Network behaviour model

Final Version of June/2023

Deliverable number 5.6.1

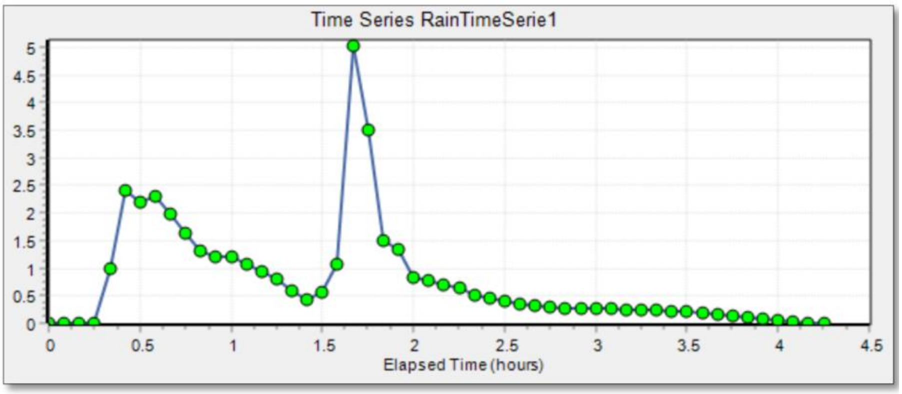
Project Acronym	STREAM
Project ID Number	10249186
Project Title	Strategic Development of Flood Management
Priority Axis	2 – Safety and Resilience
Specific objective	2.2 - Increase the safety of the Programme area from natural and man-made disaster
Work Package Number	5
Work Package Title	Pilot projects
Activity Number	5.6
Activity Title	ADSU Pilot project
Partner in Charge	LP
Partners involved	PP10
Status	Final
Distribution	Public

Table of contents

1. Introduction

This study is conducted within the framework of the STREAM project, a part of the Italy-Croatia CBC Programme. This financial instrument supports cooperation between the territories of the two European Member States overlooking the Adriatic Sea. Under the Priority Axis of Safety and Resilience, specifically SO 2.2, the STREAM project aims to increase knowledge about floods in the involved areas. Local authorities and emergency services will enhance their flood risk management, and people will learn how to behave in case of flood hazards. This initiative will contribute to reducing human and socio-economic losses caused by flooding. The project partner, ADSU Teramo, has involved Ruzzo Reti S.p.A. as a technical partner for the development of a pilot project. The primary objective of this project is to develop a real-time control system for the sewer network, known as S3Mart (Smart Sewer System for Mitigating Alluvial Risks and Technology integration), with the aim of reducing the environmental impacts caused by the management of stormwater within the sewer network. The increasing need for efficient water management systems has led to the exploration of real-time control systems in drainage networks. These systems provide a dynamic approach to managing discharges, potentially reducing pollutant releases caused by overflow events. This study employs the Storm Water Management Model (SWMM), a robust modelling software, to simulate and analyse the behaviour of the specific drainage network serving the Corropoli wastewater treatment plant under various conditions.

A particular focus of this study is the network's response to an intense meteorological event lasting four hours, a scenario that presents significant challenges for stormwater management. The analysis encompasses both the hydraulic and environmental behaviour of the network, with a specific emphasis on the concentration of total suspended solids (TSS) as a key parameter.



2. Network behavior model

2.1. Site description

The study focuses on the combined sewer network serving the Corropoli wastewater treatment plant. The Combined Sewer System is a network where domestic wastewater and stormwater are collected and conveyed through the same pipe. Both domestic sewage and rainwater are channelled into a single system and transported to a wastewater treatment plant.

During normal conditions, the combined sewer system conveys the wastewater and stormwater to the wastewater treatment plant, where it undergoes treatment before being discharged into a receiving water body. However, during intense rainfall or when the capacity of the sewer system is exceeded, the excess of water volume can overwhelm the system.

To prevent the system from becoming overloaded, CSOs are designed to divert the excess flow. The plant and its associated network are located in Corropoli, a Municipality with specific hydraulic and environmental characteristics that present unique challenges and opportunities for the implementation of a real-time control system.

The sewer network can be divided into two main branches. One extends for several kilometres to a town located in a hilly area, while the other derives from a more urbanized area, which also includes an industrial zone. At the end of these two branches, near the wastewater treatment plant, there are two Combined Sewer Overflow. This configuration is optimal for analysing the potential scenarios that could arise from a dynamic management of the network, allowing for the regulation of the inflow to the treatment plant in a dynamic manner.

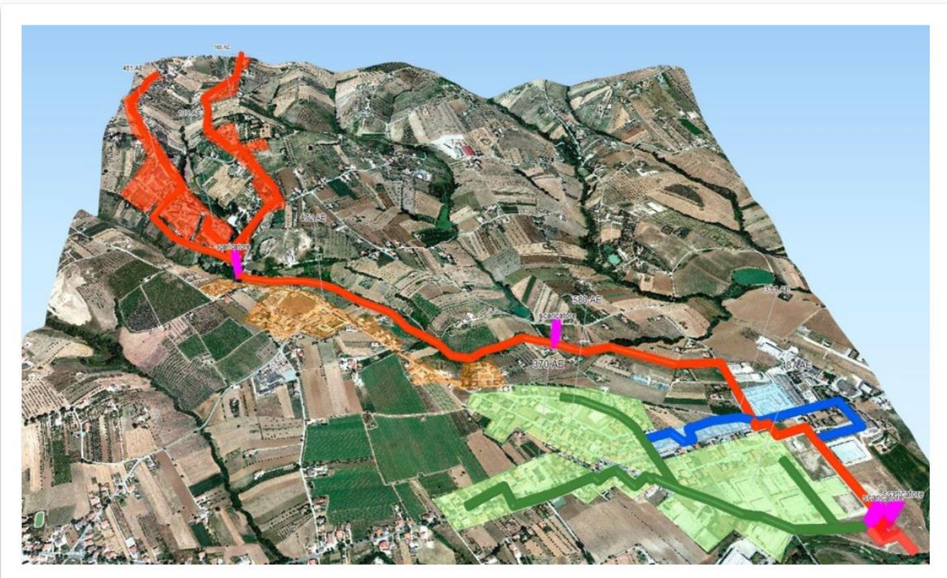


Figure 2 The site chosen is a small agglomeration near the Adriatic coast. Served by a wastewater treatment plant in Corropoli, Teramo Province

Figure 3 This image provides a visual representation of the Corropoli wastewater treatment plant and the two main sewer lines feeding into it. The two white dots are the combined sewer overflows stormwater overflow located at the end of these sewer lines. These CSOs play a crucial role in managing excess water during intense meteorological events.

2.2. Methods

The study began with the modelling of the examined area's network, allowing for the simulation of the network's behaviour. The SWMM was used to analyse the hydraulic and environmental behaviour of the system, with a specific focus on the concentration of total suspended solids (TSS). TSS was chosen as a key parameter due to its significant impact on water quality and its relevance in stormwater management.

The creation of a hydraulic model in SWMM involves several steps:

1. **Define the study area**: This includes identifying the boundaries of the drainage area and the location of the wastewater treatment plant.
2. **Collect data**: Gather all necessary data, including topographic information, soil characteristics, land use data, and rainfall data.
3. **Build the network**: Define the nodes (junctions, outfalls, storage units) and links (pipes, pumps, orifices) that make up the drainage network.
4. **Set parameters**: Define the parameters for each element of the network, such as the size and shape of pipes, the storage capacity of units, and the characteristics of the treatment plant.
5. **Run simulations**: Use the SWMM to simulate the behaviour of the network under various conditions, including different rainfall events and operational scenarios.

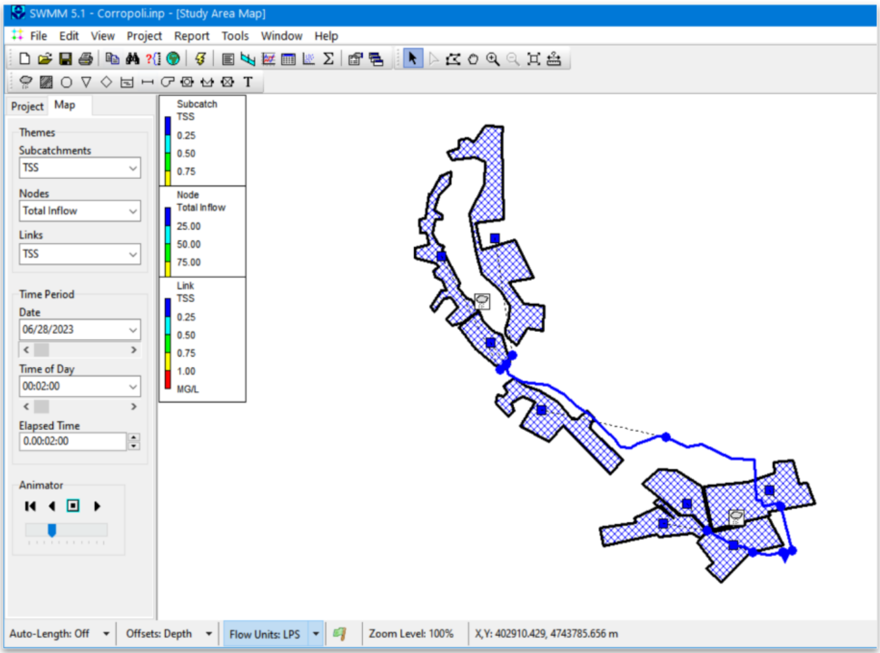


Figure 4 Caption: This screenshot showcases the user interface of the Storm Water Management Model (SWMM) software. The displayed network diagram represents the drainage system serving the Corropoli wastewater treatment plant. The various nodes and links visible in the diagram correspond to junctions, pipes, and other elements of the sewer network. The differently shaded areas represent distinct catchment areas, each contributing to the overall stormwater runoff within the system. This visual representation aids in understanding the network and the interactions between its various components.

2.3. Results

Preliminary results from the study provide intriguing insights into the behaviour of the drainage network during an intense meteorological event. The simulation demonstrated a differentiated behaviour between the trend of pollutant concentration and hydraulic flow. Notably, a higher concentration of pollutants was observed in the initial phase of the event, a phenomenon commonly referred to as the "first flush". This peak in pollutant concentration did not correspond with the peak in hydraulic flow, suggesting a complex relationship between rainfall intensity, runoff generation, and pollutant transport. The application of an intelligent real-time control system, as suggested by the study, could potentially mitigate this first flush effect, thereby reducing overall pollutant releases from stormwater overflows.

The results from the model, derived from an analysis of the data output from the SWMM, suggest a significant potential for pollutant reduction through the application of an intelligent real-time control system. By comparing the static behaviour of the network with a dynamic management scenario, it was observed that real-time control could potentially reduce pollutant releases from stormwater overflows by 40%. This substantial reduction underscores the potential effectiveness of real-time control systems in managing stormwater discharges and mitigating their environmental impact.

The findings highlight the value of dynamic management strategies in enhancing the performance of drainage networks, particularly during intense meteorological events.

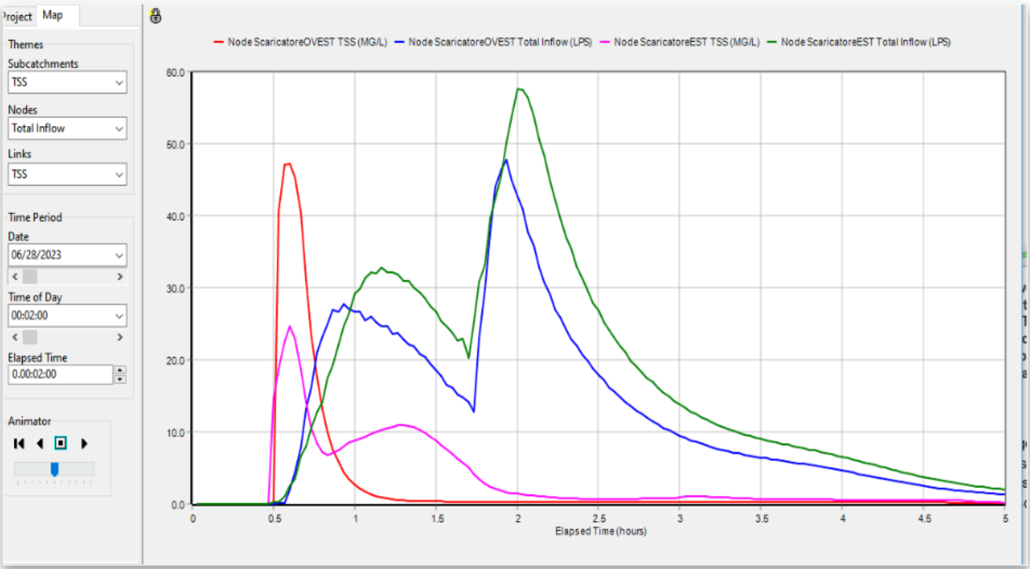


Figure 5 This graph illustrates the trends in total suspended solids (TSS) concentration and flow rates at the two Combined Sewer Overflows (CSOs) during an intense meteorological event. The x-axis represents time, while the left y-axis represents TSS concentration.

Hours	Total Inflow(LPS)	TSS AVERAGE(MG/L)	Total Pollutant (MGPS)	B) DownStreamCapacity (LPS)	Total Pollution Discharged WithOut SS(MGPS)	Total Inflow(LPS)	TSS AVERAGE(MG/L)	Total Pollution (MGPS)	DownStreamCapacity (LPS)	Total Pollution Discharged WithOut SS(MGPS)	Total Inflow (LPS)	Total Capacity(LPS)	Water exceding treatment capacity	Total Pollution Discharged WithOut SS(KGP2MIN)	Total Pollution Discharged With SSS
00:02:00	4.0	150.0	600.0	25.0	-	5.0	130.0	650.0	35.0	-	9.0	39.0	0	-	-
00:04:00	4.0	150.0	600.0	25.0	-	5.0	130.0	650.0	35.0	-	9.0	39.0	0	-	-
01:04:00	29.4	27.7	814.9	25.0	13,389	36.3	58.4	2,118.6	35.0	38,728	65.7	39.0	26.7	6.25	5.47
01:06:00	29.9	25.9	775.0	25.0	13,121	37.1	59.5	2,208.9	35.0	42,213	67.0	39.0	28	6.64	5.90
01:08:00	29.2	25.4	739.6	25.0	11,953	37.0	61.0	2,252.3	35.0	42,681	66.1	39.0	27.1	6.56	5.85
01:10:00	28.7	24.8	712.2	25.0	11,161	37.8	61.7	2,332.6	35.0	46,186	66.5	39.0	27.5	6.88	6.20
01:12:00	28.7	24.2	695.1	25.0	10,913	37.1	63.2	2,341.7	35.0	44,656	65.8	39.0	26.8	6.67	6.00
01:14:00	27.6	24.5	677.9	25.0	9,912	37.1	63.9	2,370.6	35.0	45,206	64.7	39.0	25.7	6.61	5.96
01:16:00	27.7	24.1	668.7	25.0	9,823	36.8	64.8	2,384.2	35.0	44,870	64.5	39.0	25.5	6.56	5.92
01:18:00	26.9	24.5	658.3	25.0	9,117	36.0	65.3	2,347.2	35.0	42,178	62.8	39.0	23.8	6.16	5.52
01:20:00	26.1	24.9	650.9	25.0	8,546	36.0	64.8	2,330.7	35.0	41,905	62.1	39.0	23.1	6.05	5.43
01:22:00	25.8	25.0	646.9	25.0	8,300	35.0	64.3	2,246.3	35.0	38,075	60.8	39.0	21.8	5.57	1.69
01:24:00	24.8	25.9	641.6	25.0	7,564	34.3	62.9	2,158.0	35.0	35,197	59.1	39.0	20.1	5.13	1.55
01:26:00	24.3	26.2	638.6	25.0	7,236	33.6	61.3	2,057.1	35.0	32,029	57.9	39.0	18.9	4.71	1.45
01:28:00	23.4	27.1	635.0	25.0	6,623	32.4	59.5	1,931.0	35.0	27,864	55.9	39.0	16.9	4.14	1.28
01:30:00	22.5	28.1	631.5	25.0	5,999	31.7	57.4	1,819.5	35.0	24,927	54.2	39.0	15.2	3.71	1.15
01:32:00	21.7	29.0	629.2	25.0	5,468	30.4	55.6	1,687.6	35.0	20,876	52.1	39.0	13.1	3.16	0.99
01:34:00	20.5	30.5	626.4	25.0	4,717	29.6	53.3	1,579.4	35.0	18,353	50.2	39.0	11.2	2.77	0.84
01:36:00	20.1	31.1	625.8	25.0	4,449	28.7	51.3	1,473.6	35.0	15,767	48.8	39.0	9.81	2.43	0.74
01:38:00	19.1	32.6	623.5	25.0	3,822	27.6	49.4	1,365.1	35.0	13,146	46.8	39.0	7.76	2.04	0.58
01:40:00	18.8	33.2	622.1	25.0	3,584	28.0	46.5	1,301.8	35.0	13,005	46.8	39.0	7.75	1.99	0.58
01:42:00	18.1	34.3	621.2	25.0	3,187	25.2	45.8	1,156.8	35.0	8,363	43.4	39.0	4.36	1.39	0.33
01:44:00	16.9	36.7	618.0	25.0	2,385	30.3	38.5	1,165.3	35.0	14,287	47.1	39.0	8.12	2.00	0.60
01:46:00	26.9	23.5	633.2	25.0	8,808	35.8	32.9	1,176.2	35.0	20,900	62.7	39.0	23.7	3.57	2.96
01:48:00	33.9	19.0	644.8	25.0	13,471	38.2	29.5	1,124.0	35.0	22,650	72.0	39.0	33	4.33	3.72
01:50:00	41.7	15.8	656.5	25.0	18,815	44.6	25.1	1,121.7	35.0	29,883	86.3	39.0	47.3	5.84	5.21
04:58:00	5.4	111.4	600.6	25.0	-	7.1	92.0	652.2	35.0	-	12.5	39.0	0	-	-
05:00:00	6.3	118.4	750.6	25.0	-	7.0	93.0	651.8	35.0	-	13.4	39.0	0	-	-

	Without SSS	With SSS
KG SST DISCHARGED	272	192

Figure 6 This screenshot showcases an excerpt from the spreadsheet used for the comparative analysis in this study. The spreadsheet contains data extracted from the Storm Water Management Model (SWMM), representing various scenarios of static and dynamic network management. The columns represent different parameters, including time, total suspended solids (TSS) concentration, and flow rates, among others. The data presented in this spreadsheet was crucial in identifying the potential for a 40% reduction in pollutant releases through the application of a real-time control system.

3. Conclusion

This preliminary feasibility study provides valuable insights into the potential benefits of implementing a real-time control system in a drainage network. The significant reduction in pollutant releases observed in this study highlights the potential of such systems in improving stormwater management and reducing environmental impacts.

4. Annexes

- Network model