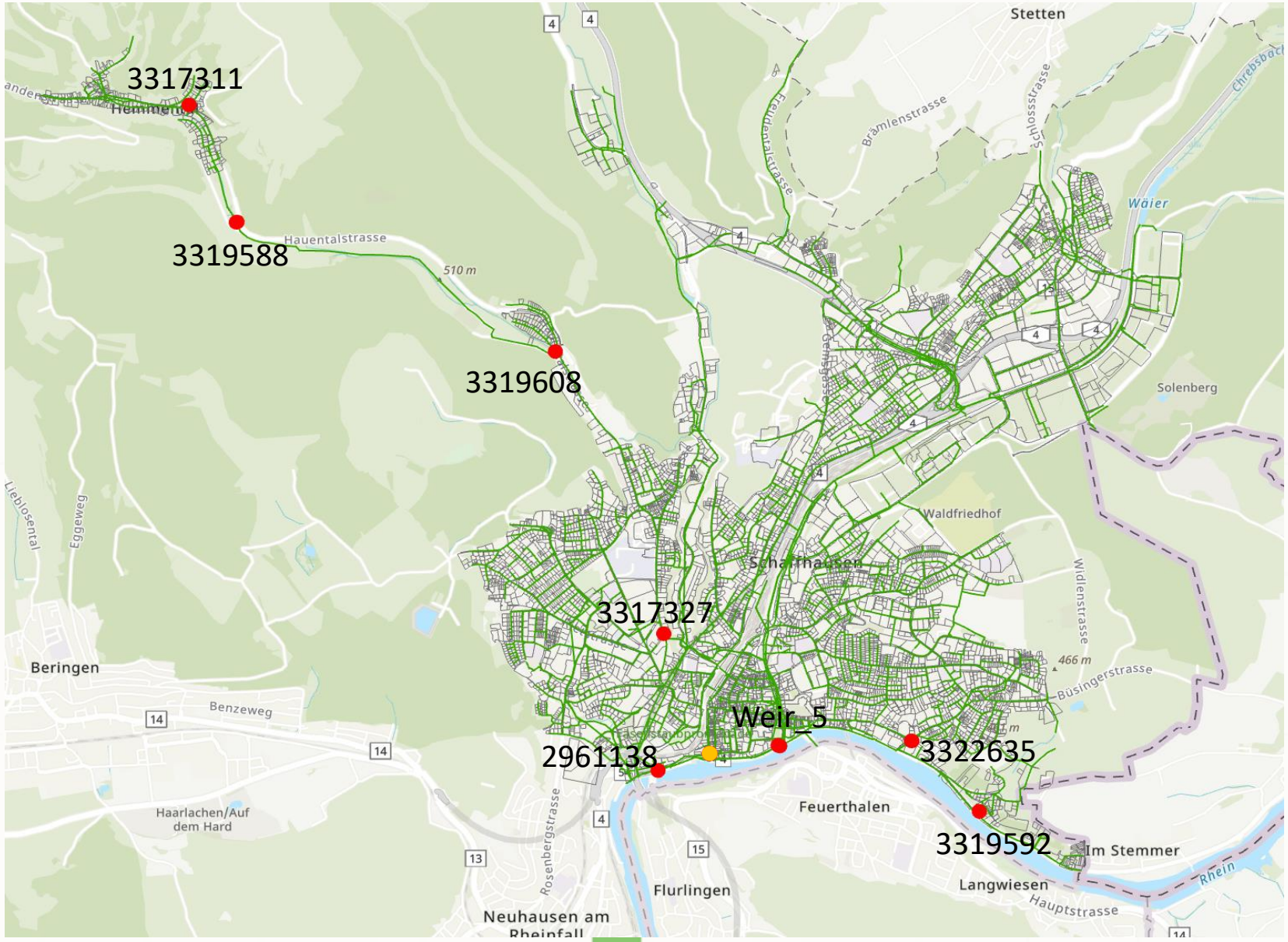
Overflow under various rainfall patterns and siltation

	Total Volume (mm)	Duration (hour)	Average (mm/hour)
Event 1	47.71	7.25	6.58
Event 3	8.50	2.5	3.40
Event 6 - adjusted	8.50	11.1	0.77



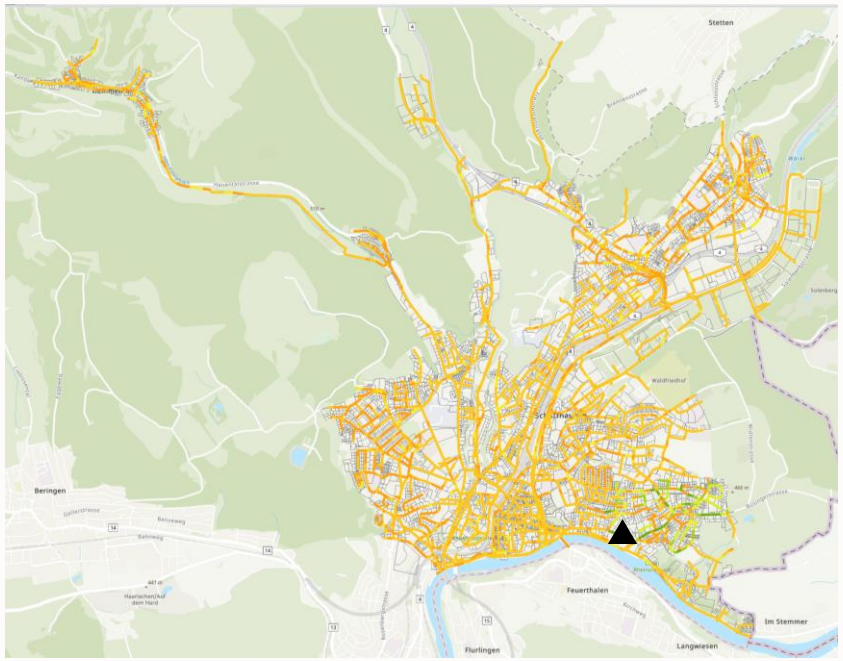


Overflow Locations

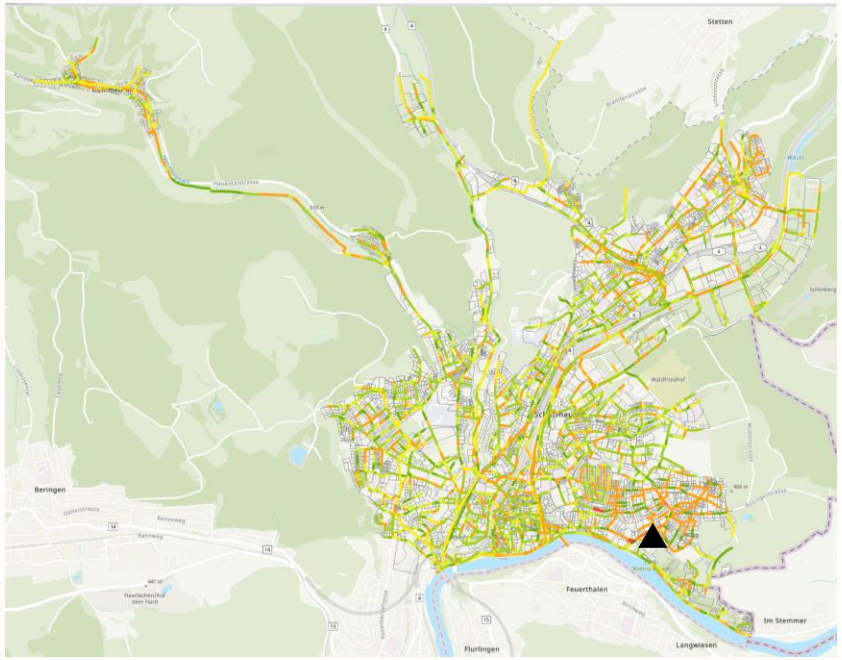


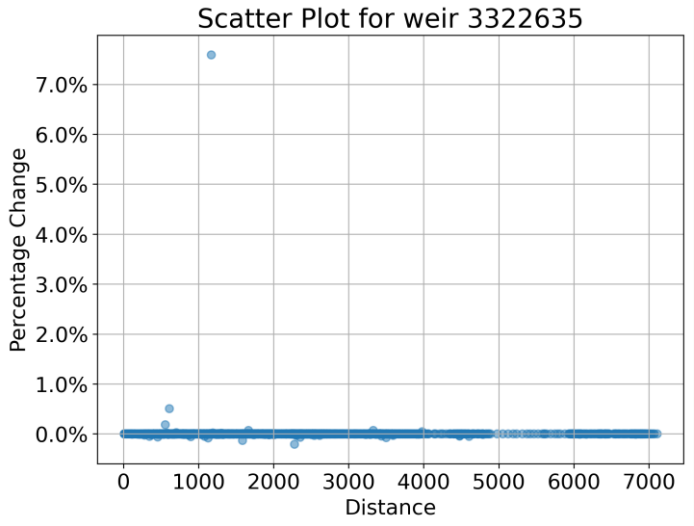
Overflow 3322635

Event 1

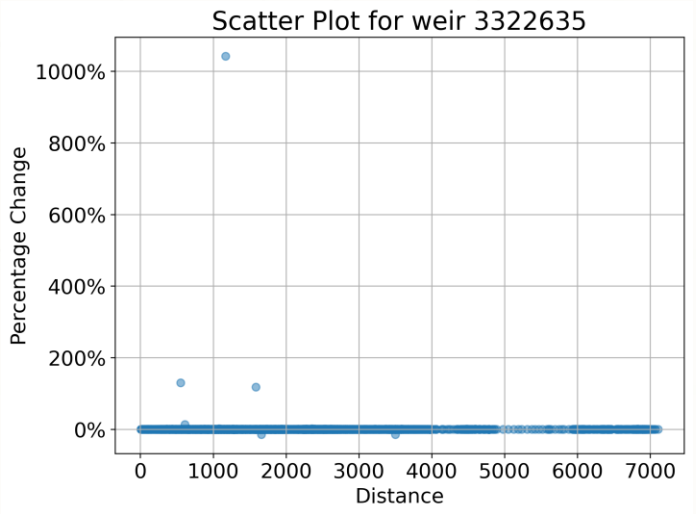


Event 3



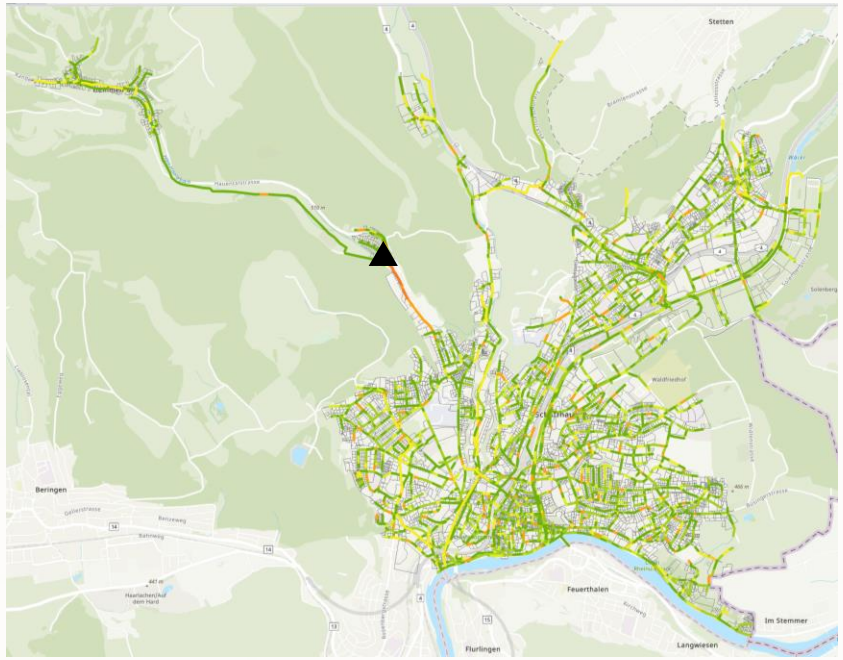


Symbol	Label
	-100.000% - -21.555%
	-21.555% - -5.150%
	-5.150% - -0.014%
	-0.014% - -0.004%
	-0.004% - -0.001%
	-0.001% - 0.000%
	0.000% - 0.000%
	0.000% - 0.570%
	0.570% - 13.000%
	13.000% - 1042.347%

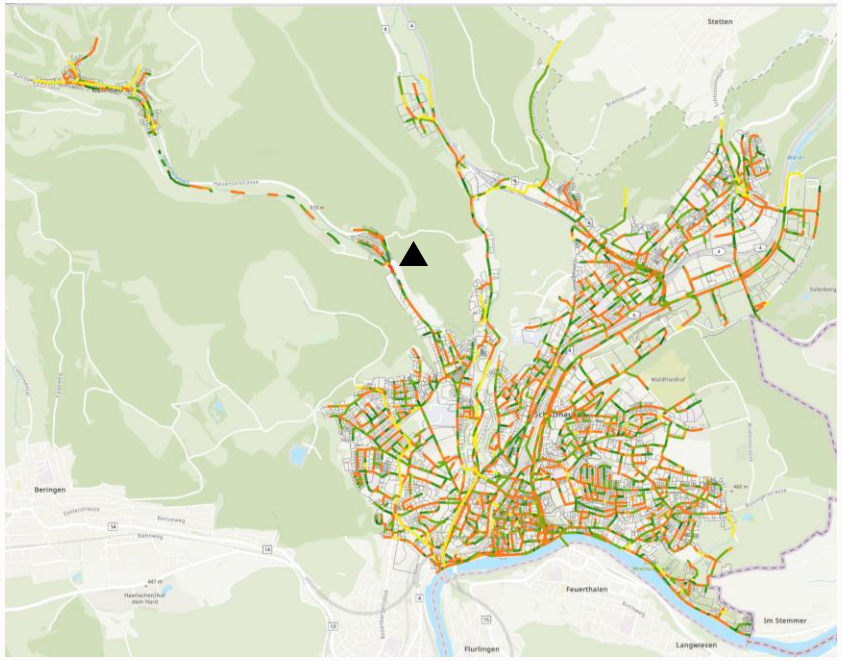


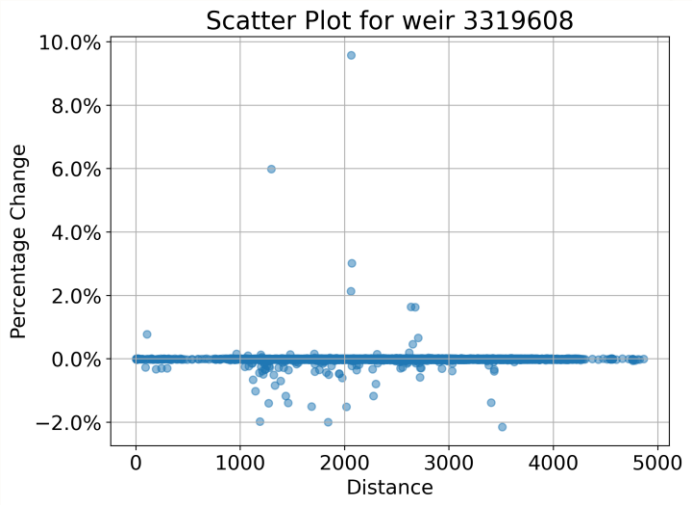
Overflow 3319608

Event 1

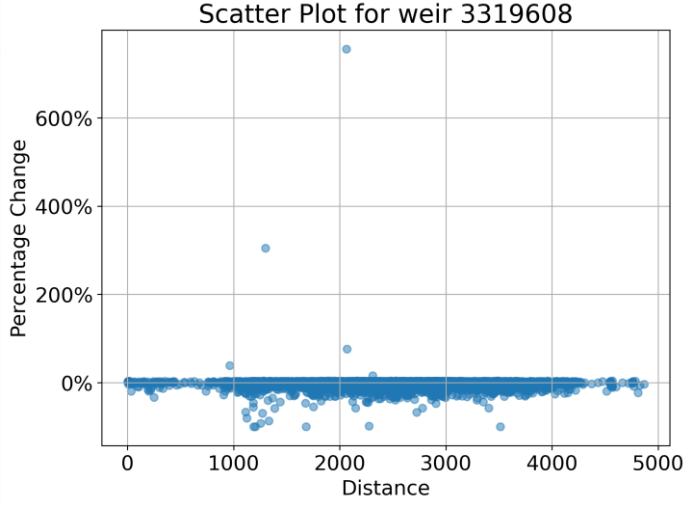


Event 3



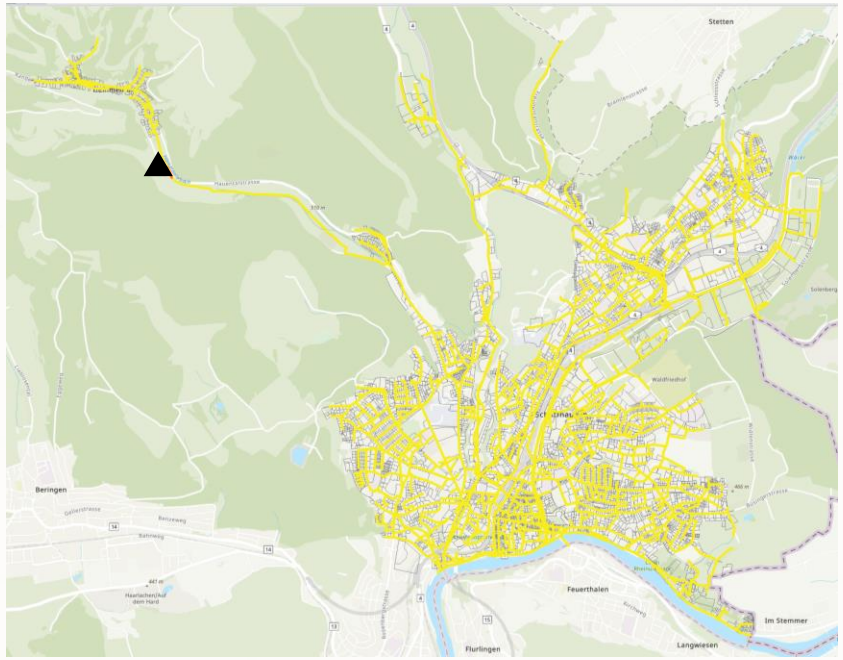


Symbol	Label
	-100.000% - -21.555%
	-21.555% - -5.150%
	-5.150% - -0.014%
	-0.014% - -0.004%
	-0.004% - -0.001%
	-0.001% - 0.000%
	0.000% - 0.000%
	0.000% - 0.570%
	0.570% - 13.000%
	13.000% - 1042.347%

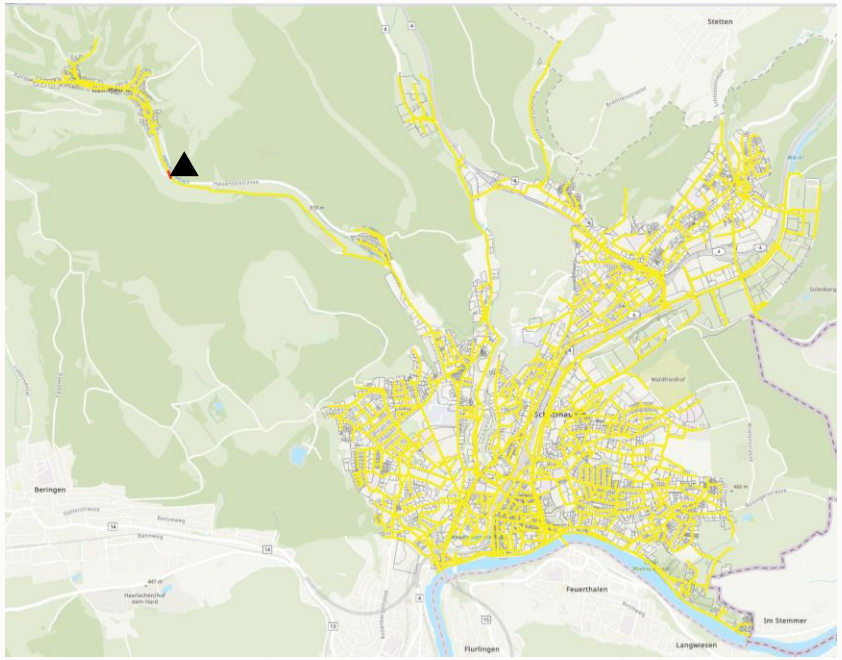


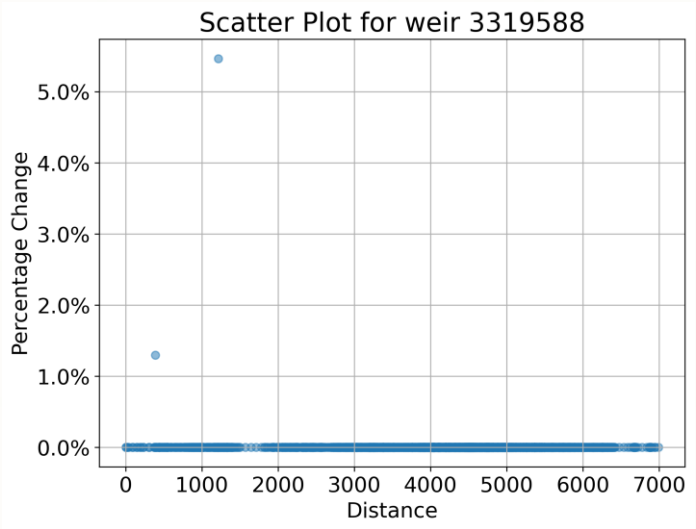
Overflow 3319588

Event 1



Event 3





Symbol	Label
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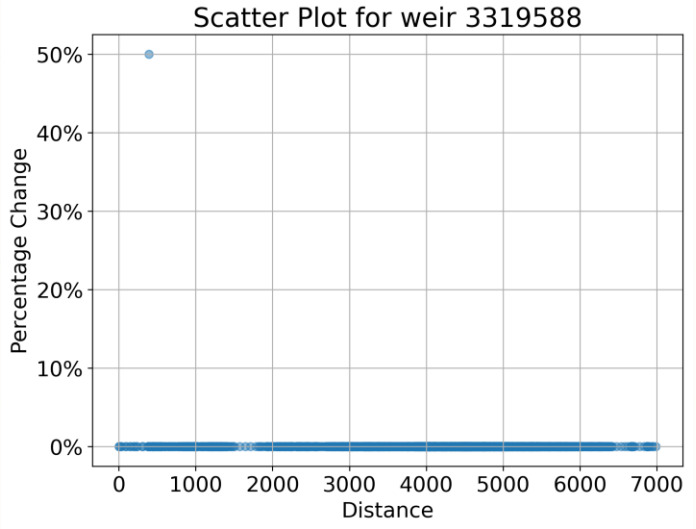
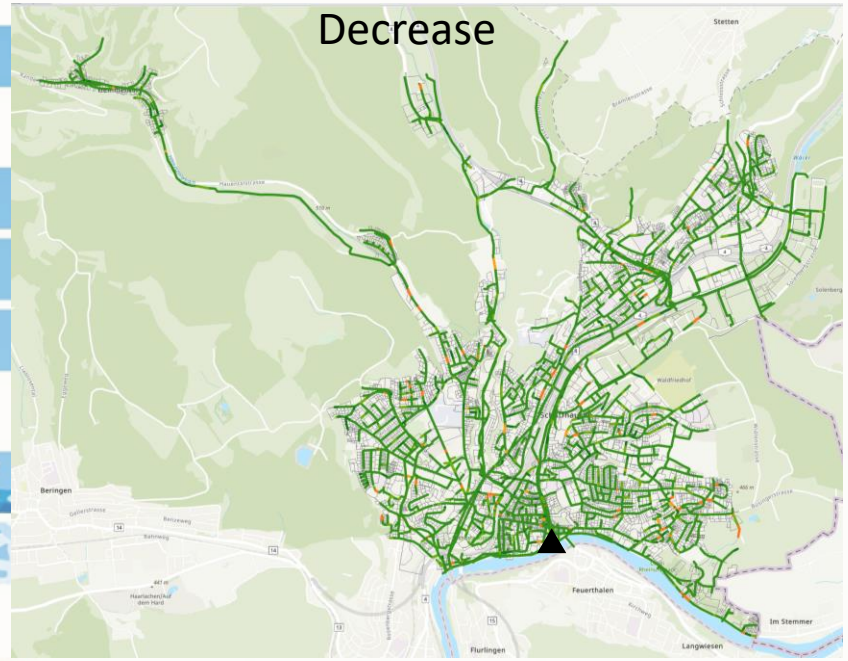
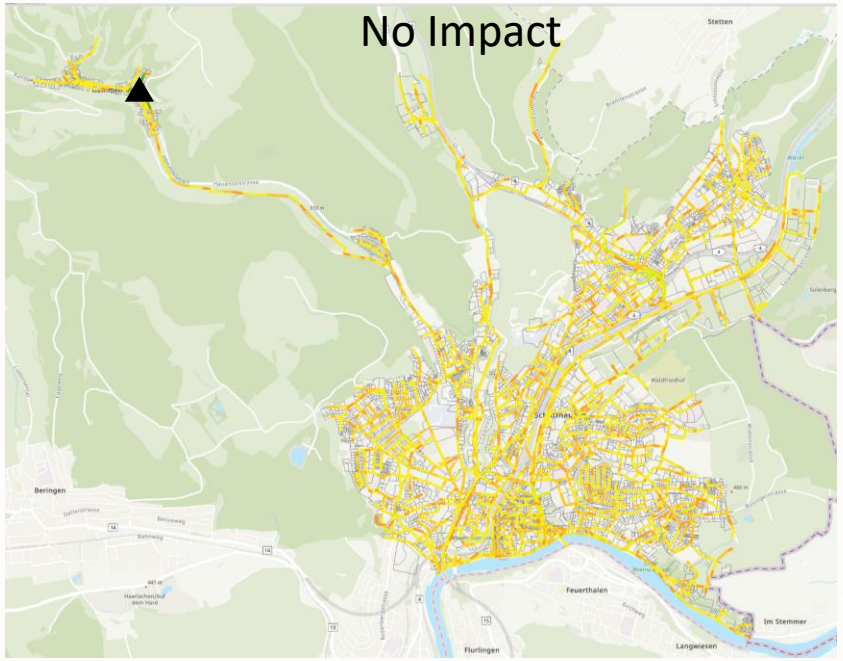
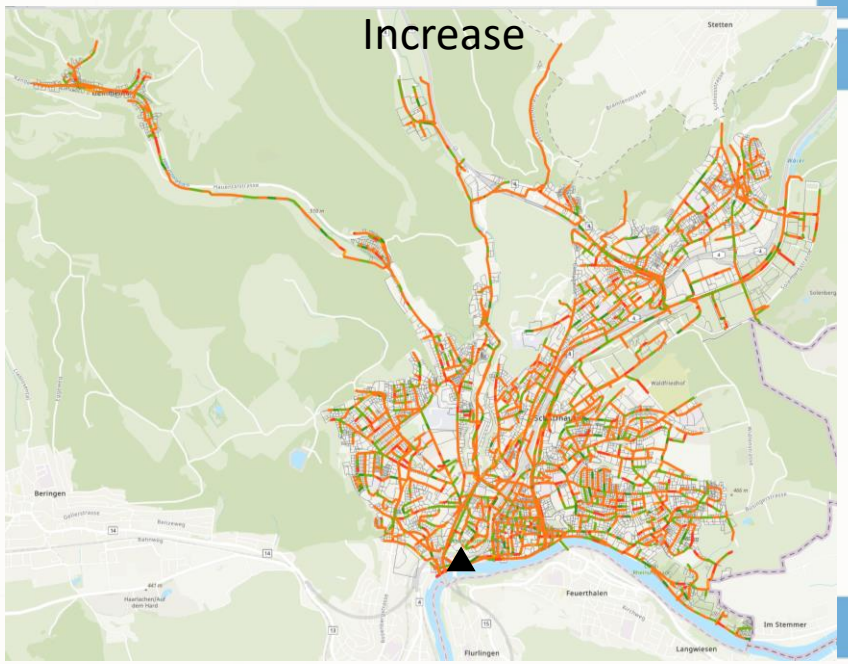
	-21.555% - -5.150%
	-5.150% - -0.014%
	-0.014% - -0.004%
	-0.004% - -0.001%
	-0.001% - 0.000%
	0.000% - 0.000%
	0.000% - 0.570%
	0.570% - 13.000%
	13.000% - 1042.347%

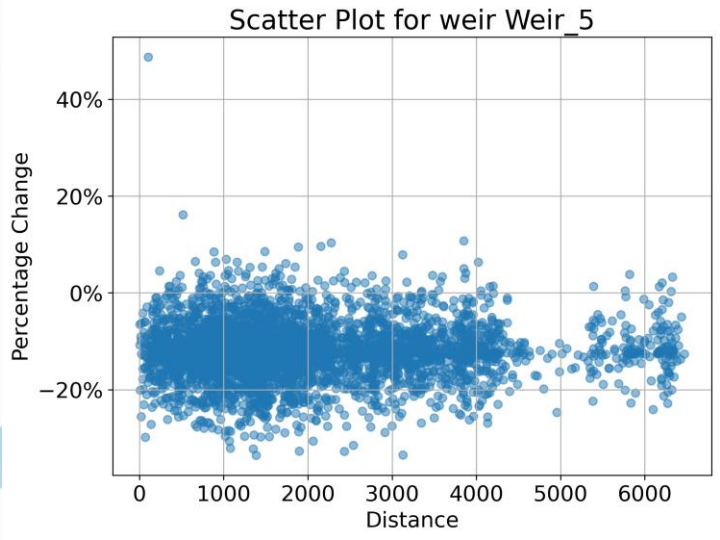


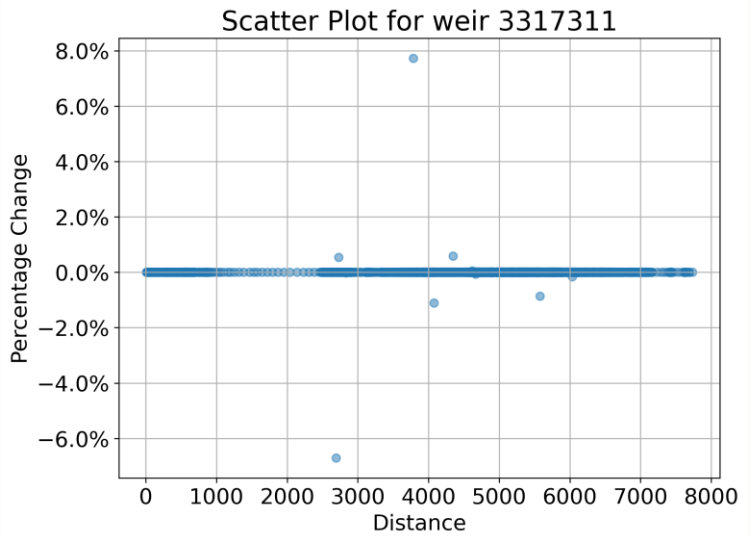
Other Overflows – Event 1

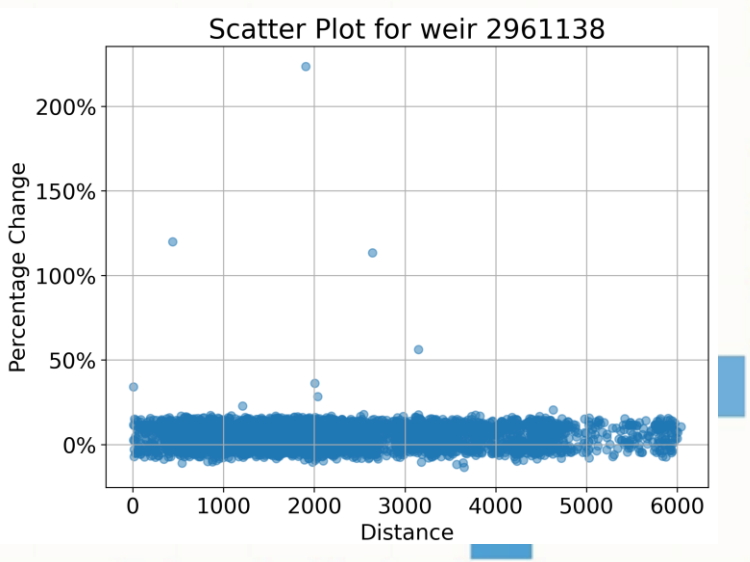












Summary

- number of pipes caused increase/decrease in overflow

	3322635		3319608		3319588						
	Event 1	Event 3	Event 1	Event 3	Event 1	Event 3	3317311	Weir_5	2961138	3319592	3317327
Decrease	376	2819	4095	1962	0	0	2569	4335	1138	3315	3681
No Change	0	415	0	403	4444	4445	0	0	0	0	0
Increase	4070	1212	351	2081	2	1	1877	111	3308	1131	765

	3322635		3319608		3319588						
	Event 1	Event 3	Event 1	Event 3	Event 1	Event 3	3317311	Weir_5	2961138	3319592	3317327
Decrease	8%	63%	92%	44%	0%	0%	58%	98%	26%	75%	83%
No Change	0%	9%	0%	9%	100%	100%	0%	0%	0%	0%	0%
Increase	92%	27%	8%	47%	0%	0%	42%	2%	74%	25%	17%

Conclusion

- The flood risk pattern can vary for different defect types and different rainfall scenarios.
- For the Schaffhausen sewer network, analysis showed that pipes near outfalls and north east part of the city are more prone to causing floods, suggesting these areas as maintenance priorities.
- Defects in pipes can lead to both positive and negative effects on system overflows; the extent and nature of these effects are influenced by the pipe's location and the characteristics of the network.

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