INTERACTION OF ABOVE/BELOW GROUND URBAN FLOODS

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INTRODUCTION

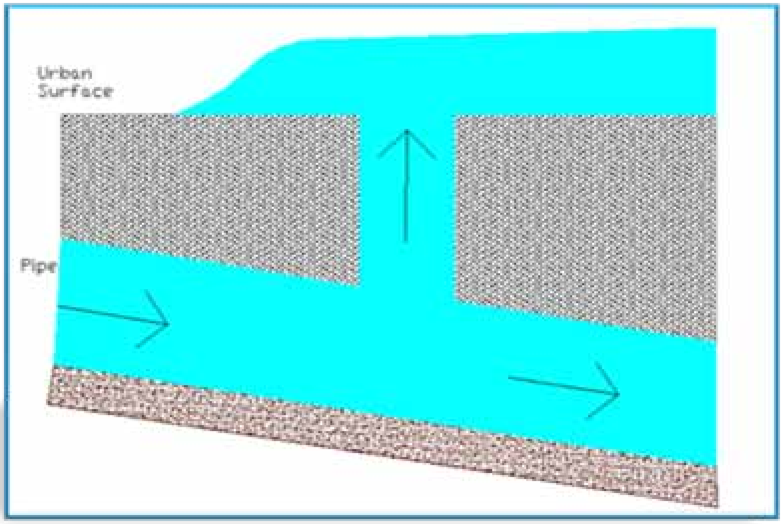
The ***frequency*** and ***severity*** of pluvial flood events is expected to increase worldwide due to some important factors:

- **Climate change** (short duration high intensity rainfall events are becoming more frequent , like for example the July 2007 flood in South Yorkshire, UK);
- **Changes in urban hydrology**, especially regarding groundwater level and infiltration (Ashley et al. 2005);
- The **increase of urbanisation** and **urban creep**;
- The **deterioration of existing sewer systems** and changes in local flood pathways and urban form.

URBAN FLOODING

Pluvial flooding occurs when sewers are overwhelmed by heavy rainfall.

The process of urban flooding
is combination
of surface water flow and water that flows
from the sewer system.



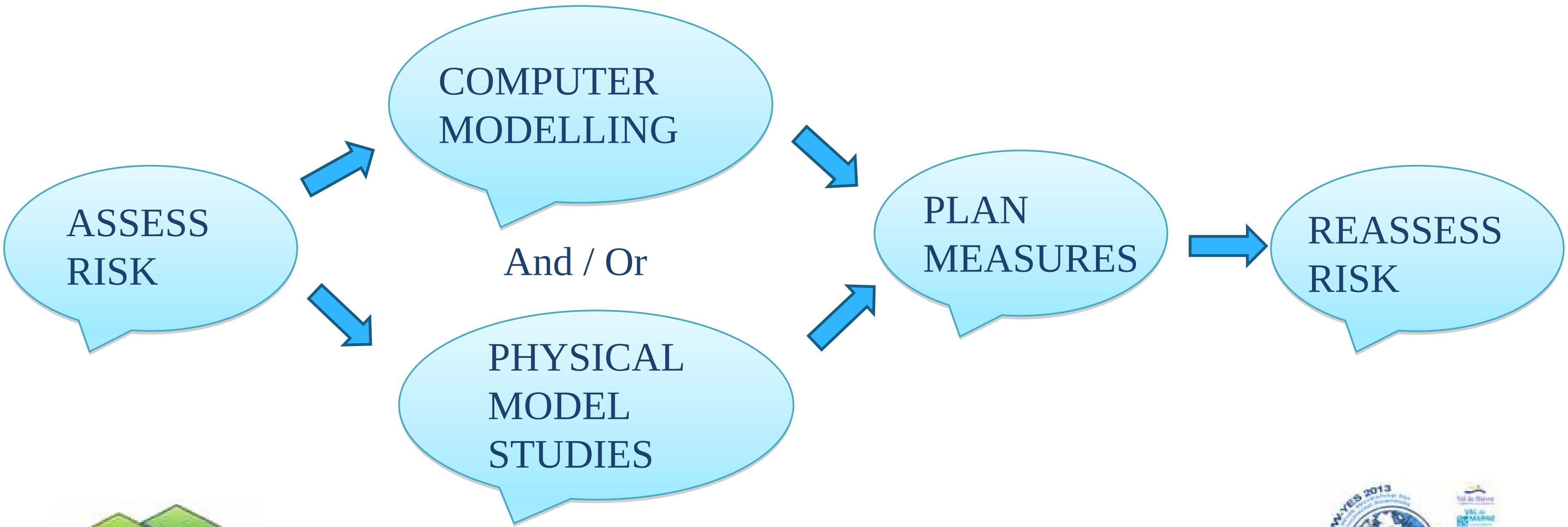
→ *Complex interaction*

This research includes an experimented study to investigate aspects of flooding and surcharge in a pipe network which mimics part of a full scale system.

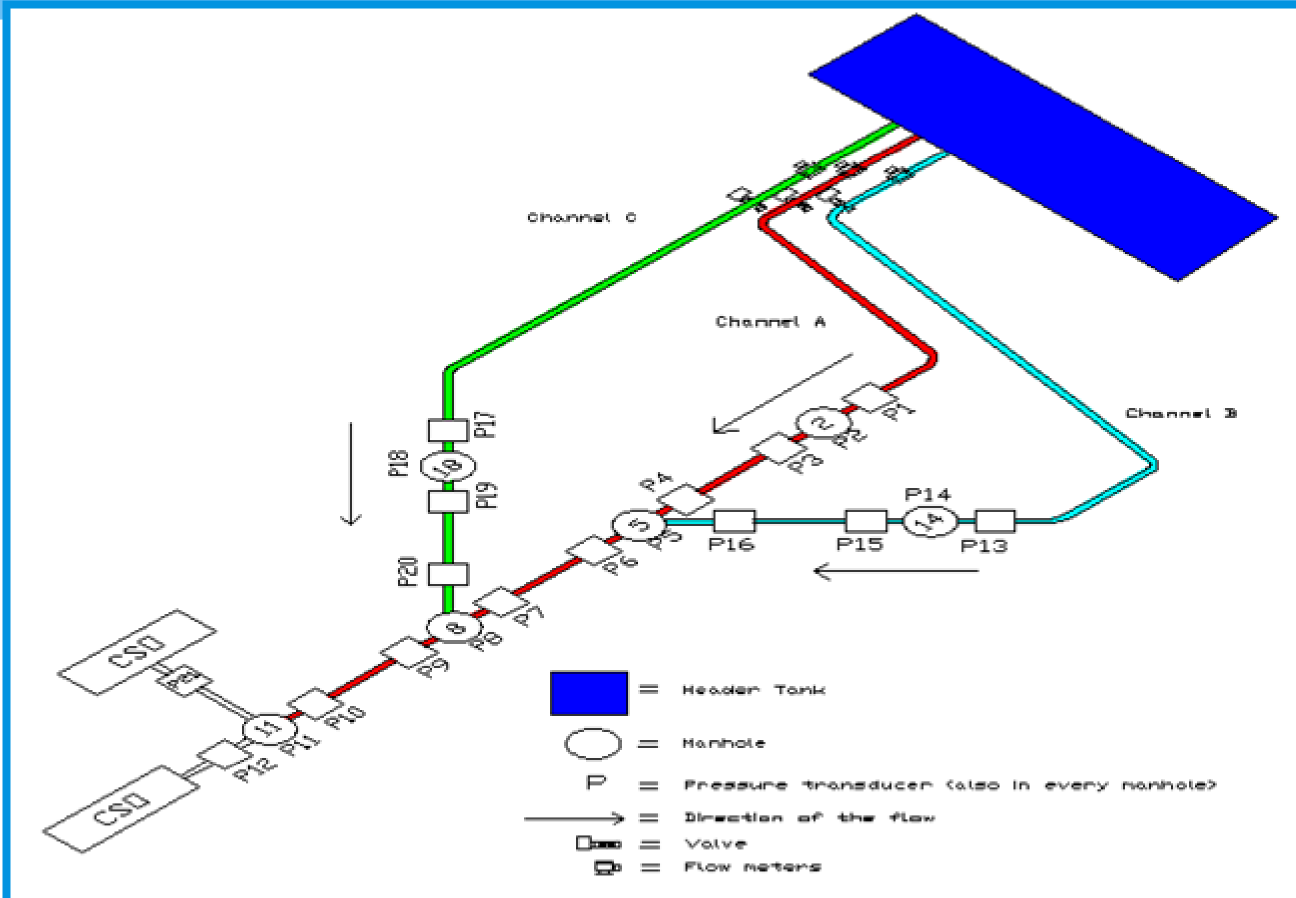
EXAMPLES

IMPROVING URBAN DRAINAGE SYSTEMS

Understanding the hydraulic performance of the physical system and its interaction with the environment is a prerequisite for effective planning and management of urban drainage and storm water systems.



EXPERIMENTAL FACILITY SCHEME



EXPERIMENTAL FACILITY

INPUTS TO SYSTEM

Based on simulation using ***INFOWORKS***.

To determine flow hydrographs, Infoworks uses the following specific parameters and values:

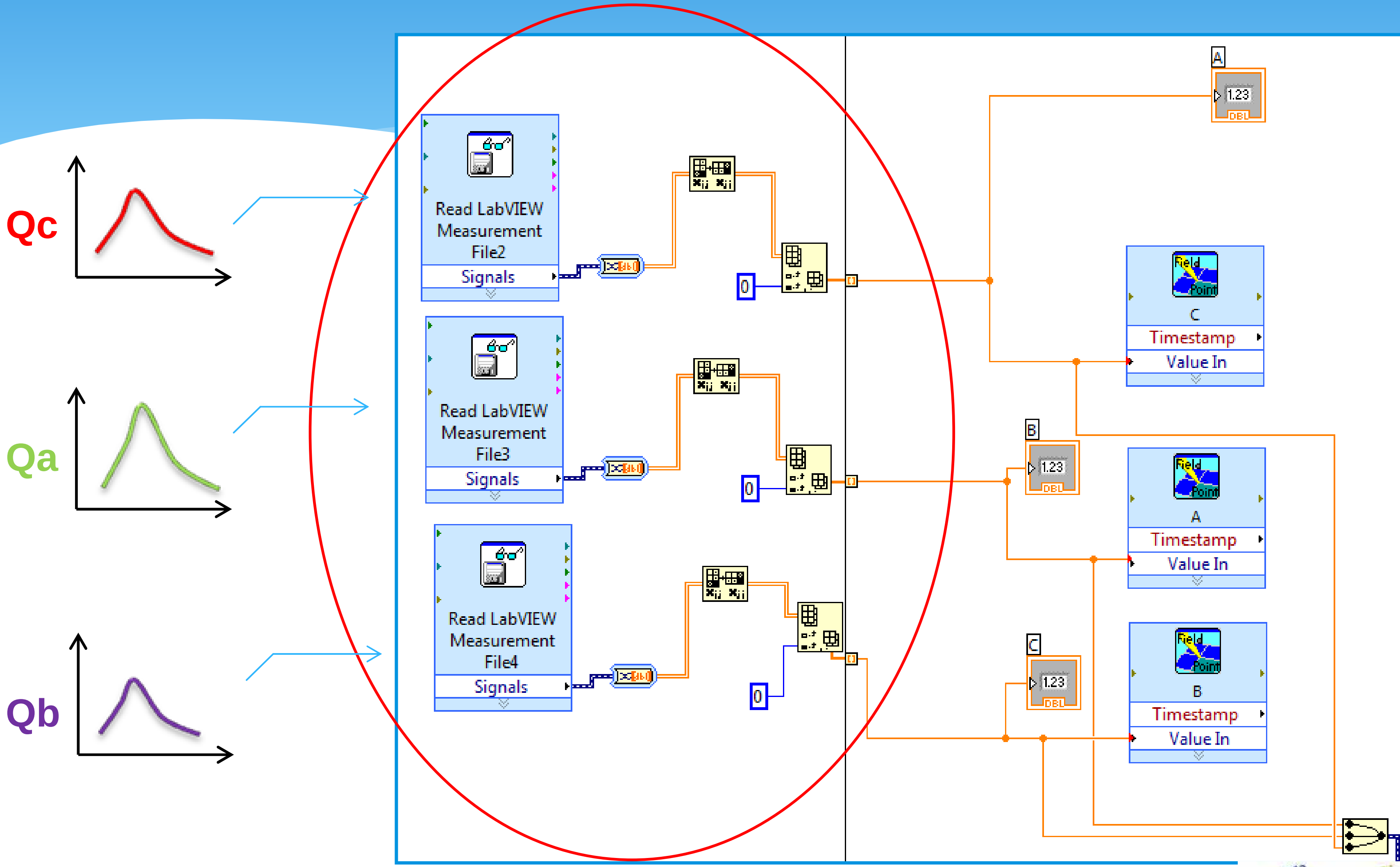
* Dimensions and characteristics of the sewer system;
* Intensity of measured rainfall events (mm/h) and recorded water depth (mm);
* Time of beginning of the rainfall event and its duration;
* Antecedent conditions, obtained calculating the UCWI (Urban Catchment Wetness Index).

RAINFALL SIMULATIONS

* The rainfall events for the simulations are based on rain gauge data taken within the catchment. Events of duration 15 ± 1, 30 ±2, 45 ±1 and 60 ± 2 minutes have been used in this work.

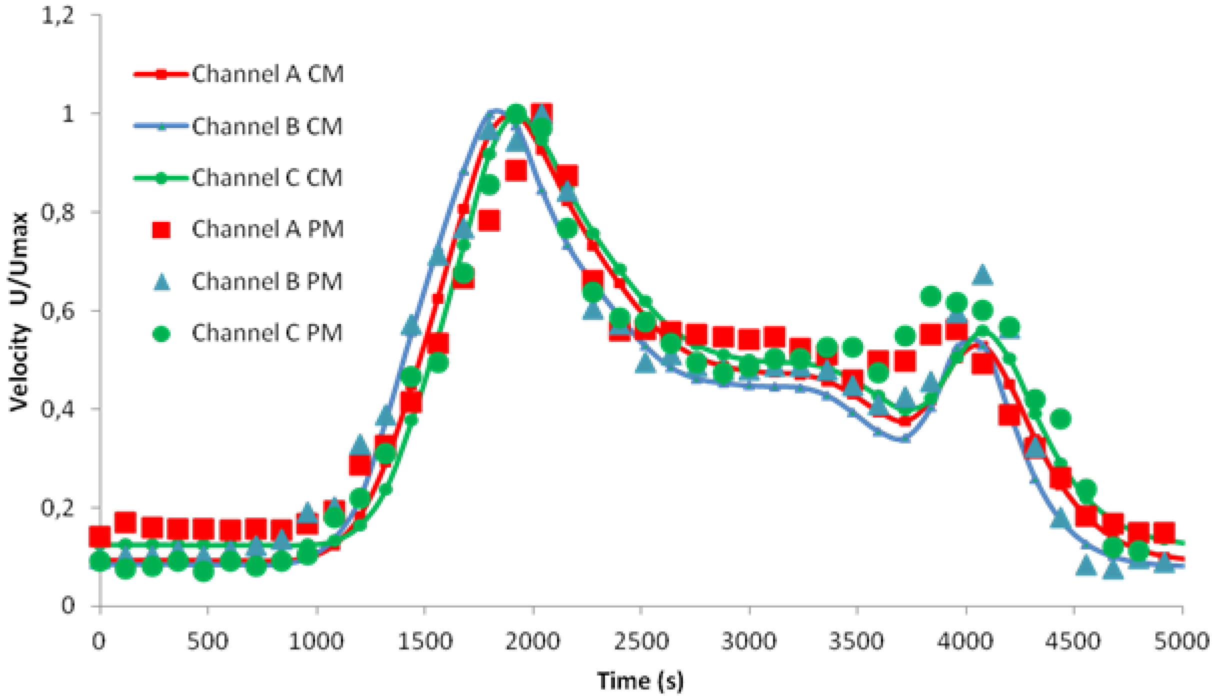
N°of event	Day	Duration	Average Intensity (mm/h)	Rainfall Depth (mm)	UCWI (-)
1	11 Feb. 09	15 Min.	3	0.8	147
2	21 Jan. 09	15 Min.	2	0.6	153
3	17 Nov. 08	15 Min.	2	0.6	135
4	29 June 08	15 Min.	4.5	1.2	158
5	4 May 09	30 Min.	1.2	0.6	109
6	9 Feb. 09	30 Min.	1.2	0.6	159
7	28 Dec. 08	30 Min.	1.6	1.2	144
8	2 Nov. 08	45 Min.	1.8	1.4	134
9	4 May 08	45 Min.	2	1.6	145
10	8 March 08	45 Min.	3.4	2.6	164
11	26 March 09	45 Min.	2.9	2.2	155
12	3 June 08	60 Min.	2	2	164
13	8 Nov. 08	60 Min.	1.6	1.6	139
14	10 March 08	60 Min.	2.5	2.6	170
15	11 Apr. 08	60 Min.	2.6	2.6	137

MODIFICATION LABVIEW INTERFACE



EXAMPLE RESULTS

Example comparison of velocity values within the urban drainage system using InfoWorks simulations and the physical model results.



CORRELATION COEFFICIENT R^2 FOR SIMULATED AND MEASURED RESULTS

$$R^2 = 1 - \left[\frac{\sum_{i=1}^{n}(m_t - p_t)^2}{\sum_{i=1}^{n} m_t^2}\right]$$

Where:

* **m_t** = value measured in the physical model ;
* **p_t** = value obtained from the computer model ;
* **N** = the total number of samples in data set .

Event	R^2 Channel A	R^2 Channel B	R^2 Channel C
15 Minutes			
11 Feb. 09	0.827	0.792	0.810
21 Jan. 09	0.838	0.927	0.981
17 Nov. 08	0.863	0.923	0.889
29 June 08	0.952	0.963	0.949
30 Minutes			
4 May 09	0.966	0.936	0.937
9 Feb. 09	0.932	0.966	0.947
28 Dec. 08	0.942	0.877	0.859
45 Minutes			
2 Nov. 08	0.965	0.946	0.972
4 May 08	0.977	0.975	0.987
8 March 08	0.983	0.954	0.952
26 March 09	0.944	0.925	0.945
60 Minutes			
3 June 08	0.965	0.941	0.942
8 Nov. 08	0.948	0.894	0.959
11 Apr. 08	0.964	0.979	0.971
10 March 09	0.955	0.957	0.969

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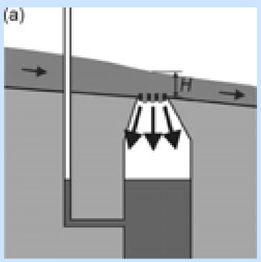
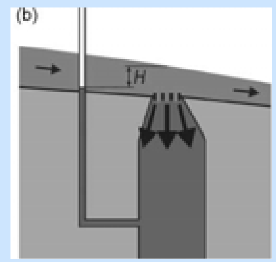
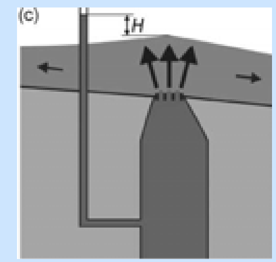
HYDRAULICS

A methodology for characterising the hydraulic performance of manholes in flood conditions (Djordjevic *et al.*, 2005)







a) free inflow, inlet as a weir	*b) submerged inflow, inlet as an orifice*	*c) outflow*
$Q = \frac{2}{3} C_w W \sqrt{2g} (h_u - z_{crest})^{\frac{3}{2}}$ **Free Weir Equation**	$Q = \frac{2}{3} C_w W \sqrt{2g} (h_u - z_{crest})(h_u - h_d)^{\frac{1}{2}}$ **Submerged Weir Equation**	$Q = C_d A_0 \sqrt{2g(h_u - h_d)}$ **Orifice equation**

Basic cases of flow through equivalent inlet

PIV (Particle Image Velocimetry)

It is an image based method used to determine instantaneous velocity fields by measuring the displacement of a cluster of tracers in a fluid.

EXPERIMENTAL SETUP

* Particles (Velocity Lag, Scattering properties, Homogeneous distribution);
* Camera (Speed, Resolution, Low noise of electronics);
* Camera lens (As few aberrations as possible, Focal length);
* Triggering (Accurate, Stable);
* Calibration (Relation true particle position – particle image position)
* Computer with appropriate soft-hardware

SUMMARY

- The application of a physical model of a sewer system has been illustrated: an experimented study to investigate aspects of flooding and surcharge in a pipe network.
- Validation of a computer modelling software and potential application for RTC
- Good agreement between Infoworks simulations and laboratory measured flows and hydraulic features (velocity for the conditions into the pipes).
- Future work to include analysis of surface flows and 1D/2D modelling.
- Potential application for PIV technique and comparison with digital maps generated by computer software.

Thank you for your attention