Hydraulic tests description

1. Experimental procedure

The first set of experiments consists of a hydraulic characterization of the superficial runoff and the in-pipe flow generated by the three different rainfalls that are possible to simulate. Experiments consist of simulating a steady and homogeneous rainfall of 30, 50 or 80 mm/h of intensity with duration of 5 minutes. Online measurements of surface and pipe depths and gully pots and pipe system outlet discharges were registered from the beginning of the rain until 5 minutes after the rain stop. Files regarding hydraulic tests can be found in the zip file *'5_Hydraulic_tests.zip'*. In Figure 1, the location and the ID of the different measuring points are presented. Further details of location, sensors used, acquisition time and units for each result are also presented in *'Measuring_points.csv'*. The related dataset [WASHTREET - PIV data] complements hydraulic tests information including surface velocity distributions results measured using different PIV techniques.

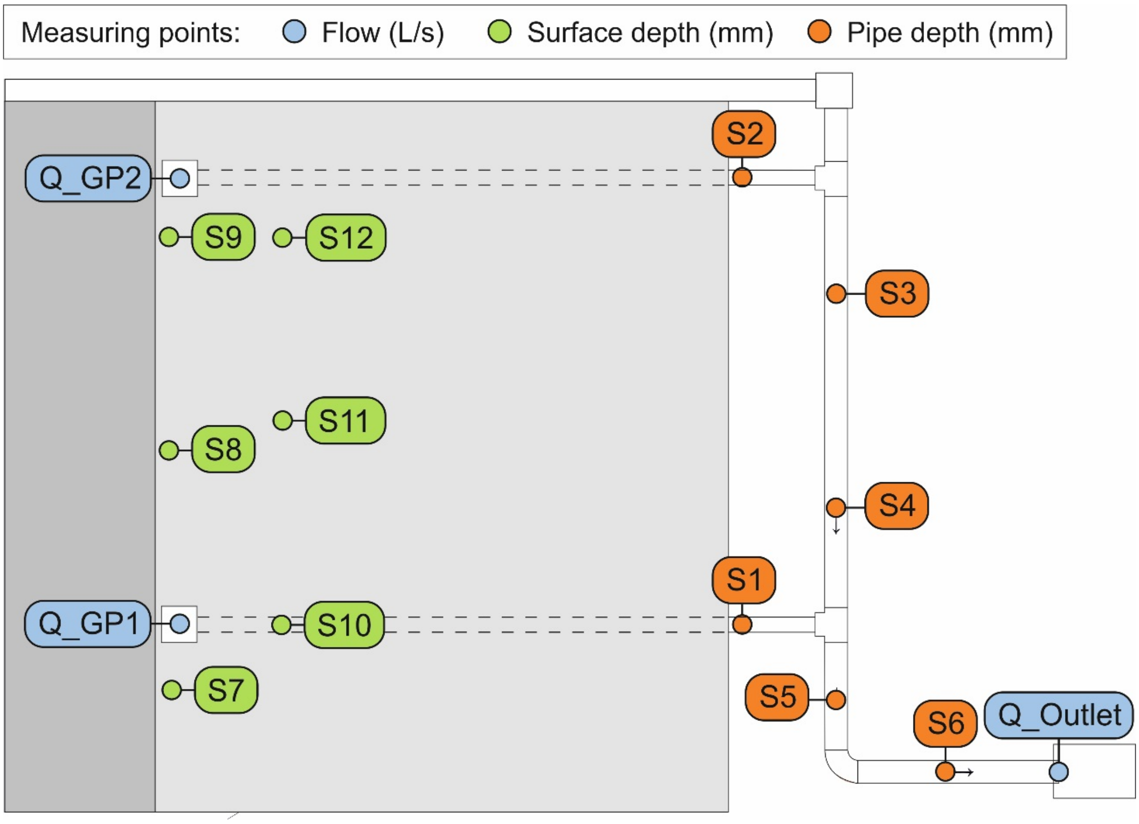

Figure 1. Measuring points in hydraulic tests.

A total of 6 surface depths and 6 pipes depths have been measured using distance sensors (UB500-18GM75-I-V15, Pepperl and Fuchs). Figure 2 includes images of sensors installed on the street surface (left) and pipes (right).

Figure 2. Distance sensors installed on the street surface (left) and on pipes (right).

A 50 cm x 60 cm size deposit was installed at the pipe system outlet in order to measure discharge (Figure 3, left). The pipe system outflow drains firstly in a 40 cm length and 16 cm diameter deposit used for turbidity and TSS measurements in the wash-off experiments (further details in '*6_Washoff_tests_description.pdf*'). Then, the water flows in the mentioned deposit, which have a v-notch where the discharge is measured using a precalibrated distance sensor (UB500-18GM75-I-V15, Pepperl and Fuchs).

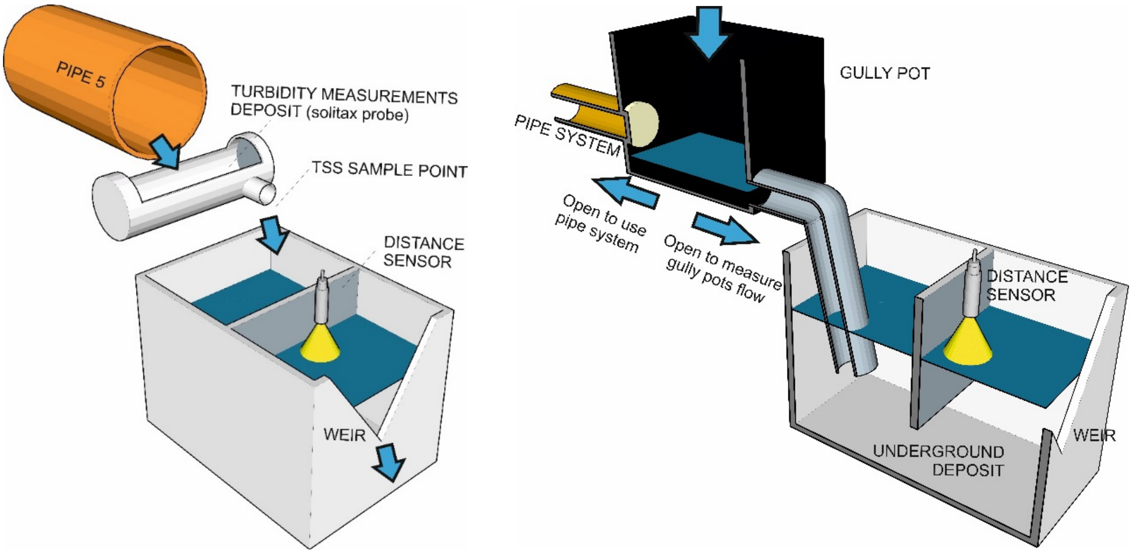

Figure 3. Flow measurement methodology in pipe system outlet (left) and in gully pots (right).

An additional deposit with a v-notch is installed bellow each gully pot in order to register discharges following the same methodology that in the case of the pipe system outlet (Figure 3, right). To measure gully pots flow, it is necessary to close pipe system connection and divert all the gully pot inflow to the underground deposit. This configuration prevent us from measuring total drained flow at the pipe system outlet, since the water that reach the outlet comes uniquely from the outflow channel. Therefore, experiments for each rainfall are repeated with and without connection between gully pots and pipe system in order to obtain discharges in the outlet or in both gully pots respectively. Table 1 shows the 6 tests performed and their configuration.

Table 1. Hydraulic tests configurations

ID	Rain intensity (mm/h)	Gully pots-pipes connection?
HY01_30_GP	30	No
HY02_30_O	30	Yes
HY03_50_GP	50	No
HY04_50_O	50	Yes
HY05_80_GP	80	No
HY05_80_O	80	Yes

2. Data postprocessing

It is necessary to pre-calibrate distance sensors in order to convert the registered voltages to depths and discharges. Signal–distance calibrations are obtained measuring 5 known distances from sensors to a horizontal water surface. The distance sensors installed in flow measurement deposits have been also calibrated in the same way using 7 reference distances. The distances measured in the calibration of each sensor are shown in Table 2. In addition, raw data registered during 60 second for each distance and for each sensor is included in '*Sensors_calibration\Calibration_pipes&surface_distance*' (sensors S1-S12) and '*Sensors_calibration\Calibration_deposits_distance*' (sensors Q_GP1, Q_GP2 and Q_Outlet).

In addition, a signal–flow precalibration was also performed for sensors Q_GP1, Q_GP2 and Q_Outlet, which are installed to measure the water level in a v-notch. In this case, different steady flows measured by a flowmeter are introduced in the deposit with the v-notch. Table 2 presents the flows used in the calibration of each sensor. The data collected by the sensors during 30 seconds when the level in the deposit have been stabilized for each flow is presented in '*Sensors_calibration\Calibration_deposits_flow*'

In order to obtain pipe and surface depth results, raw time series are processed in the following way. First, a 5 seconds wide median filter is implemented to remove peak signals higher than twice the standard deviation. Then, a 20 seconds wide moving median was applied. Finally, the precalibration is used to transform signal to distance and obtain depths results from the differences between the measurements and the dry surface reference, which is measured during 60 seconds before the rain starts.

Table 2. Signal-distance calibration points (mm)

Sensor ID	Ycal1	Ycal2	Ycal3	Ycal4	Ycal5	Ycal6	Ycal7
Q_GP1	271	233	202	168	129	100	87
Q_GP2	284	245	207	166	136	101	77
Q_Outlet	283	243	200	169	134	104	84
S1	280.5	249	210	163	121		
S2	283	244	201	158	121		
S3	285	253.5	213	163	120		
S4	281.5	252	208.5	160	124		
S5	272	227	205	161	120		
S6	284.5	240	203	163	121		
S7	284.5	241	211	161.5	118		
S8	281.5	255	211.5	151	126		
S9	282	250	251.5	160	122.5		
S10	274	247.5	211	164	122.5		
S11	282.5	250	210.5	165	121		
S12	280.5	249	210	163	121		

Table 3. Signal-flow calibration points (L/s)

Sensor ID	Qcal1	Qcal2	Qcal3	Qcal4	Qcal5	Qcal6	Qcal7	Qcal8
Q_GP1	0.42942	0.37825	0.32700	0.27142	0.18550	0.12792	0.05500	0.01008
Q_GP2	0.47942	0.34458	0.24899	0.18158	0.10125	0.03725		
Q_Outlet	0.49211	0.42933	0.34967	0.23887	0.14740	0.07893	0.01267	

Regarding the flow results, the signal of sensors Q_GP1, Q_GP2 and Q_Outlet is filtered in the same way that depth raw data. Then, a 5 seconds wide moving median was applied before obtaining flow time series using precalibration. However, these results are measured at the outflow of the installed deposits below gully pots and pipes, so it is necessary to consider the volume that is retained in these deposits when the flow and thus the water depth in them vary, to obtain the final discharge in gully pots and in the pipe system outlet. To do this, the signal-depth precalibration is used with the area of the deposits, which is 0.146294, 0.147016 and 0.31 m^2 for gully pot 1, gully pot 2 and pipe system outlet deposits respectively, and the variations of volume in time steps of 5 seconds was used. The final flow time series are smoothed by a 20 seconds wide moving median.

3. Result files

Each experiment considered in Table 1 include the following files, referring the time in all cases to the beginning of the rainfall:

'*Flow_RawSignal(V).csv*': Raw time series registered by the three distance sensors installed in each deposit (gully pot 1, gully pot 2 and pipe system outlet) to measure flow.

'*Depths_RawSignal(V).csv*': Raw time series registered by the 6 distance sensor installed in the pipes (S1-S6) and the 6 distance sensors installed on the surface (S7-S12). 60 seconds before rain data was included additionally to ensure correct measurement of the distance to dry surface or pipe.

'*Flow_Processed(Ls).csv*': Processed flow time series registered by the three distance sensors installed in each deposit (gully pot 1, gully pot 2 and pipe system outlet) to measure flow.

'*Depth_Processed(mm).csv*': Processed depth time series registered by the 6 distance sensor installed in the pipes (S1-S6) and the 6 distance sensors installed on the surface (S7-S12).

Figure 4, 5 and 6 plot flow and depths results for the three rain intensities considered:

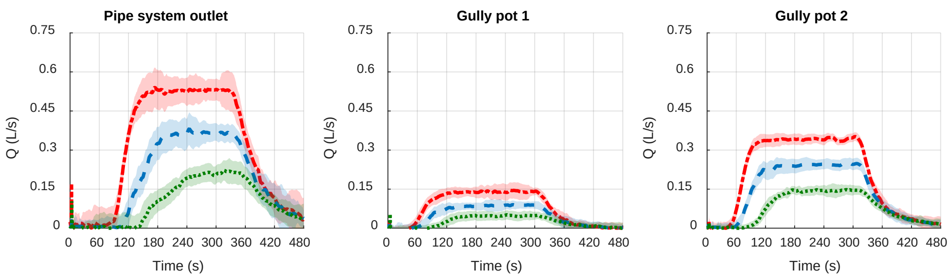

Figure 4. Flow results in pipe system outlet, gully pot 1 and gully pot 2 for rain intensities of 80 (red), 50 (blue) and 30 mm/h (green).

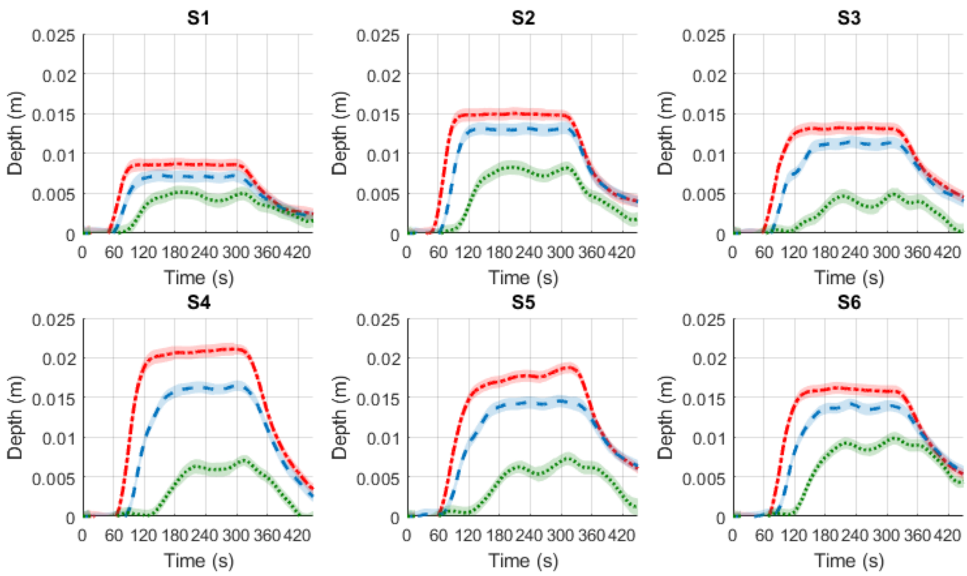

Figure 5. Pipes depth results for rain intensities of 80 (red), 50 (blue) and 30 mm/h (green).

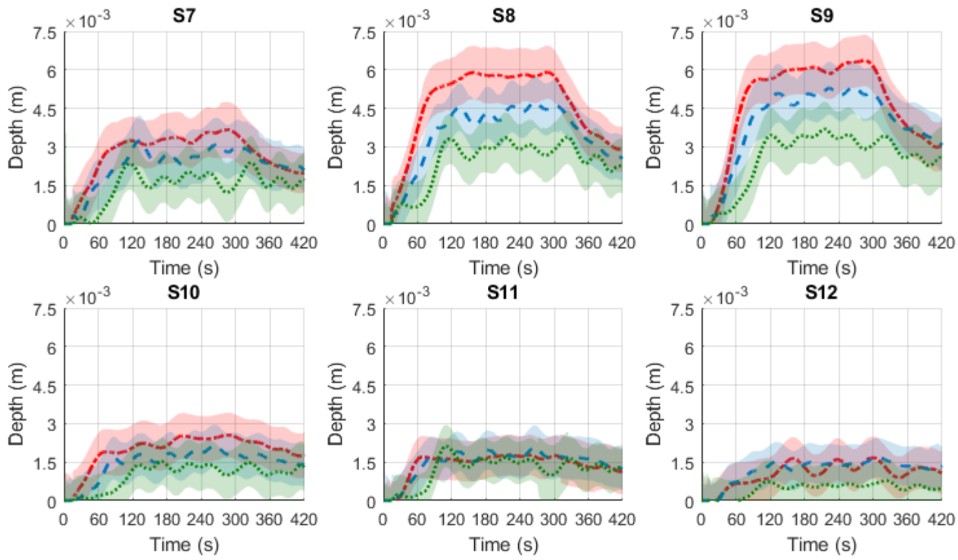

Figure 6. Surface depth results for rain intensities of 80 (red), 50 (blue) and 30 mm/h (green).