

(Low frequency) Waves as Defect Detection

The Italy Experience

1

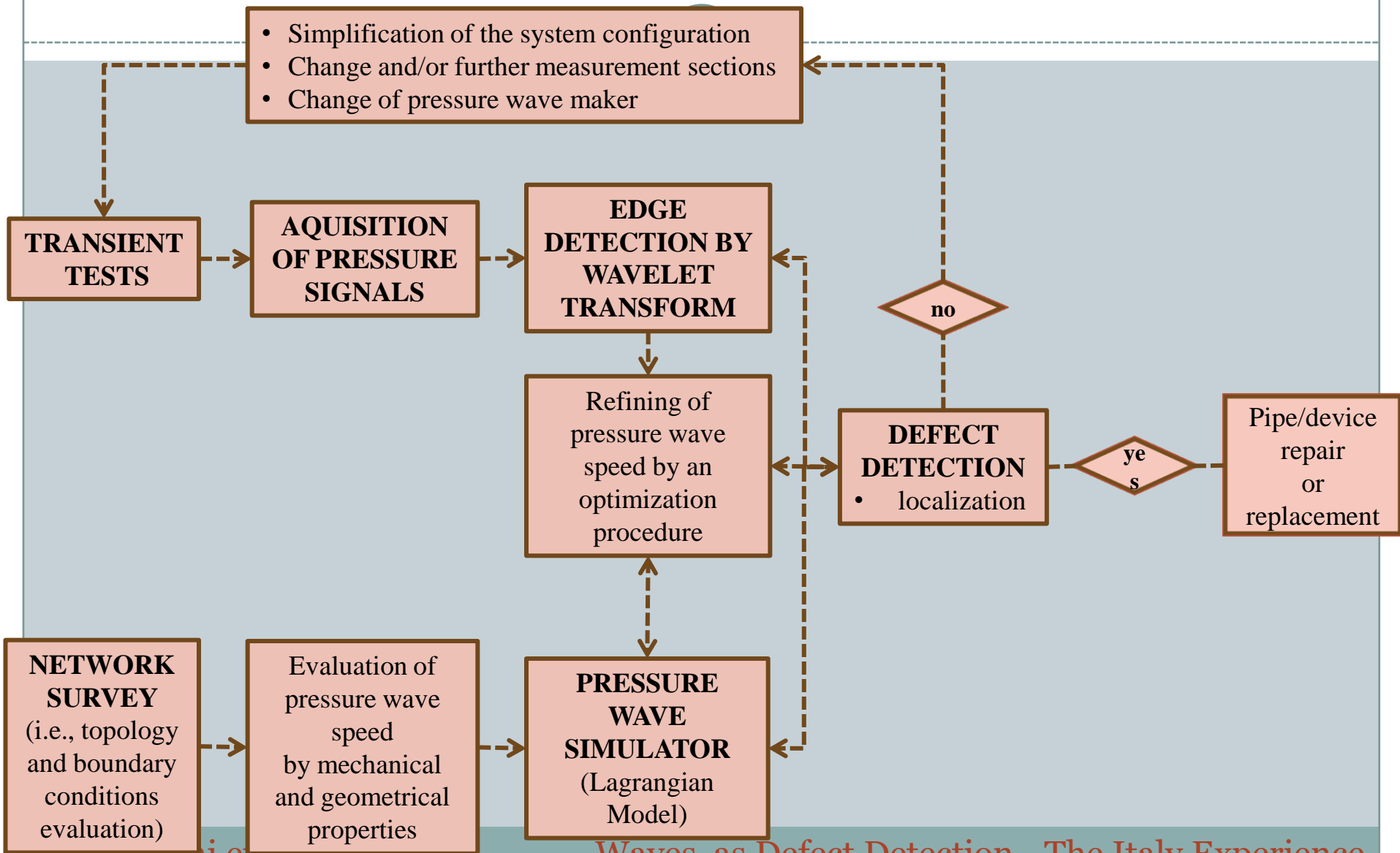
**Silvia Meniconi, Bruno Brunone,
Marco Ferrante, Caterina
Capponi, Elisa Mazzetti**

Outline

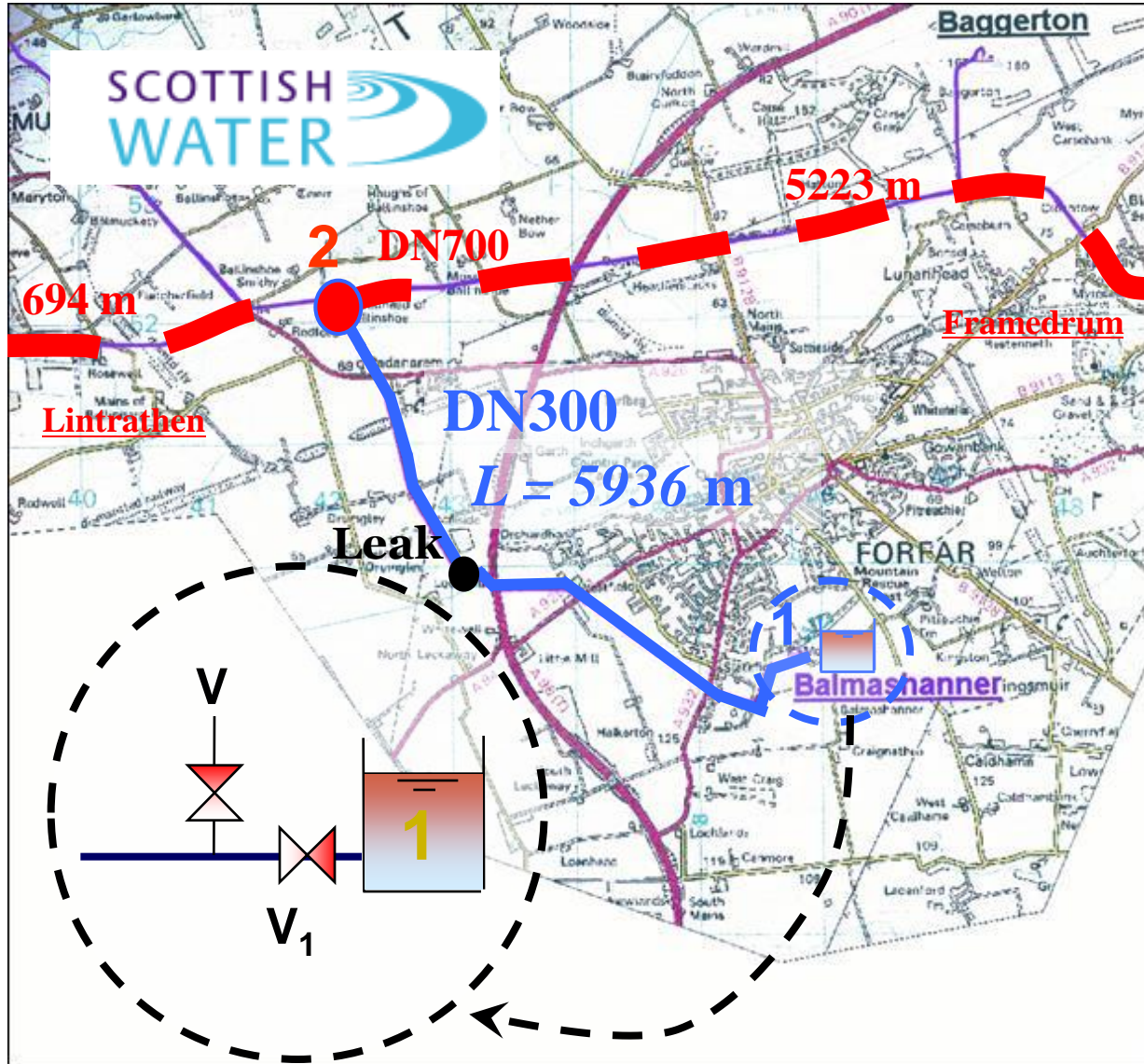
2

- Methodology: transients to diagnose a pressure pipe system
- Application of this methodology to
 1. a single damaged pipe in Scotland
 2. a Y system in the Water Engineering Laboratory of University of Perugia
 3. the Milan water distribution-transmission system
 4. the Rieti transmission main

Transients to diagnose a system



The Lintrathen East Trunk Main in Scotland



European project
Surge-net

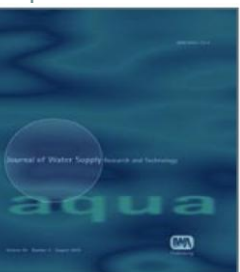


COMPETITIVE AND SUSTAINABLE GROWTH

$$L_{LEAK} = 3100 \text{ m}$$

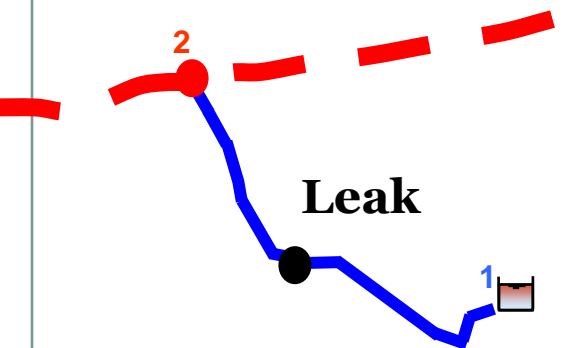
Ferrantet al. (2009).

Leak detection in branched pipe systems coupling wavelet analysis and Lagrangian model



Location of a simulated leak in the the pipe supplied by the Balmashanner reservoir (UK)

acquisition frequency
20 Hz

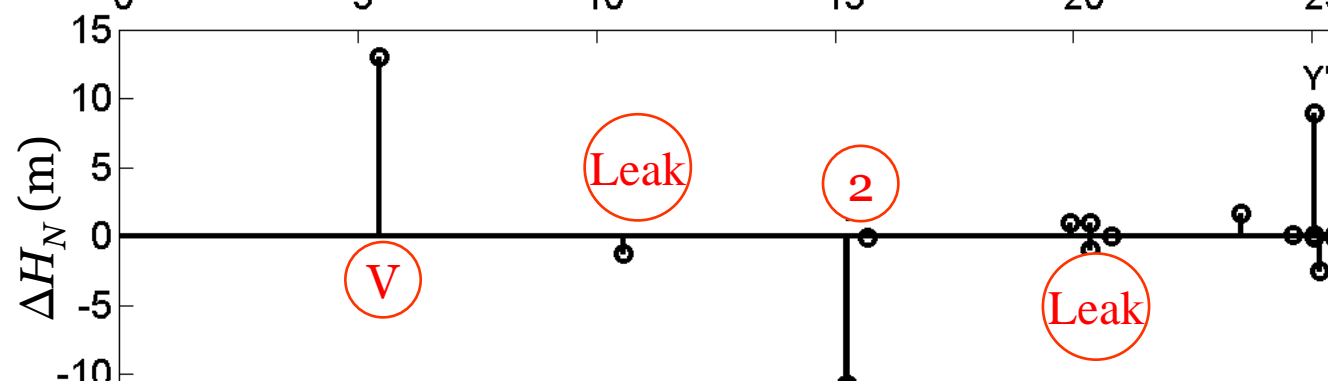
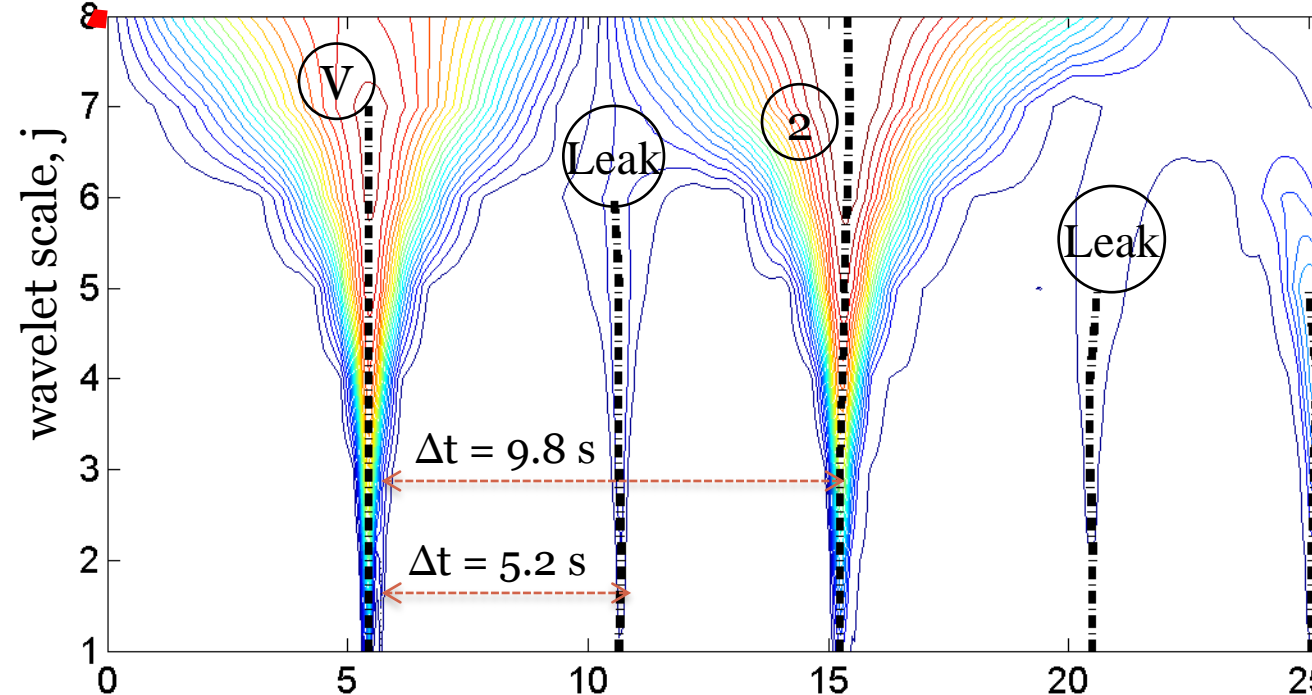
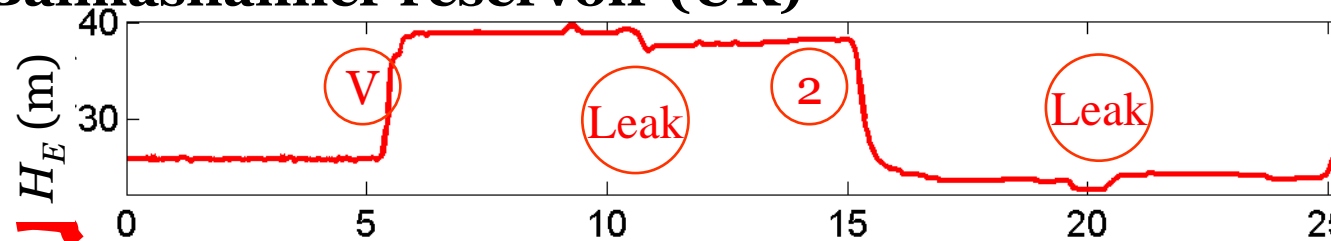


$$a = 2L/\Delta t = 1211.43 \text{ m/s}$$

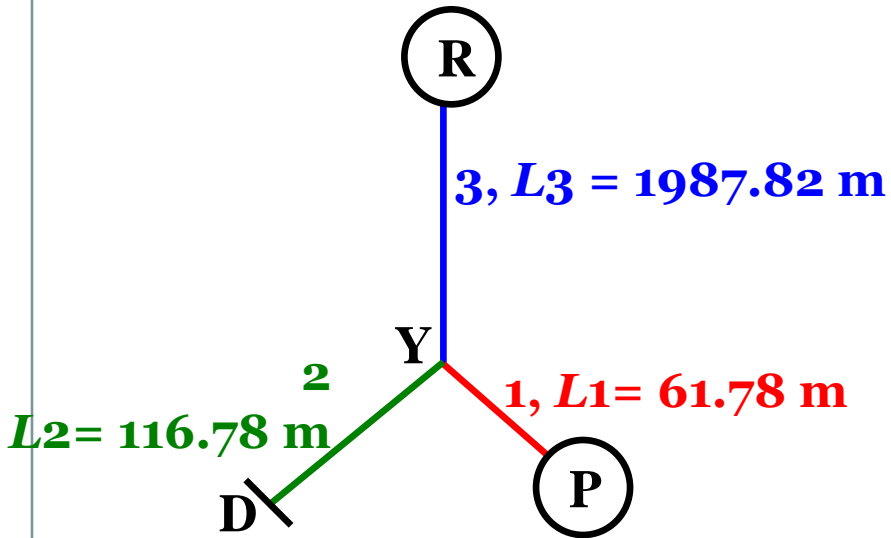
$L_{\text{LEAK}} = 3100 \text{ m}$

$L_{\text{LEAK, EN}} = 3149 \text{ m}$

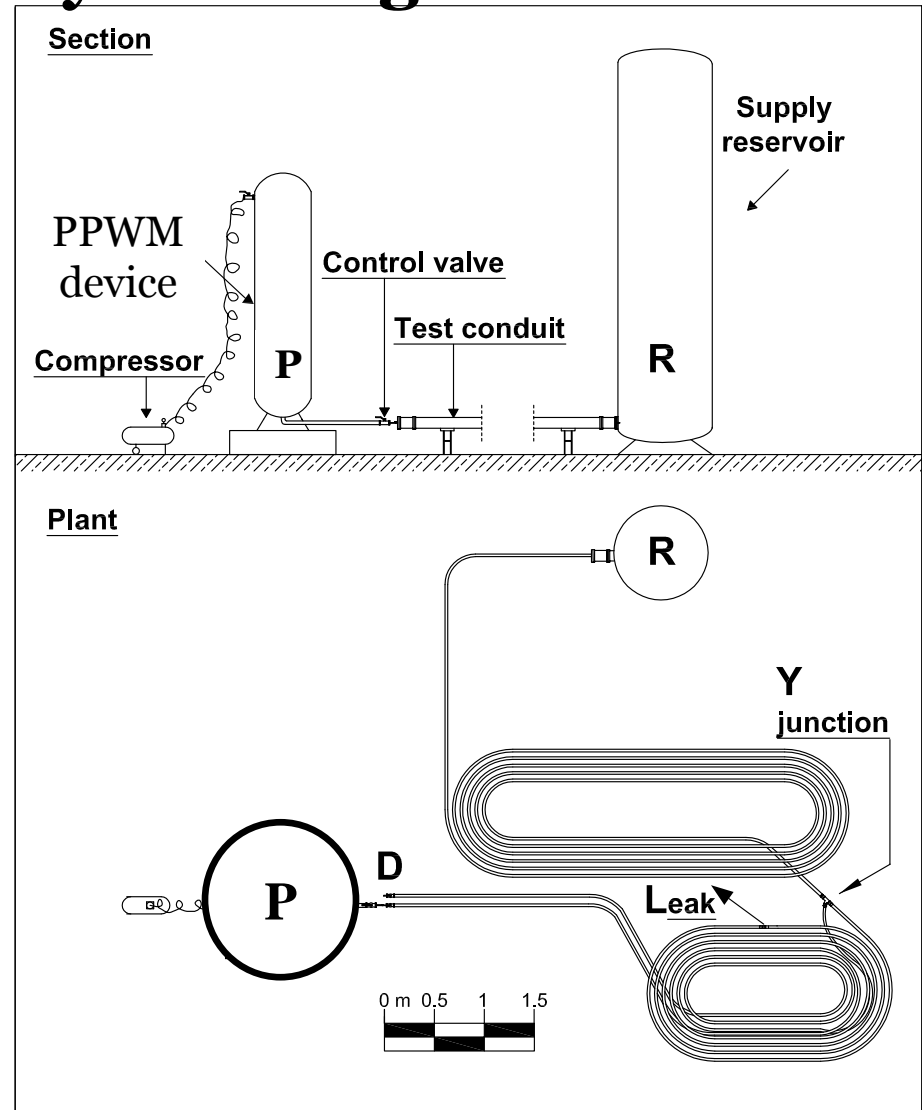
error = 2 %



The Y system in the Water Engineering Laboratory of University of Perugia

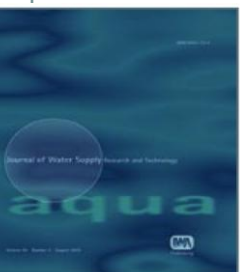


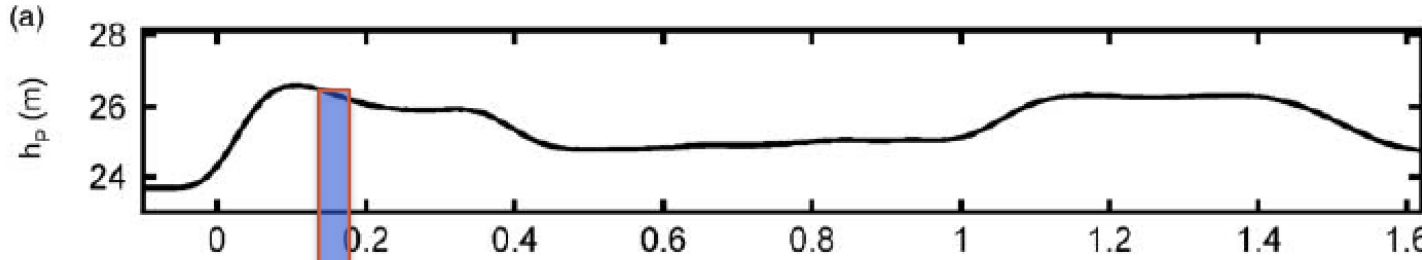
HDPE pipes DN 110



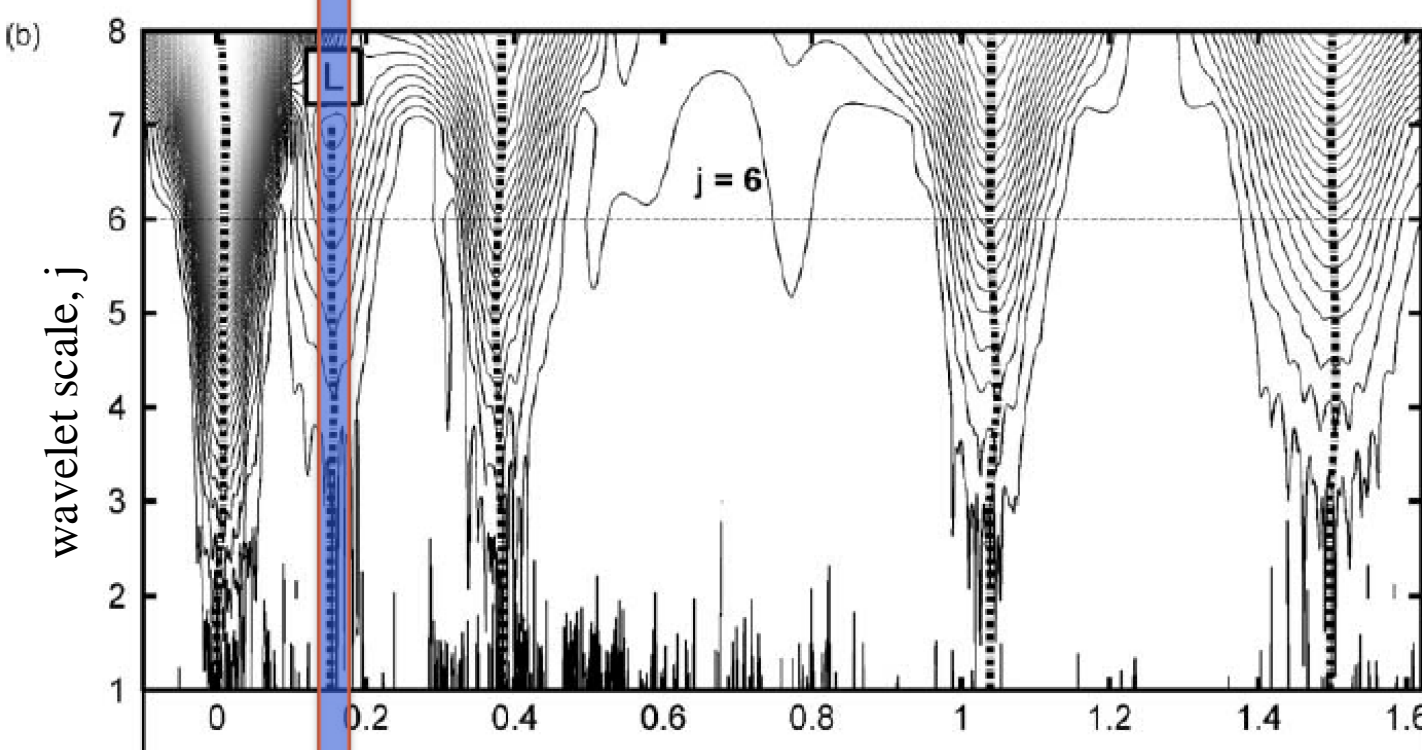
Ferrantet al. (2009).

Leak detection in branched pipe systems coupling wavelet analysis and Lagrangian model

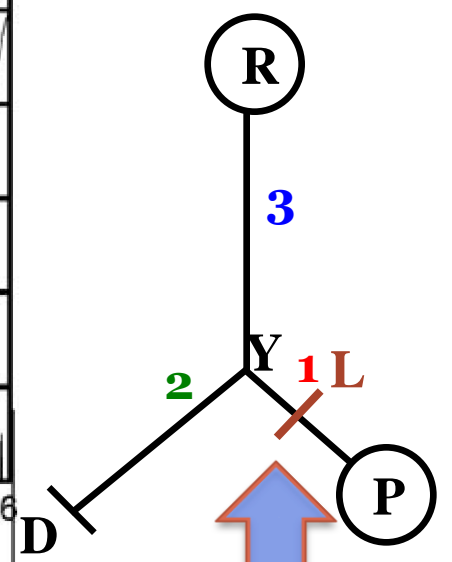
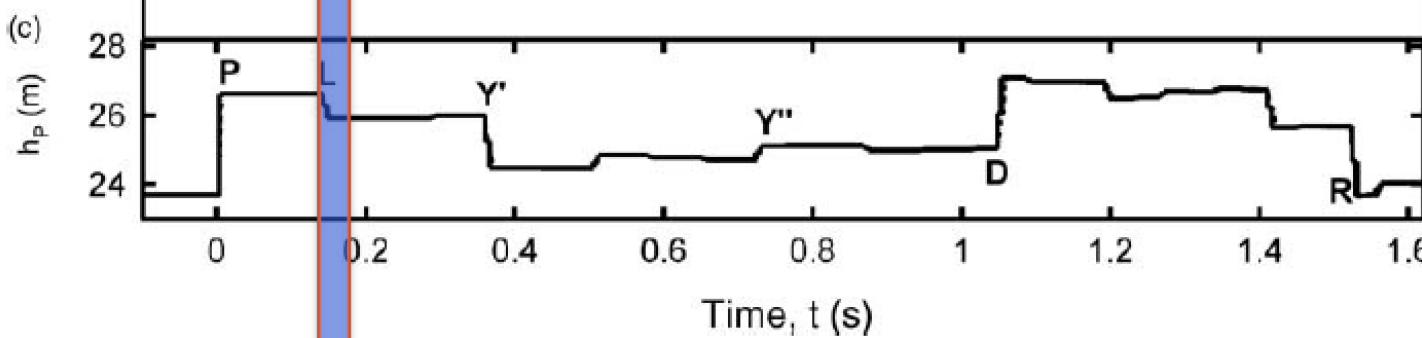




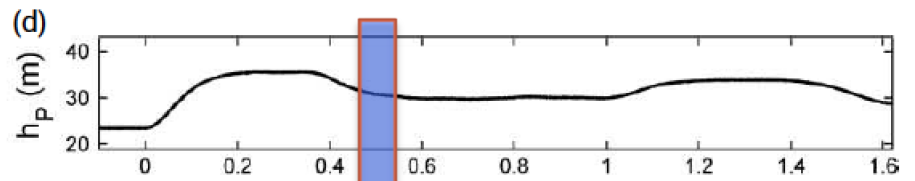
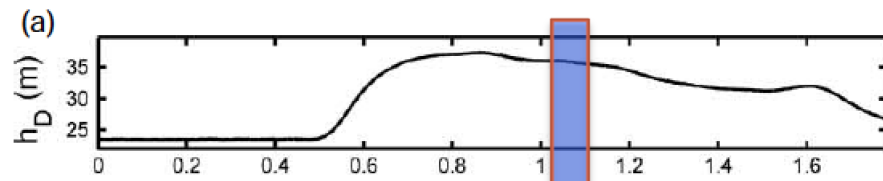
LEAK
diameter_{LEAK} = 1.49cm



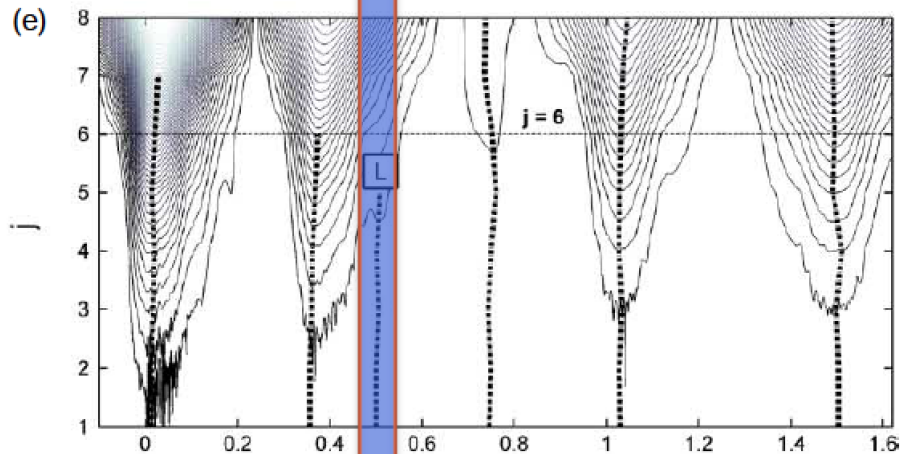
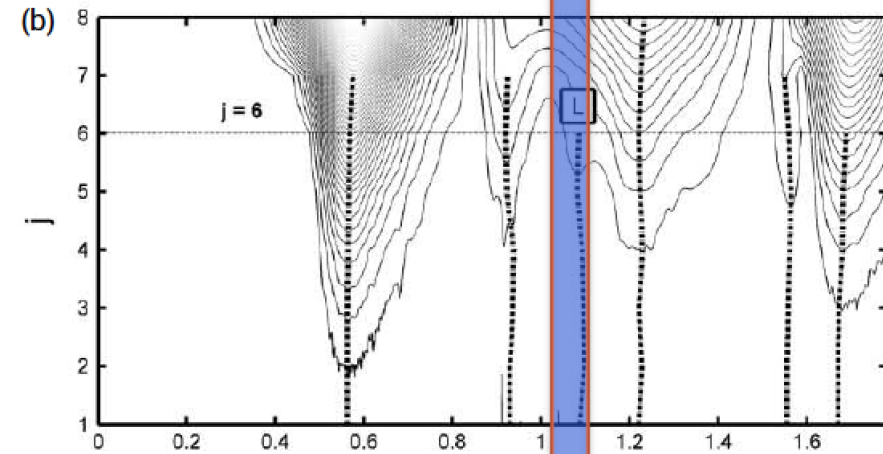
distance_{LEAK-PPPWM} = 24.68m



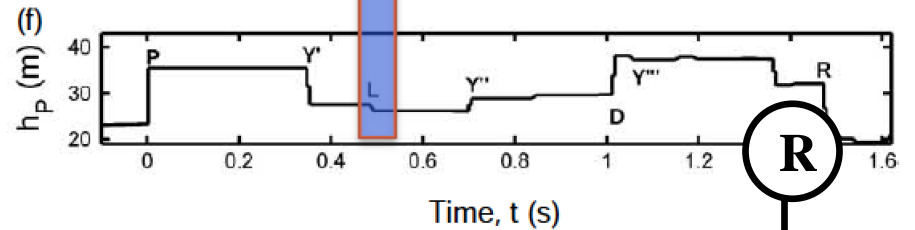
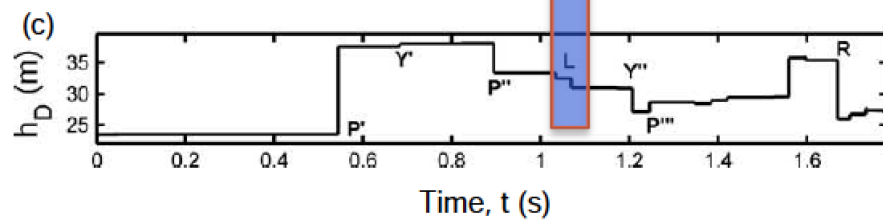
Pressure signal



Identification of singularities using the MZWT



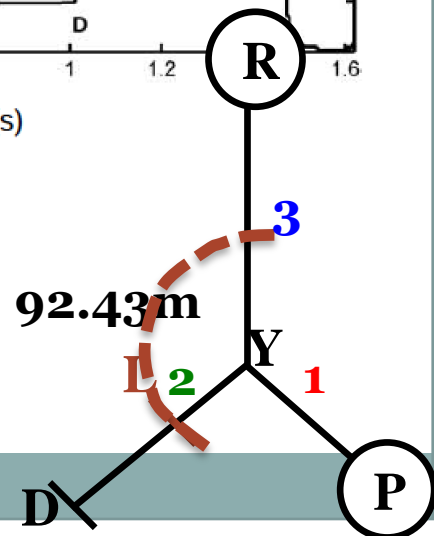
Numerical reconstruction of the signal by means of the Lagrangian model



LEAK

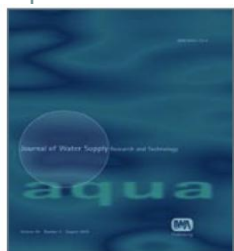
$d_{LEAK} = 1.49\text{cm}$

distance $LEAK-D = 92.43\text{m}$

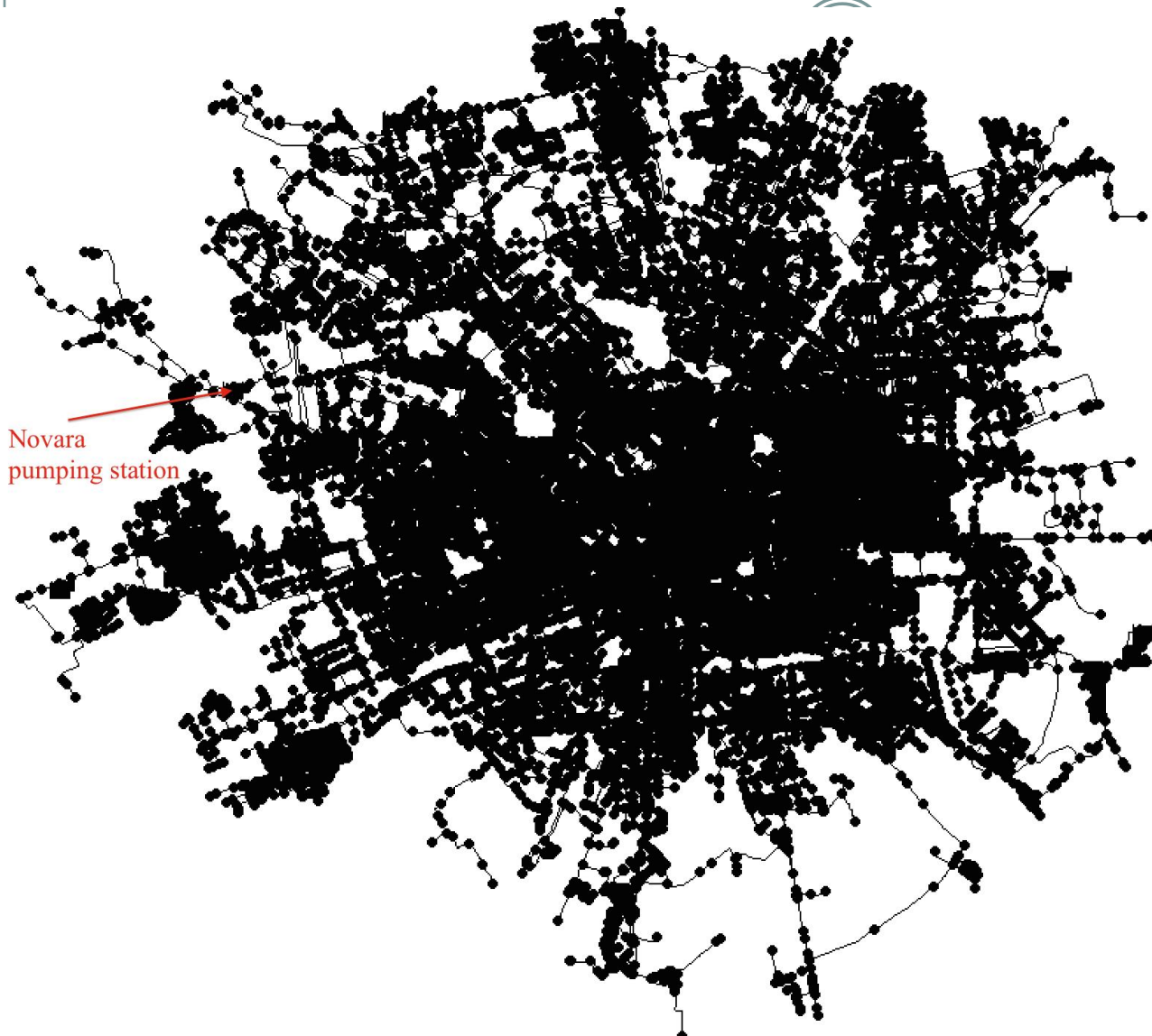


Ferrantet al. (2009).

Leak detection in branched pipe systems
coupling wavelet analysis and Lagrangian
model



Milan water distribution-transmission system

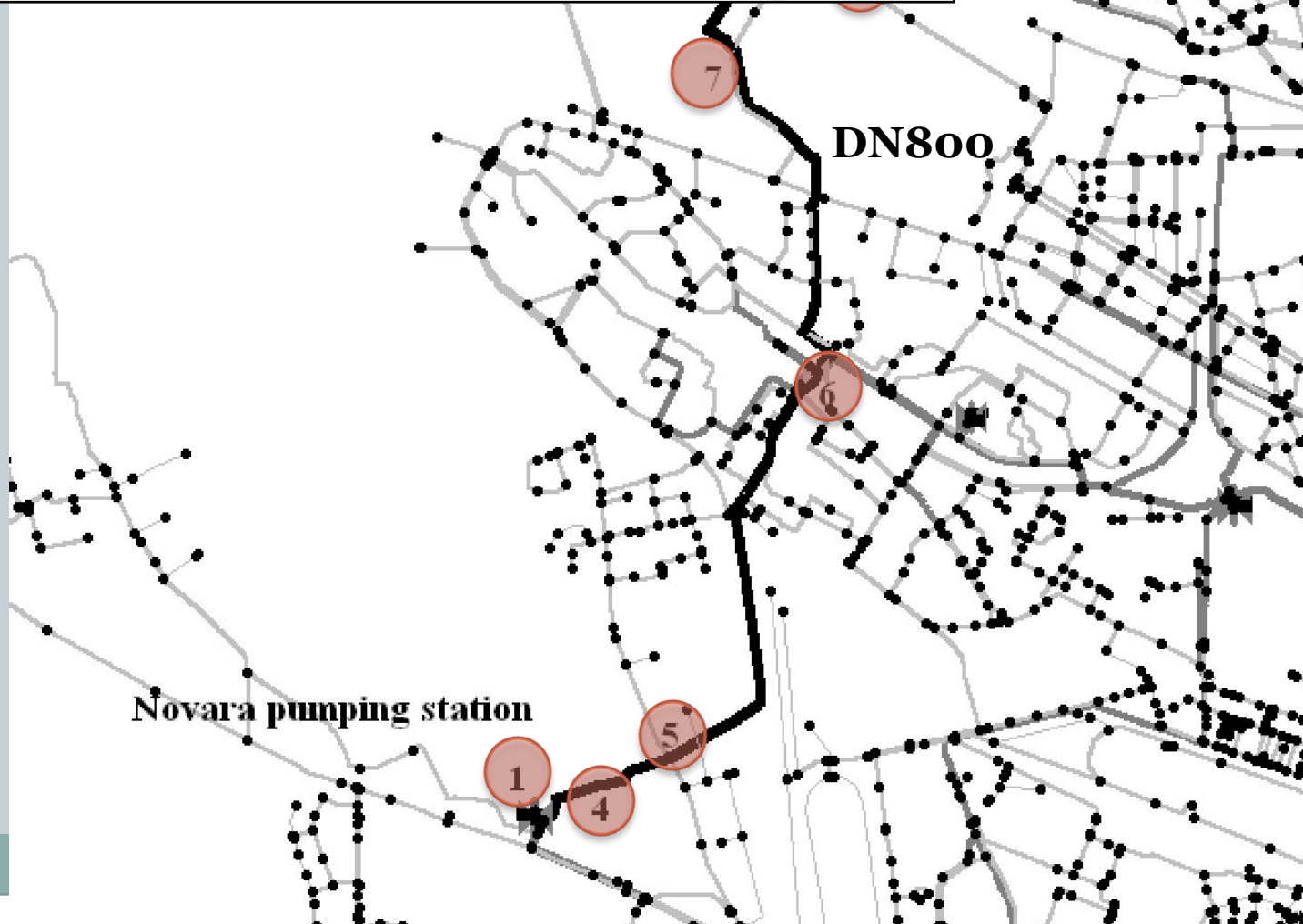
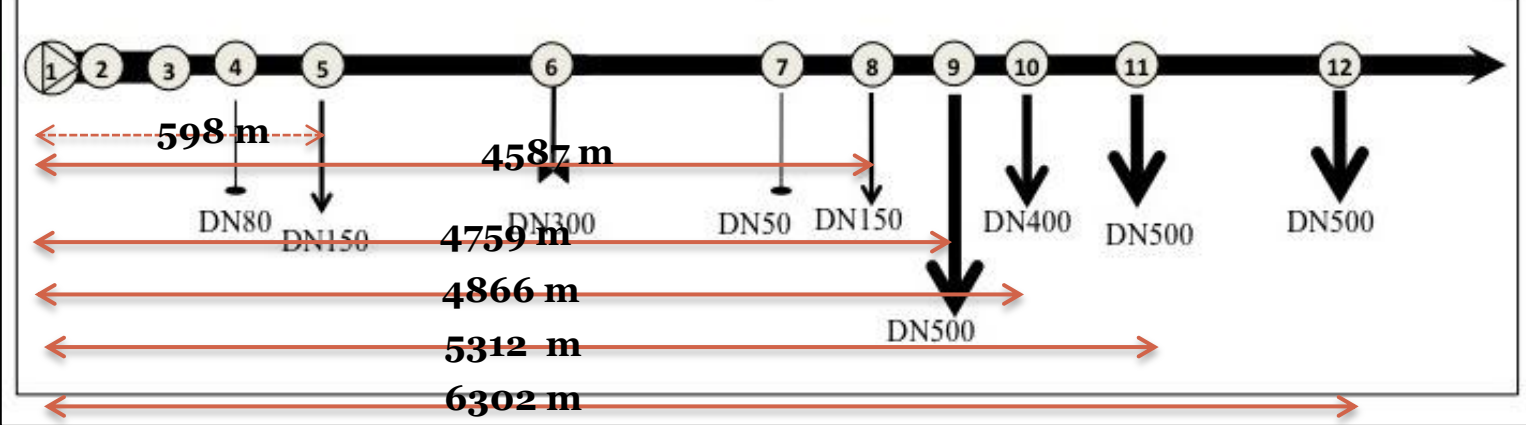


Meniconi et al. (2014).
Anomaly pre-localization in
distribution-transmission
mains by pump trip:
preliminary field tests in the
Milan pipe system

“Novara” pumping station

10

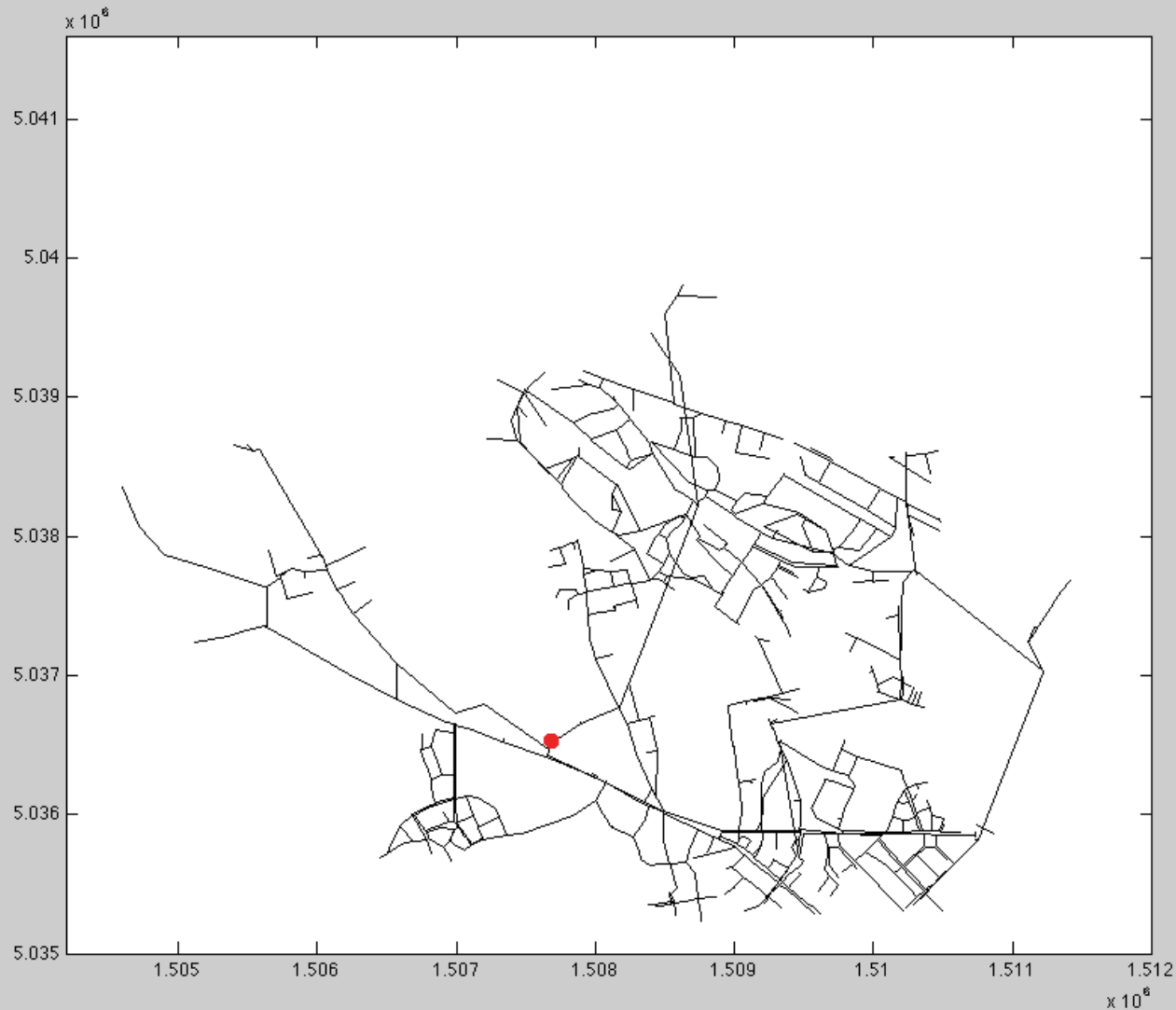




Propagation of the pressure wave generated by a pump trip in the pipe system supplied by Novara pumping station

MM

METROPOLITANA MILANESE SPA

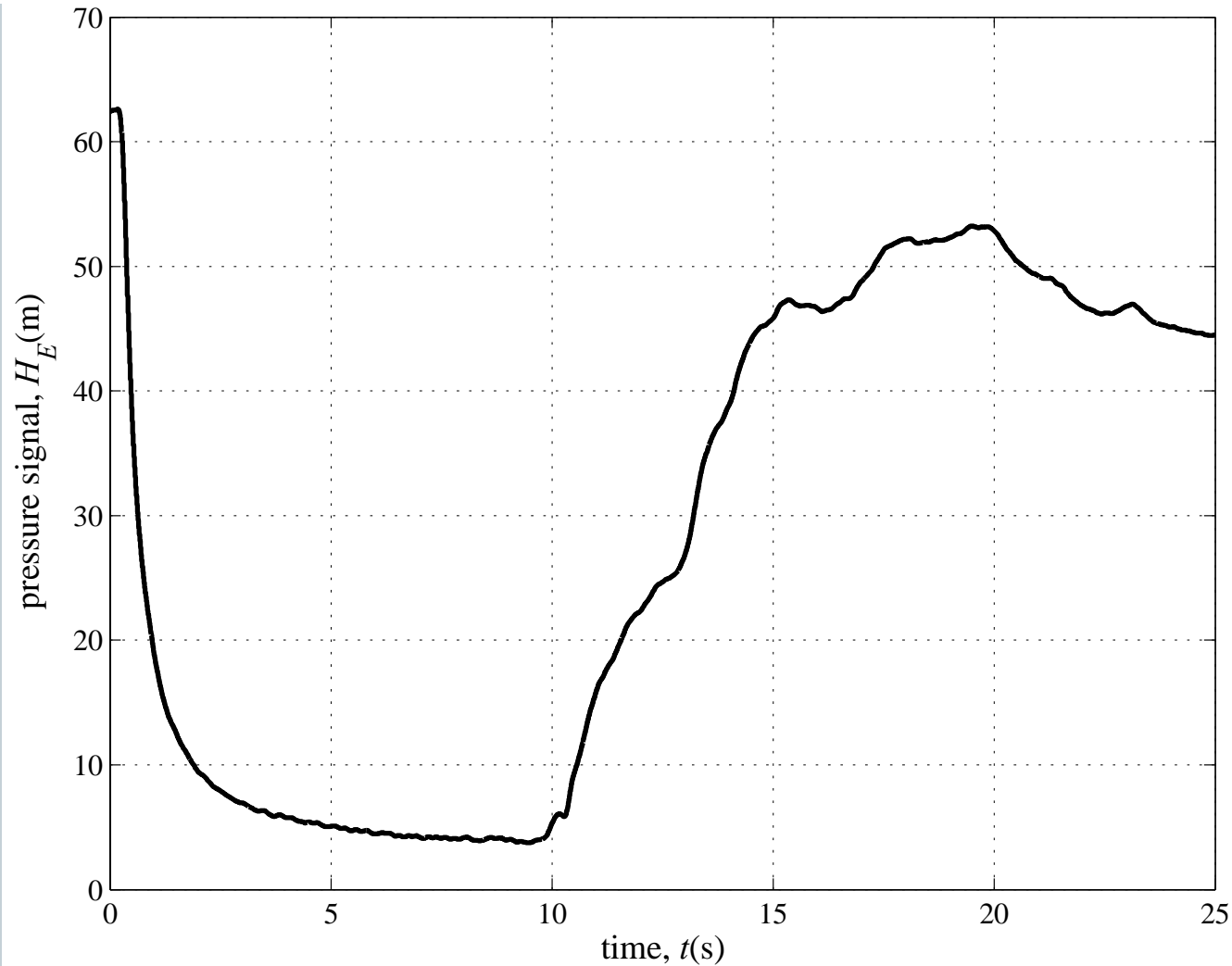


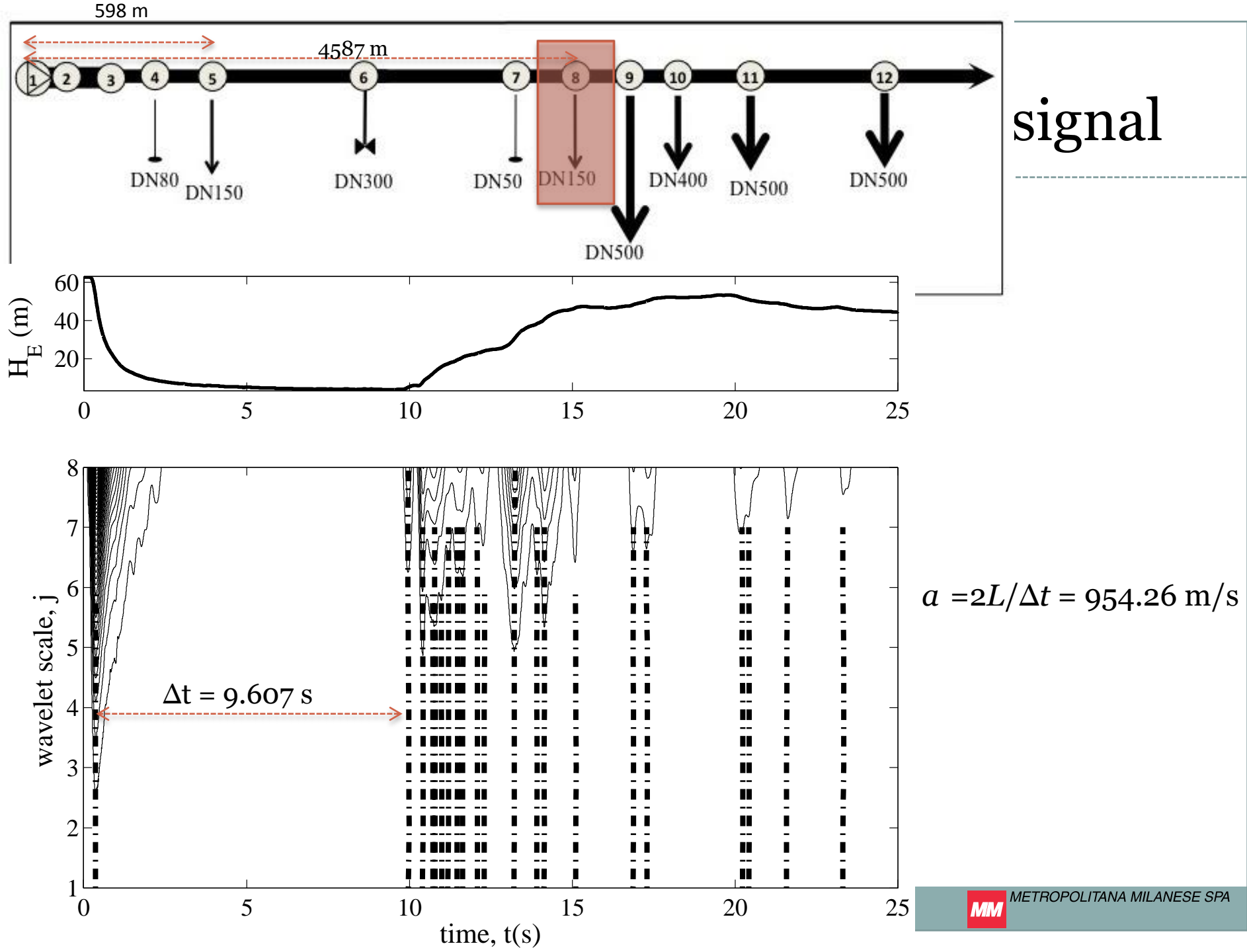
Pressure signal

13

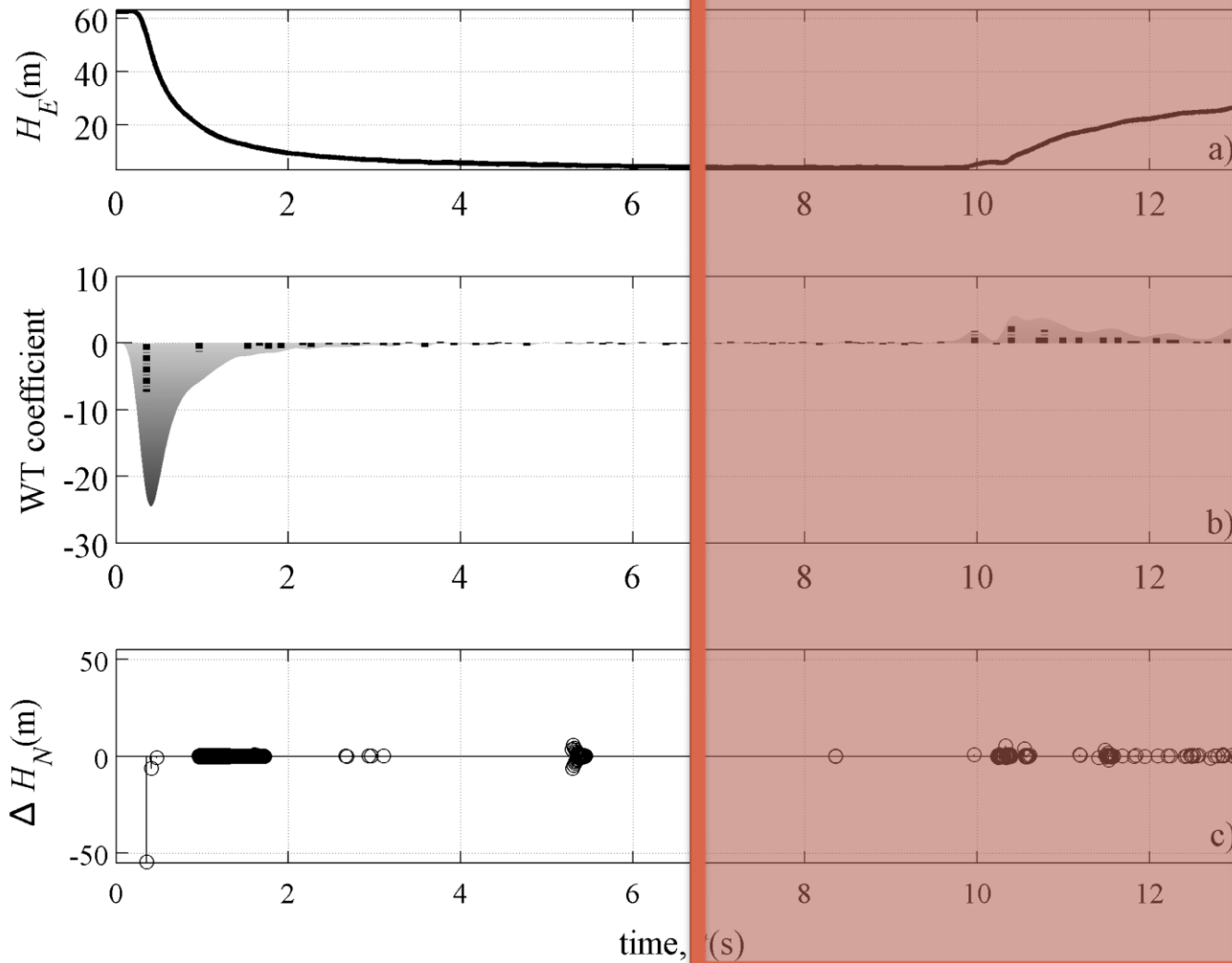
acquisition
frequency =
1000 Hz

*Full scale of
pressure
transducer =
7 bar*





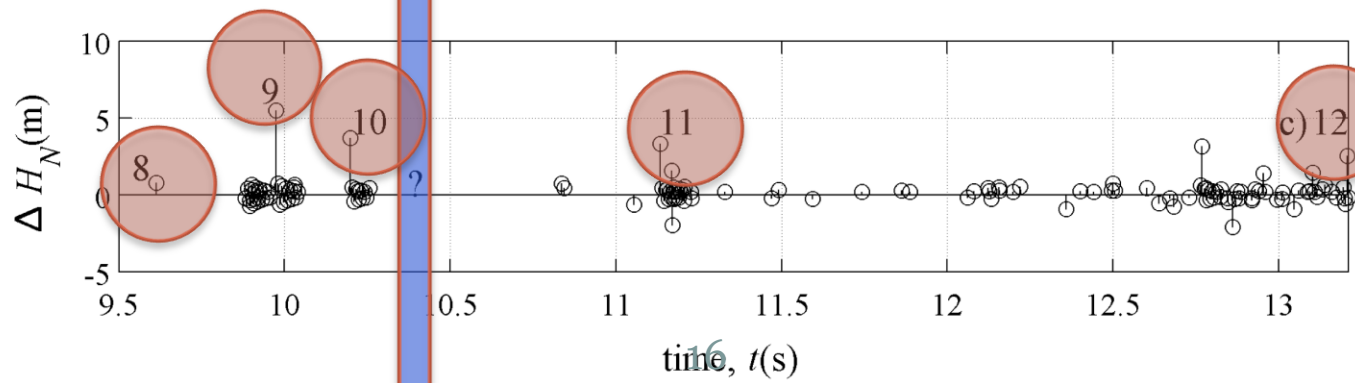
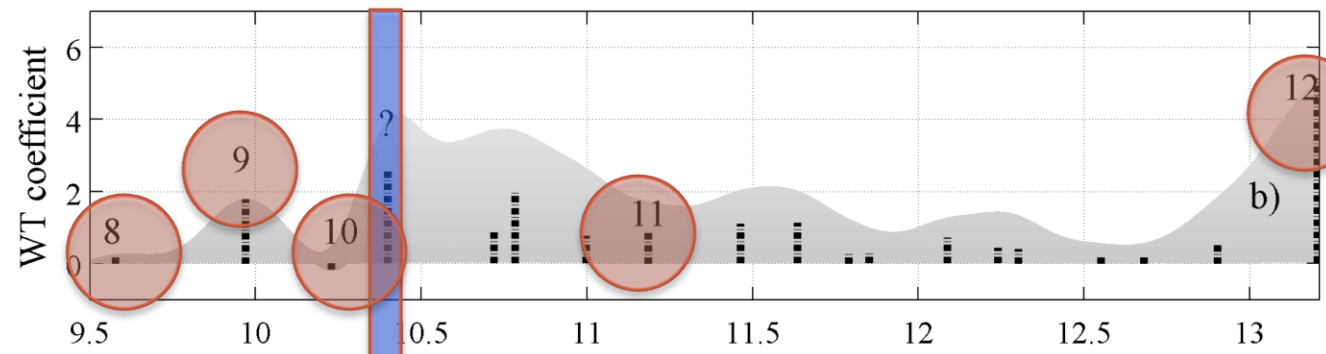
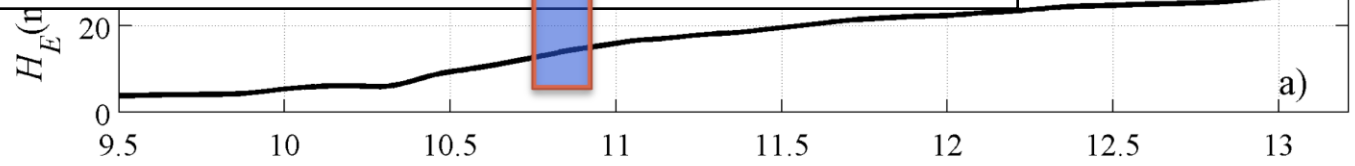
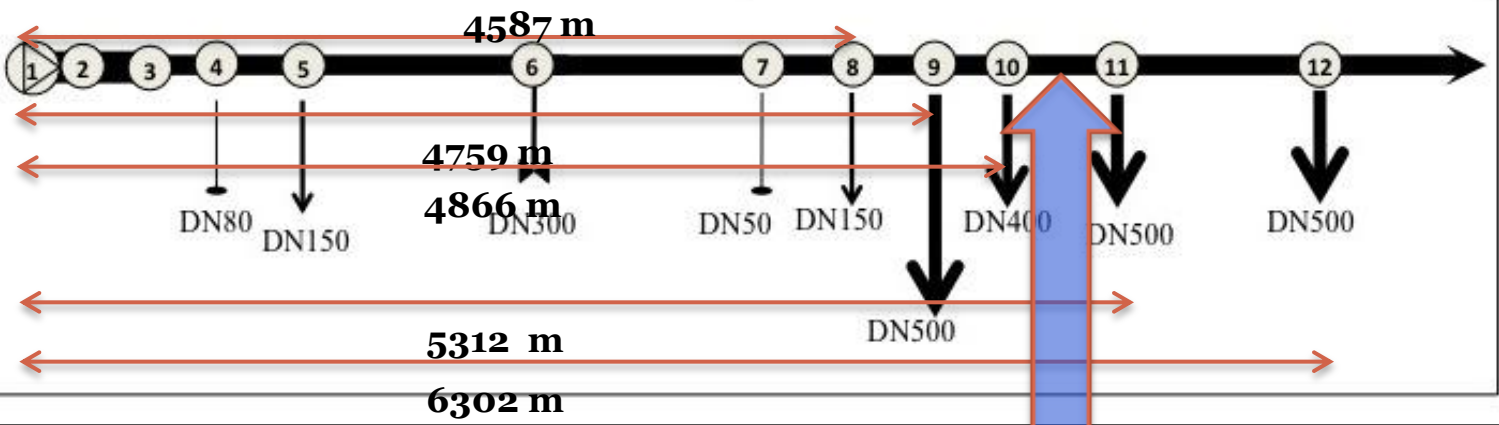
Wavelet transform and a Lagrangian model



**PRESSURE
SIGNAL**

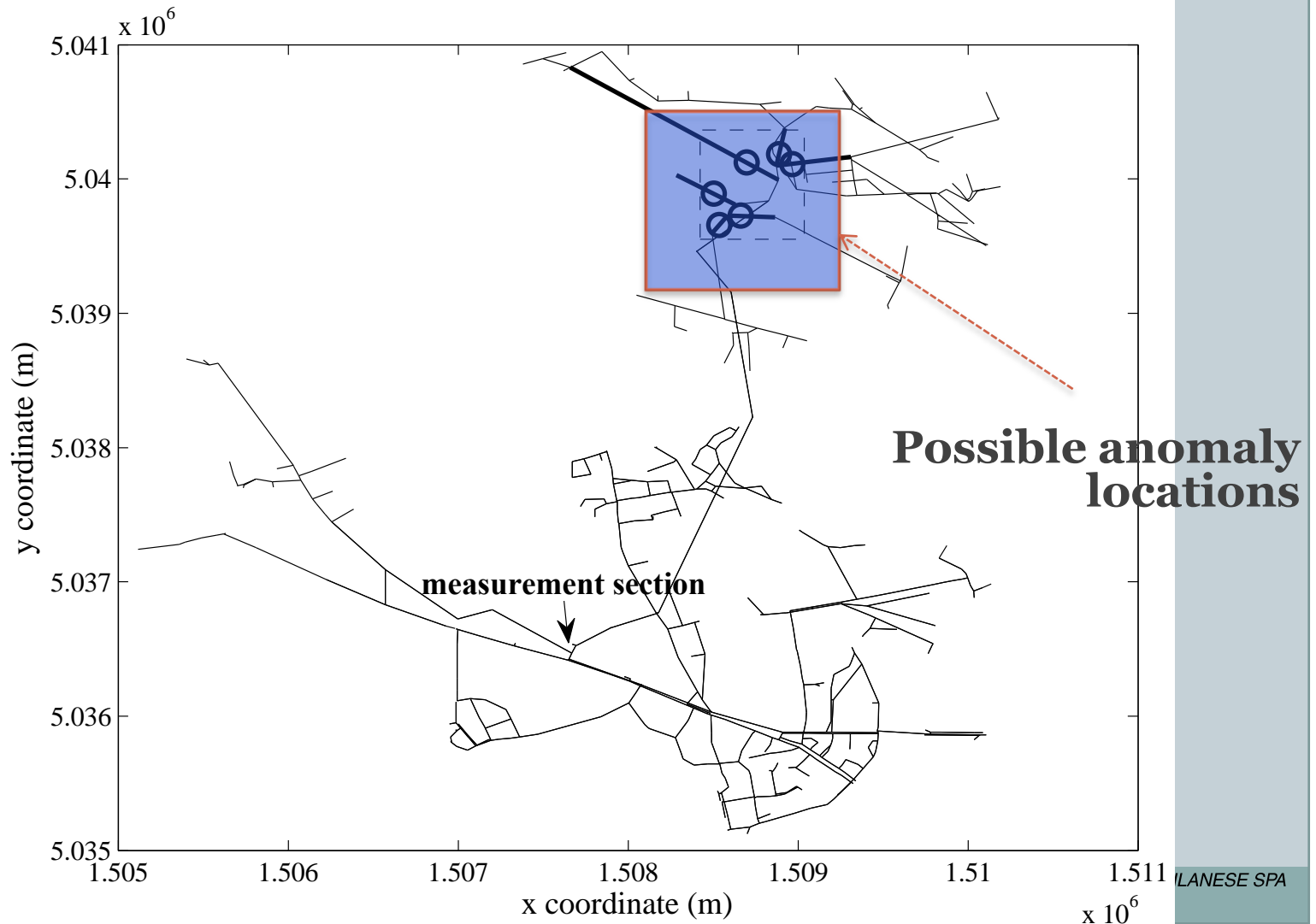
**WAVELET
TRANSFORM**

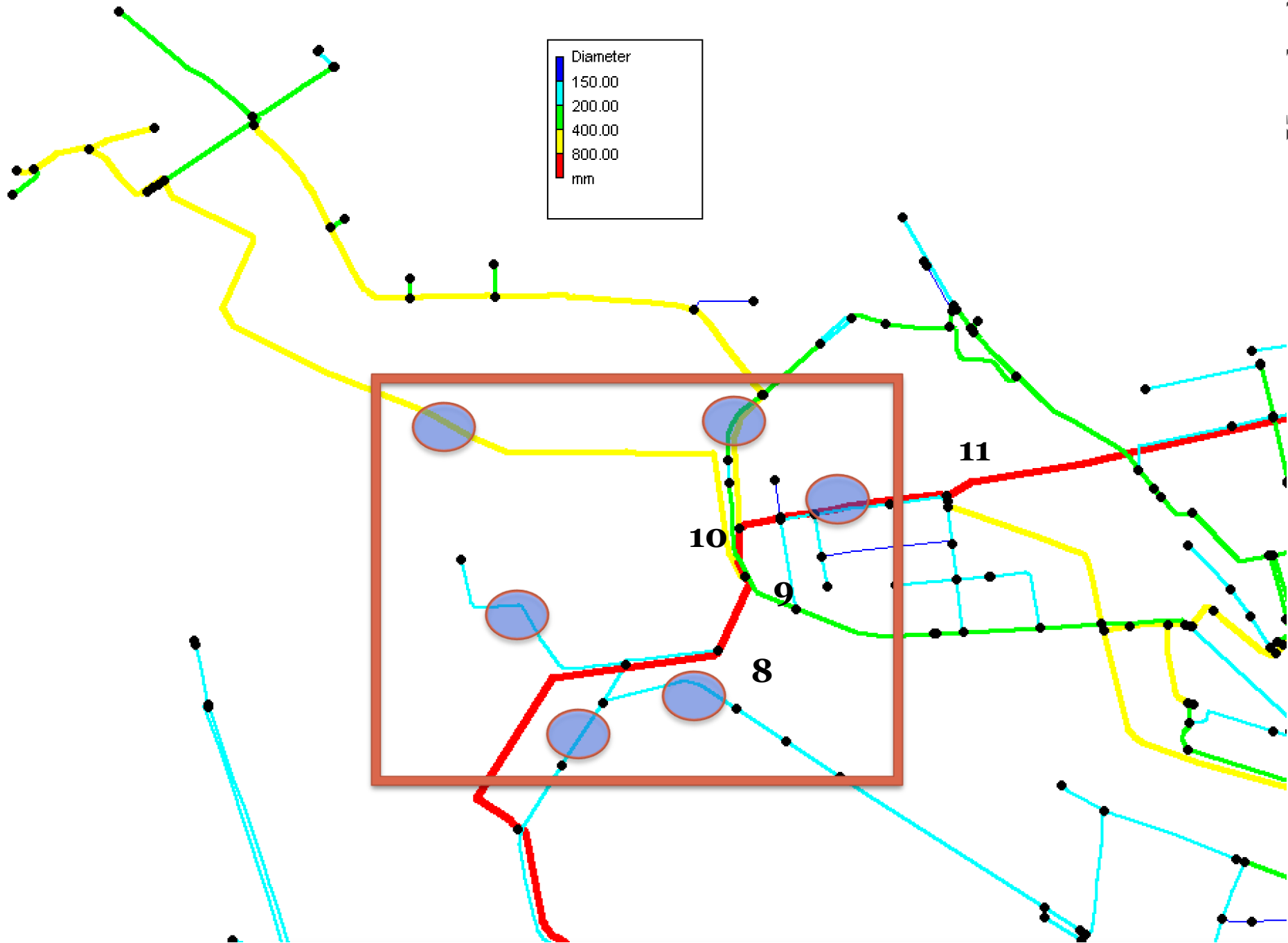
**LAGRANGIAN
MODEL**

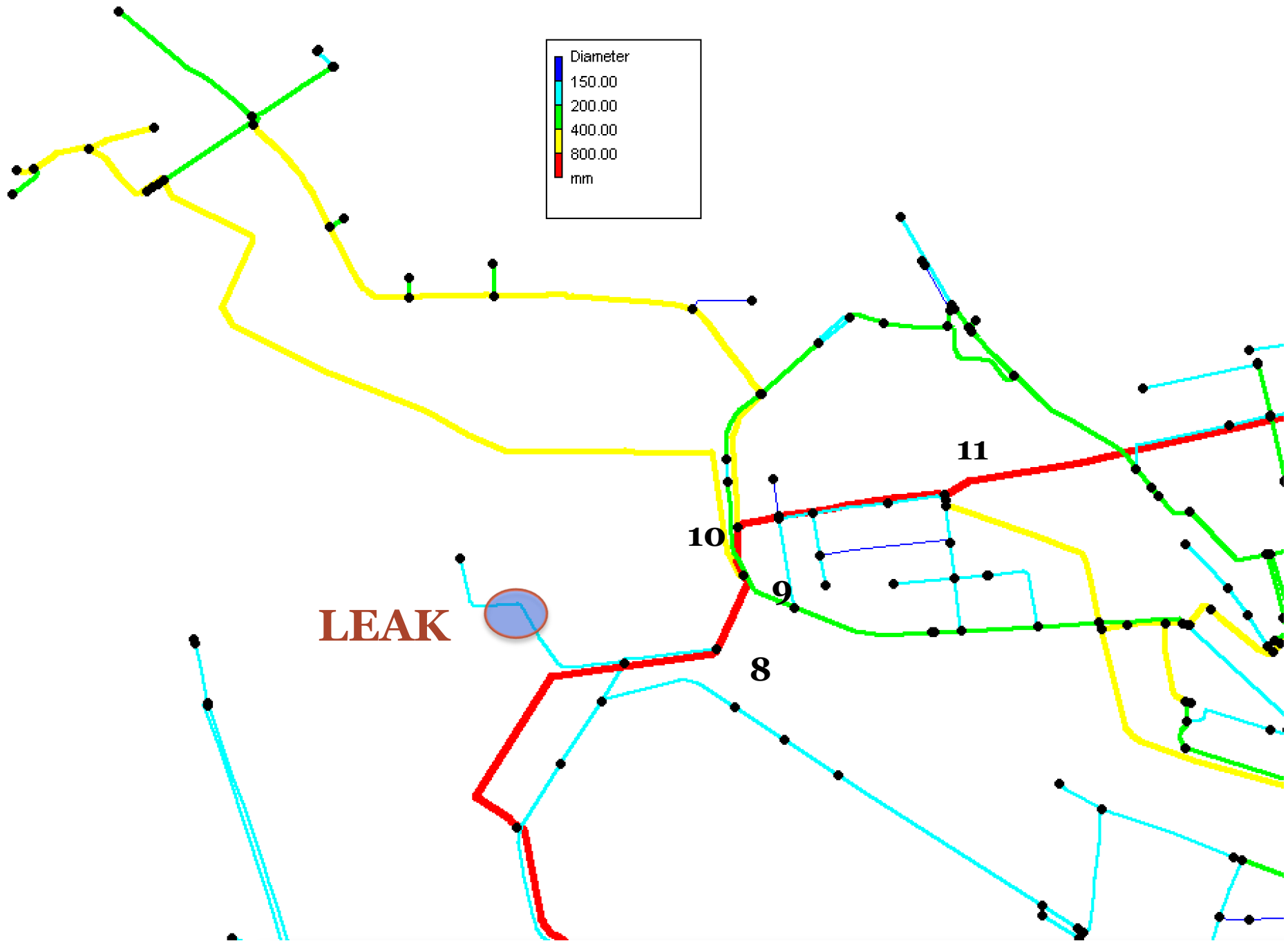


Novara system

(17)

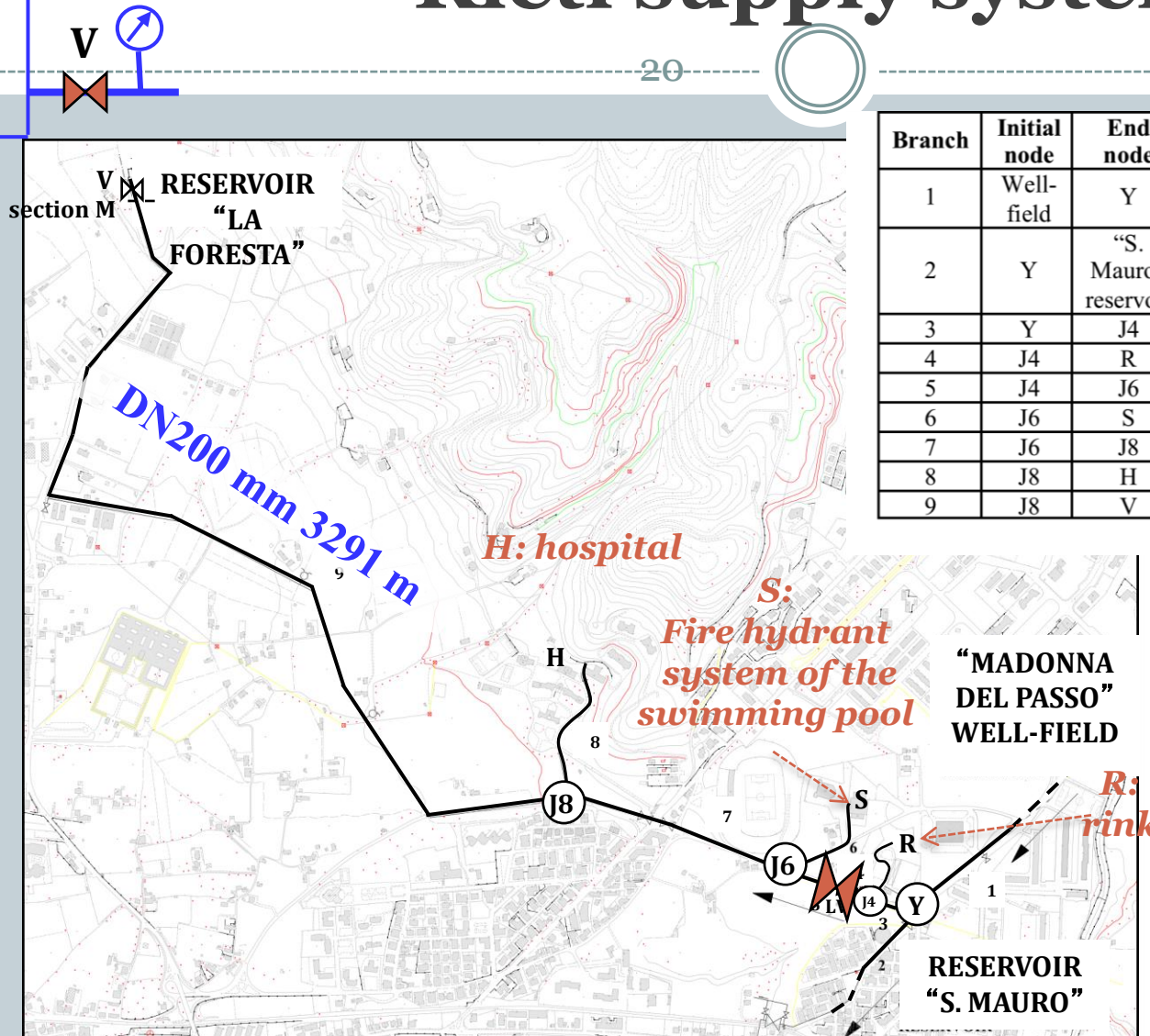




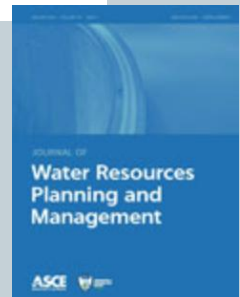


Rieti supply system

20



Branch	Initial node	End node	L (m)	e (mm)	DN (mm)	a (m/s)
1	Well-field	Y	4274	5.1	400	901
2	Y	"S. Mauro" reservoir	1849	5.1	400	901
3	Y	J4	16	4.9	200	1068
4	J4	R	80	2.9	40	1268
5	J4	J6	265	4.9	200	1068
6	J6	S	200	2.9	90	1129
7	J6	J8	500	4.9	200	1068
8	J8	H	190	2.9	90	1129
9	J8	V	2450	4.9	200	1068



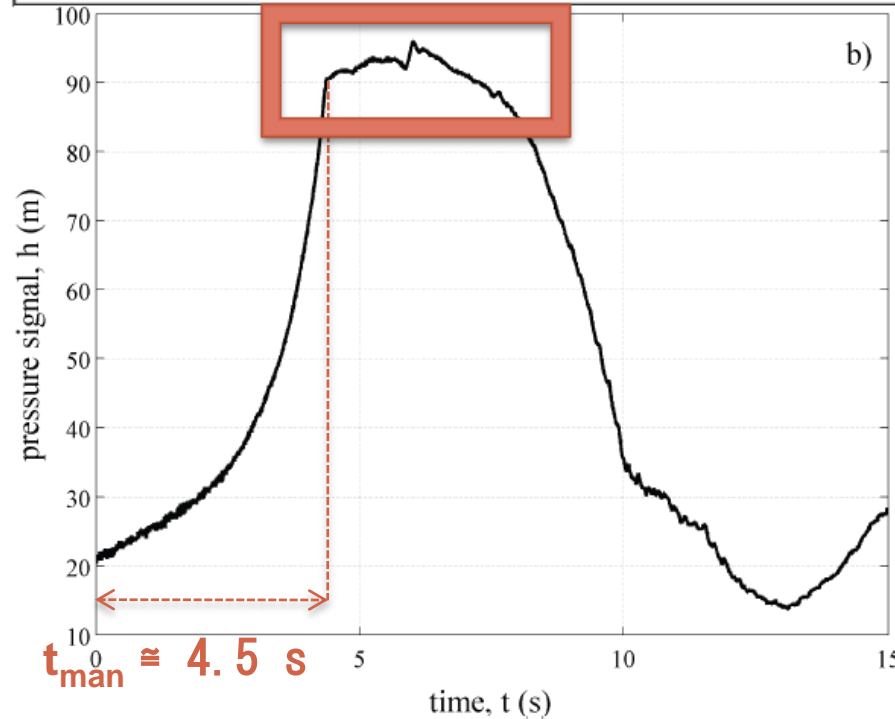
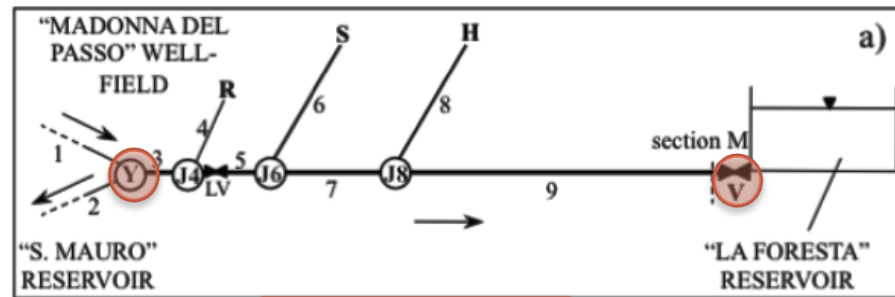
Meniconi et al. (2011).
Potential pf transient
test to diagnose real
supply pipe systems:
what can be done with a
single extemporary test

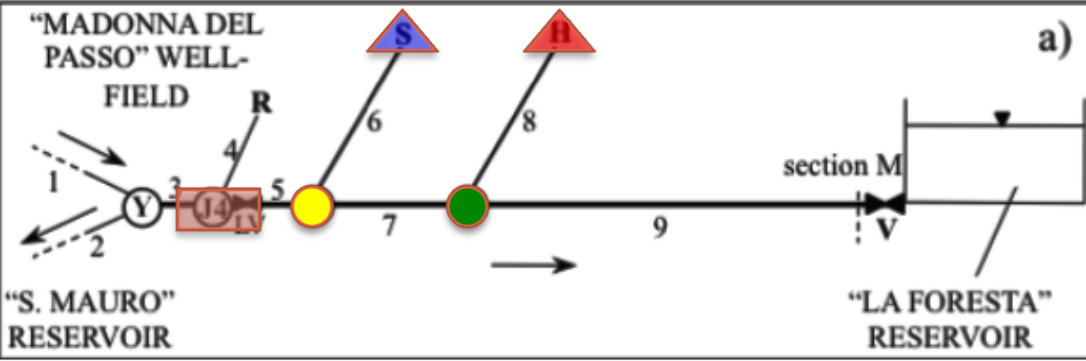
Rieti supply system

21

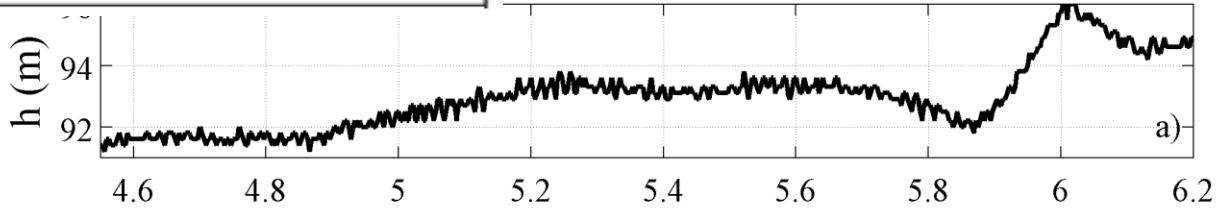
acquisition
frequency
320 Hz

$f_s = 16 \text{ bar}$

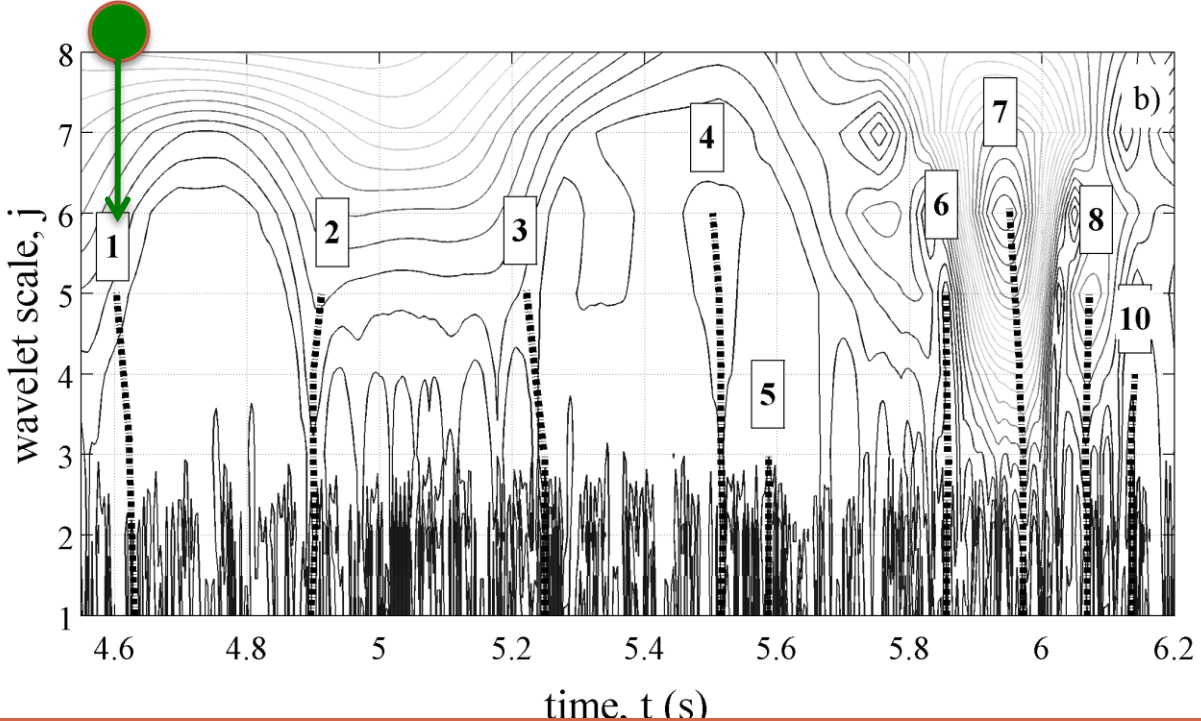




PRESSURE SIGNAL

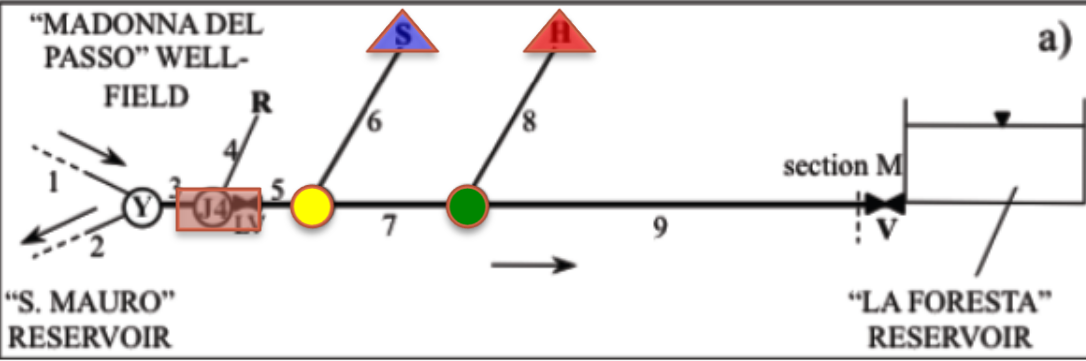


WAVELET ANALYSIS



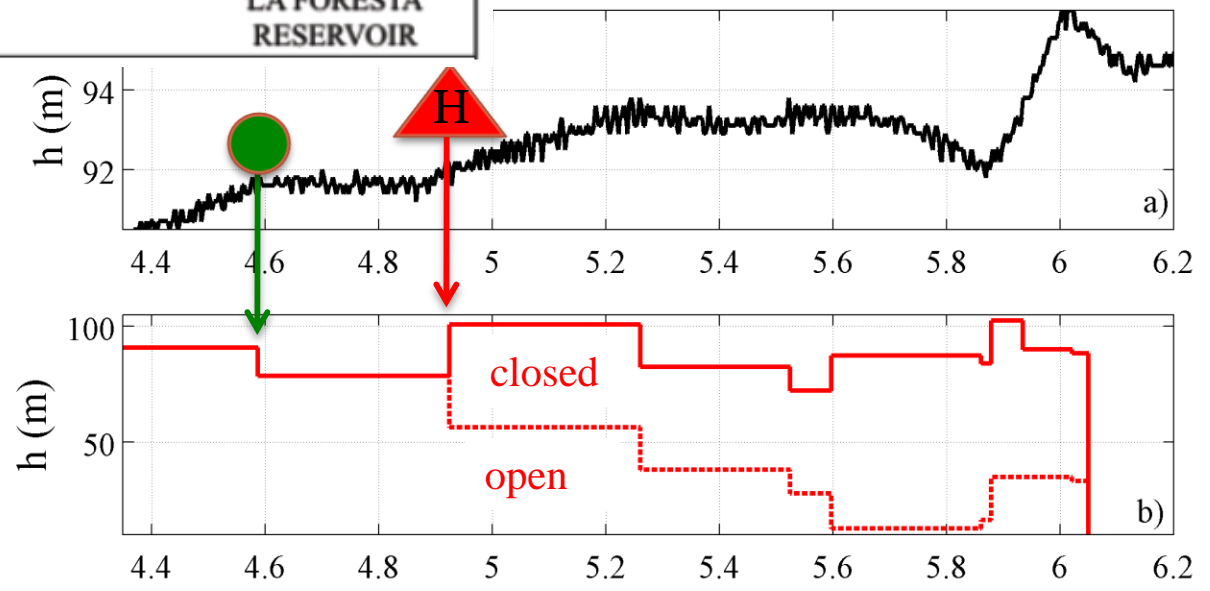
$\Delta t = 4.59 \text{ s}$

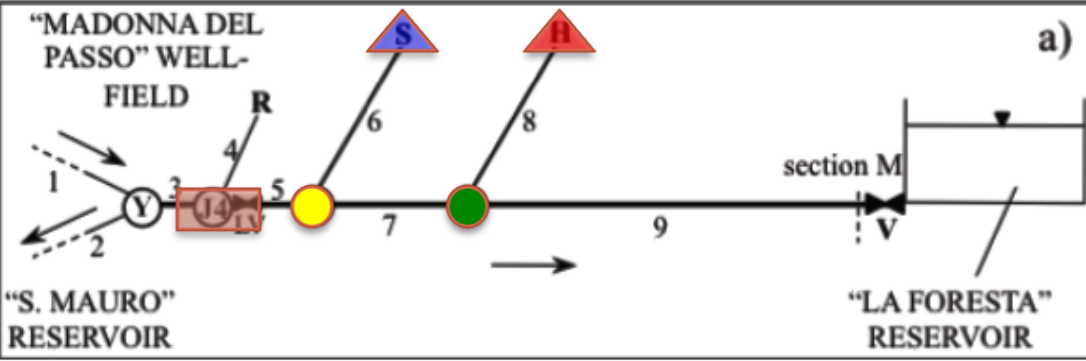
$a = 2L/\Delta t = 1068 \text{ m/s}$



PRESSURE SIGNAL

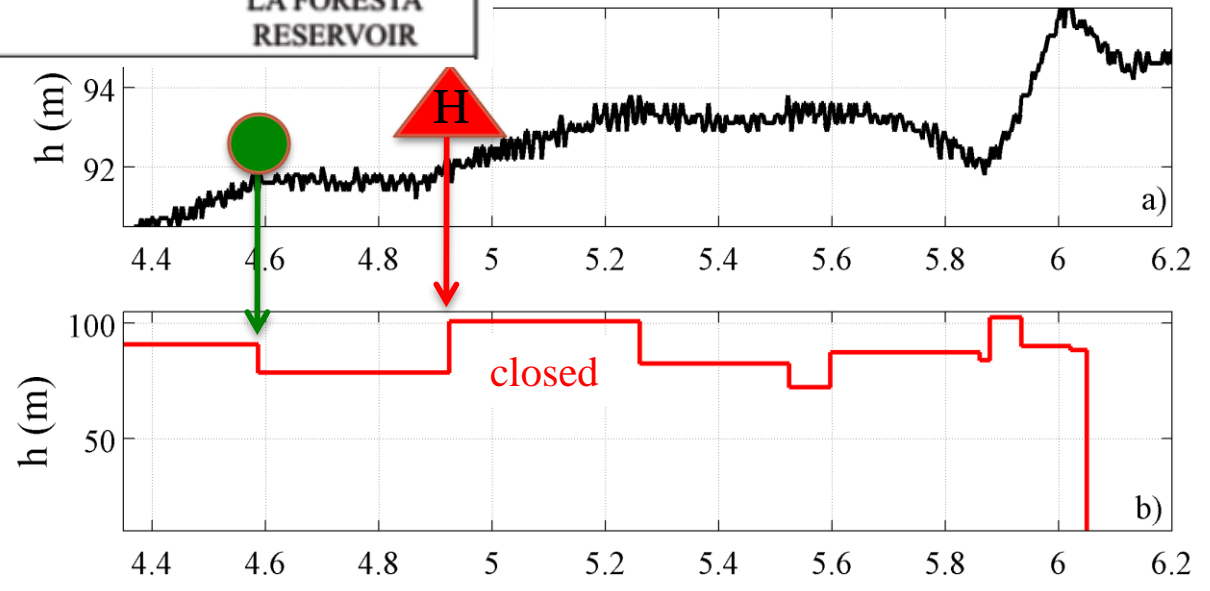
LAGRANGIAN MODEL

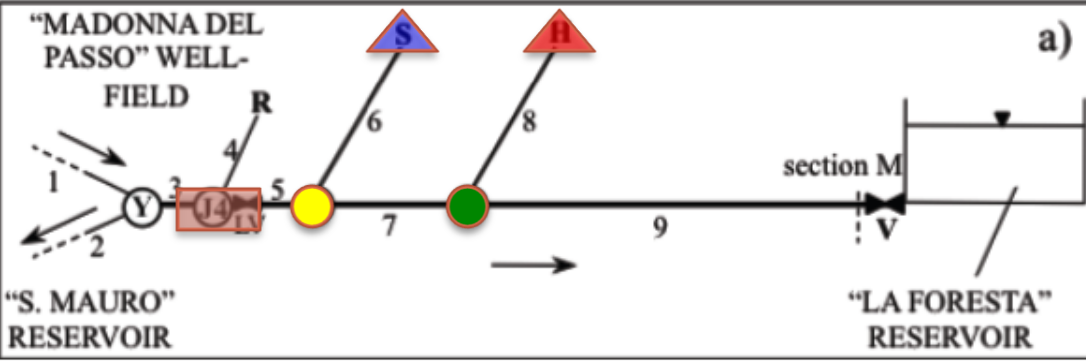




PRESSURE SIGNAL

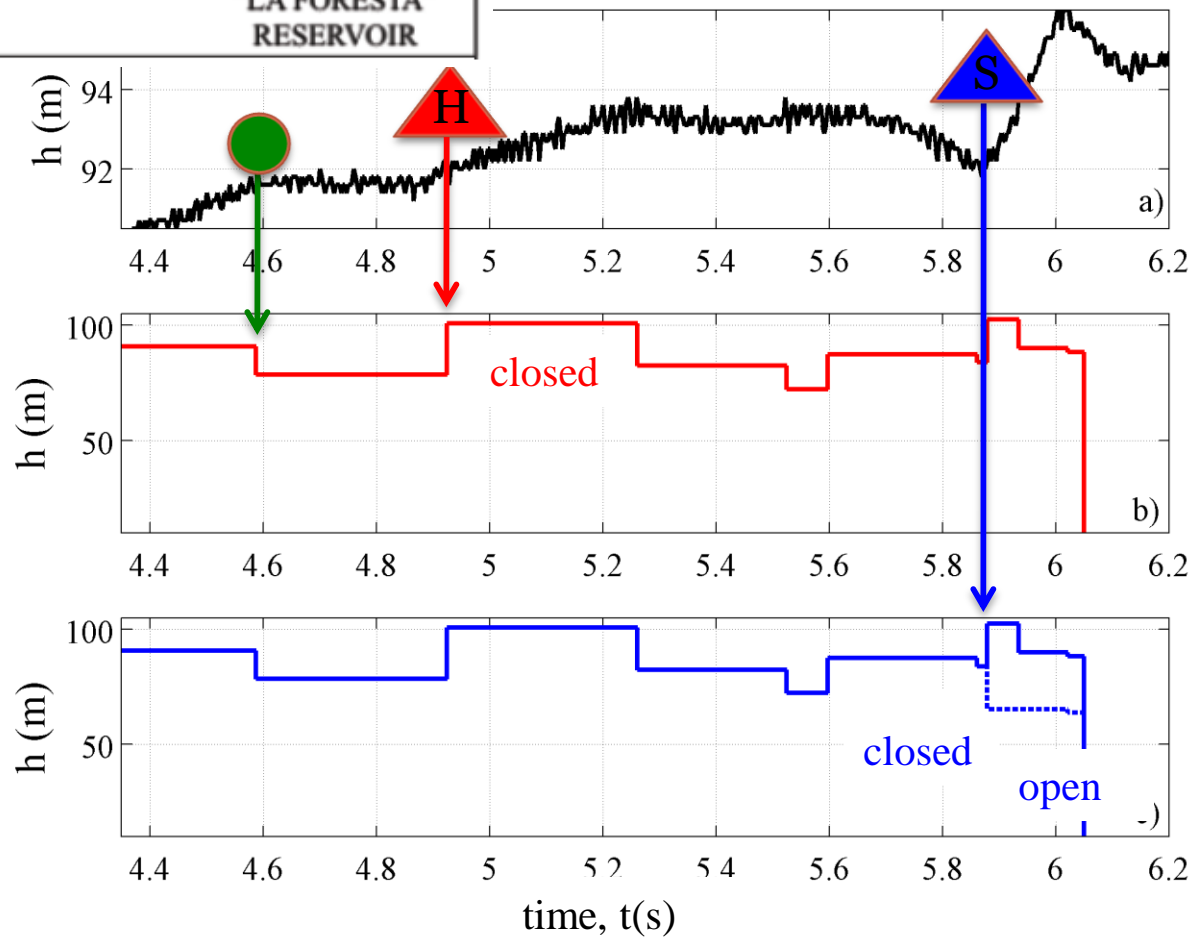
LAGRANGIAN MODEL

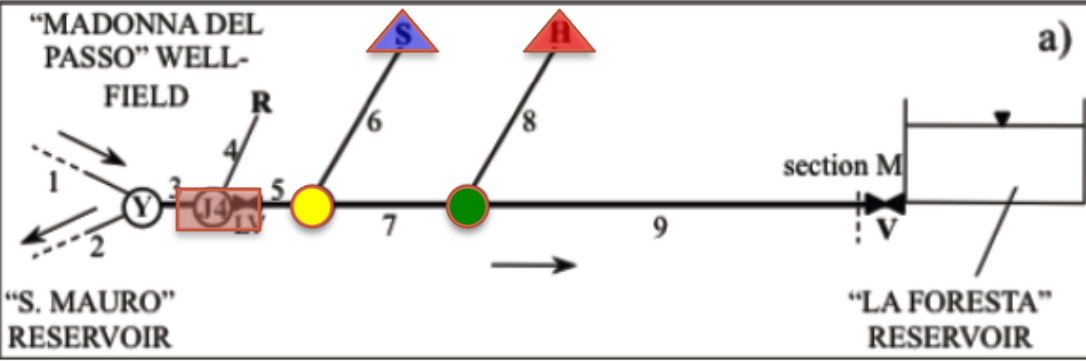




PRESSURE SIGNAL

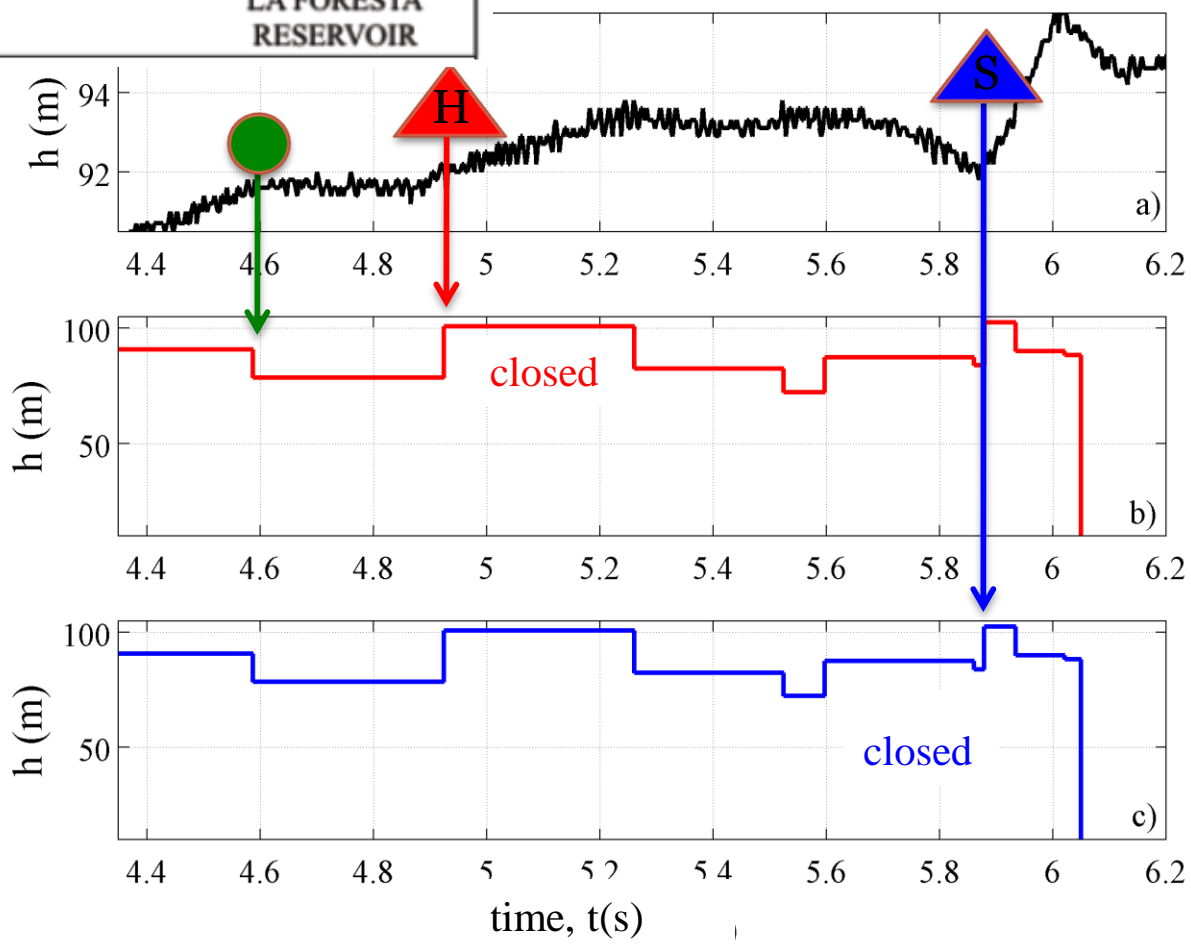
LAGRANGIAN MODEL

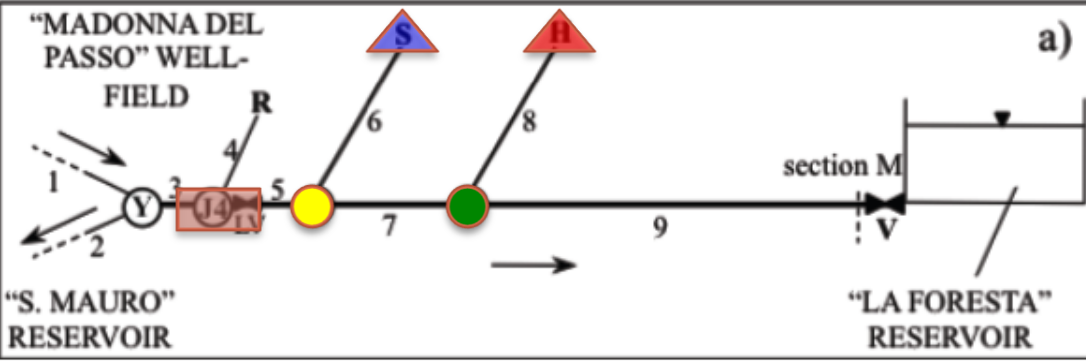




PRESSURE SIGNAL

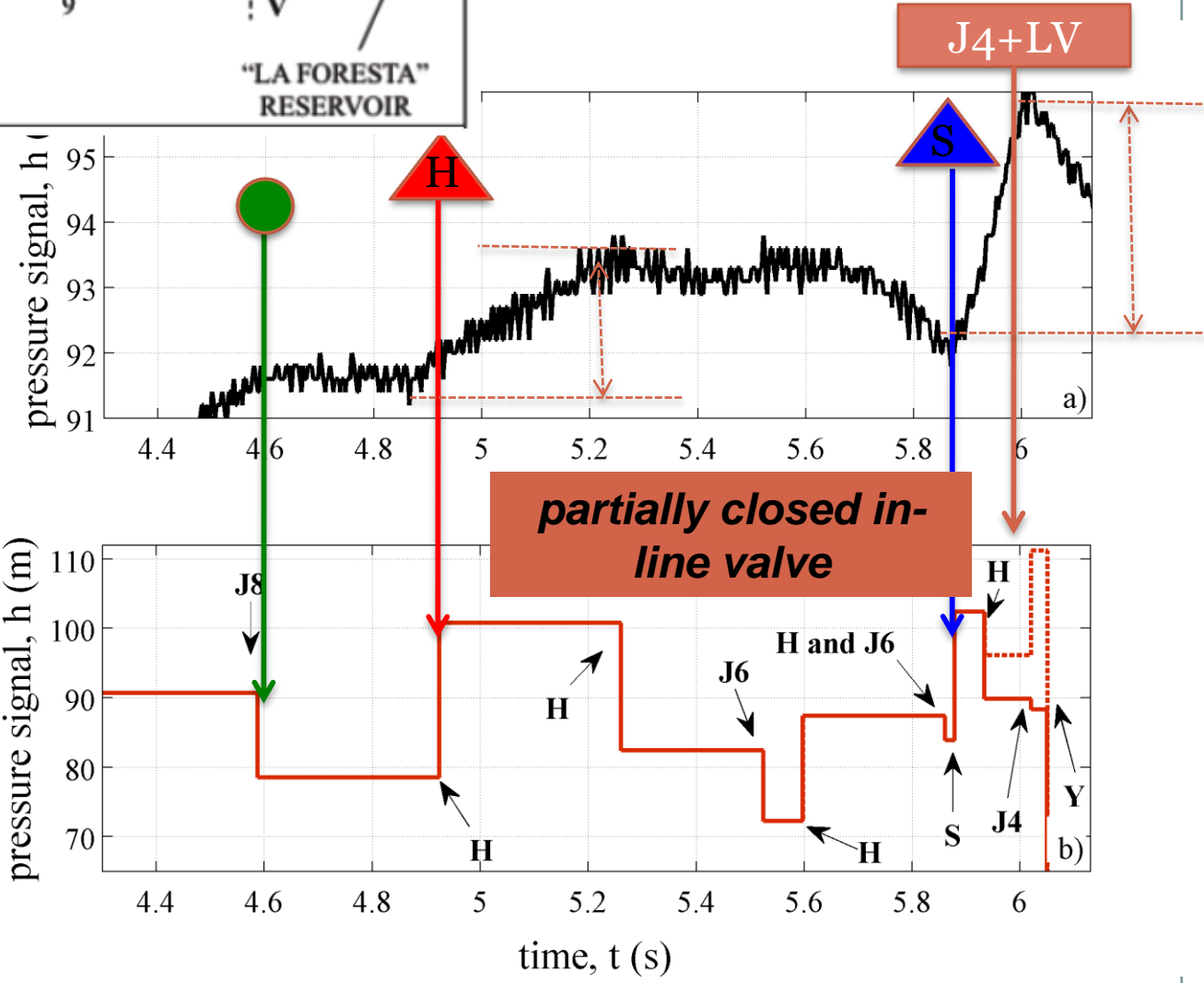
LAGRANGIAN MODEL





PRESSURE SIGNAL

LAGRANGIAN MODEL



Conclusions

- Testing water pipe systems by generating a pump trip or closing a valve can detect singularities and anomalies (for example, junctions, leaks, blockages, in-line valves and wall deterioration).
- A simulated leak was clearly detected in the single damaged pipe in Scotland. The error in the localization of the leak is equal to 2%.
- A leak was detected in the system of Milan. However, because of the complexity of such a system, and the use of just one measurement section, the possible location of the leak is not unique.
- The topology of the supply system of Rieti was checked and its functioning conditions were determined. Moreover, the unwanted status of an in-line valve – certified by the manager as fully open but actually partially closed – was pointed out.
- A Water System is like a nervous system and a Transient Test is like an electromyography. You can use this tool like a doctor to analyse the health of the system. However to improve diagnosis reliability you have to preliminary well-define the system characteristics as well as have multiple measurement sections.

Thanks for your kind attention

29

