



THE GLOBAL
LEAKAGE SUMMIT

15th Global Leakage Summit

2 - 3 September 2026, London

**Mapping pressure surge source in Water
Distribution Networks by low- and high-frequency
pressure data**

Bruno Brunone, Silvia Meniconi, and Caterina Capponi
University of Perugia, ITALY

Lorenzo Tirello and Andrea Rubin
AcegasApsAmga (Hera Group), ITALY



The Water Engineering Laboratory (WEL) of the University of Perugia
established in 1997



before 2018



today





A.D. 1308
unipg
UNIVERSITÀ DEGLI STUDI
DI PERUGIA

it
instituto de
telecomunicações



AcegasApsAmga



**MORE4WATER
COMBINED MONITORING
AND FORECAST FOR A
SUSTAINABLE
MANAGEMENT OF WATER
RESOURCES AND TIMELY
ADAPTATION TO DROUGHT**



Anomalies in Water Distribution Networks

Leaks



11,028 Leaks (HK 2013)

"Draught" water



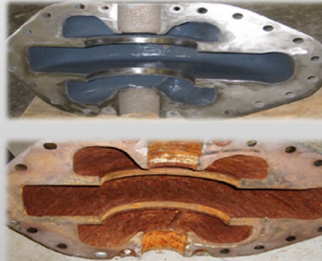
Blockages



Deteriorated/ weakened pipes



Malfunctioning devices



→ Deteriorated Pump

Bursts



257 Bursts (HK 2013)

Vulnerability of WDNs to external factors:

- pipe material corrosion due to wandering currents or aggressive terrains
- pipe breaks caused by vehicular traffic
- severe variations of the internal pressure

They all increase **LEAKAGE**.

EFFECTIVE MANAGEMENT OF WDNs IMPLIES LEAKAGE REDUCTION

TWO COMPLEMENTARY APPROACHES TO REDUCE LEAKAGE

- **REACTIONS**
- **PROACTIONS**

REACTIONS involve leak detection and pipe rehabilitation

This strategy aims is to eliminate the cause of leakage by **repairing or replacing** damaged pipes

PROACTIONS *usually* involve the control of steady-state conditions by reducing pressure by dividing the network into DMAs where PRVs are usually installed.

However, one **question** remains **unanswered**:

Why DMAs with similar pipe materials, ages, and pressure regime have different leakage rates?

One possible cause may be the type of transients that occur.

The idea that WDNs are self-protected against transients must be **reconsidered**.

Two types of transients:

UTILITY'S SCHEDULED TRANSIENTS

END-USERS TRANSIENTS

(not only those caused by hydrant flushing)

The relevance of end-users transients **could** depends on several factors:

Entity of the demand and functioning conditions (***initial conditions***)

Characteristics of the end-user: entity of demand, behavior, and modality of connection
(***boundary conditions***)

The relevance of end-users transients *could* depends on several factors:

Entity of the demand and functioning conditions (*initial conditions*)

Characteristics of the end-user: entity of demand, behavior, and modality of connection (*boundary conditions*)

ACCORDINGLY, TO IDENTIFY DANGEROUS TRANSIENTS IN WDNs (COMPLEX SYSTEMS WITH A COMPLEX AND VARIABLE BEHAVIOR THROUGHOUT THE DAY) IS NOT AN EASY TASK AT ALL!

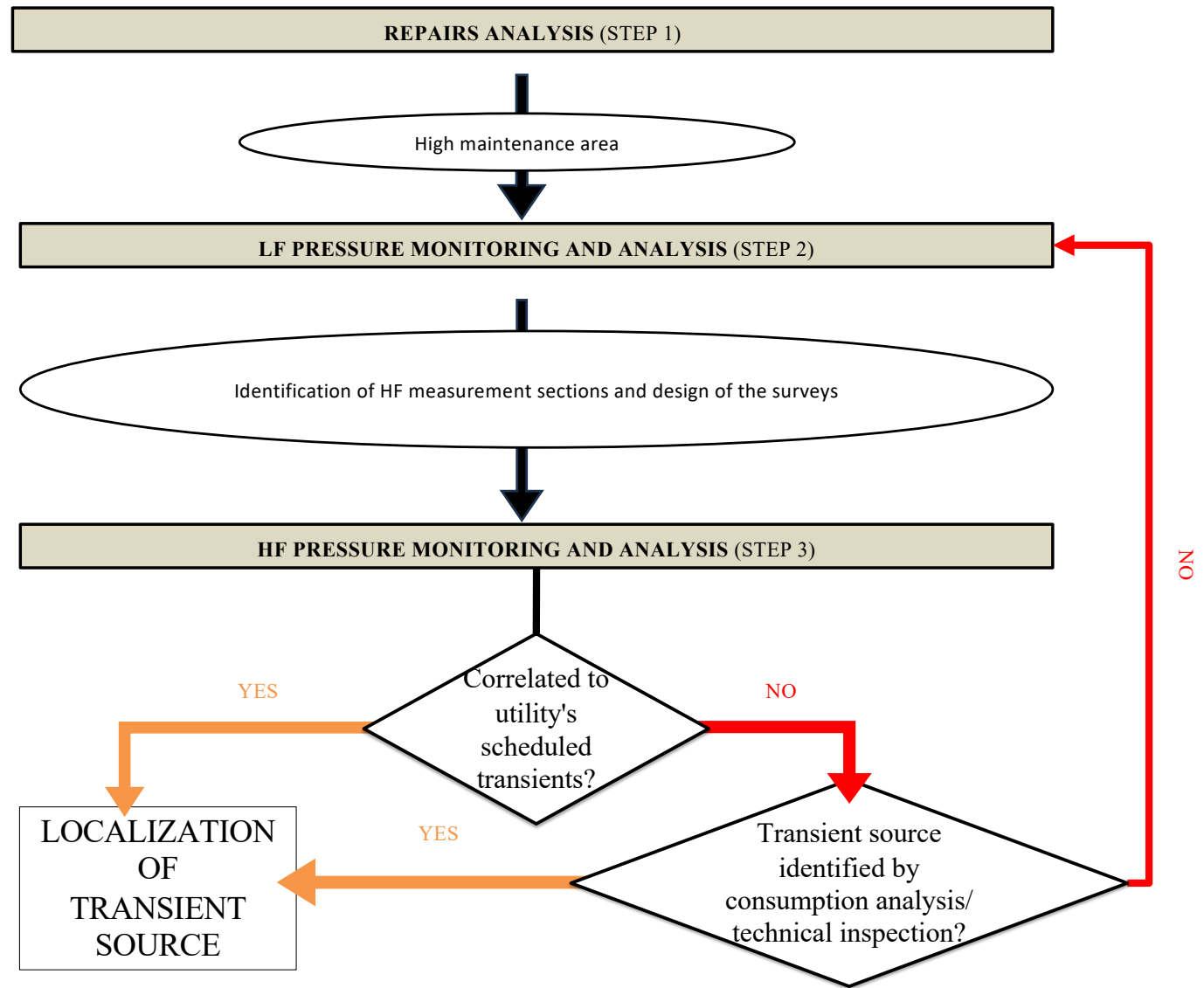
Possible approaches based on:

numerical methods

field measurements

THIS PAPER PROPOSES A SUSTAINABLE METHODOLOGY BASED ON FIELD PRESSURE MEASUREMENTS THAT HAS BEEN USING IN REAL WDNs.

The methodology



AGU

Water Resources
Research®

January 2024 • Volume 60 • Issue 1



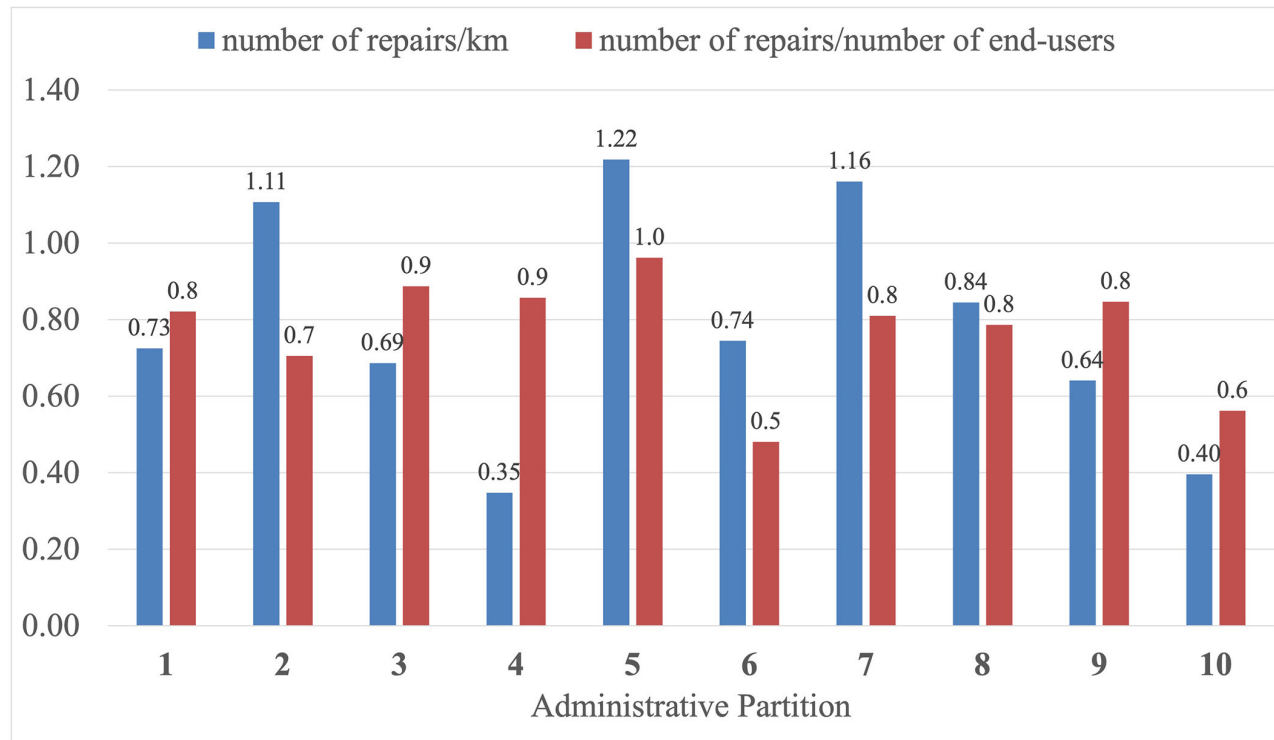
Meniconi et al., 2024

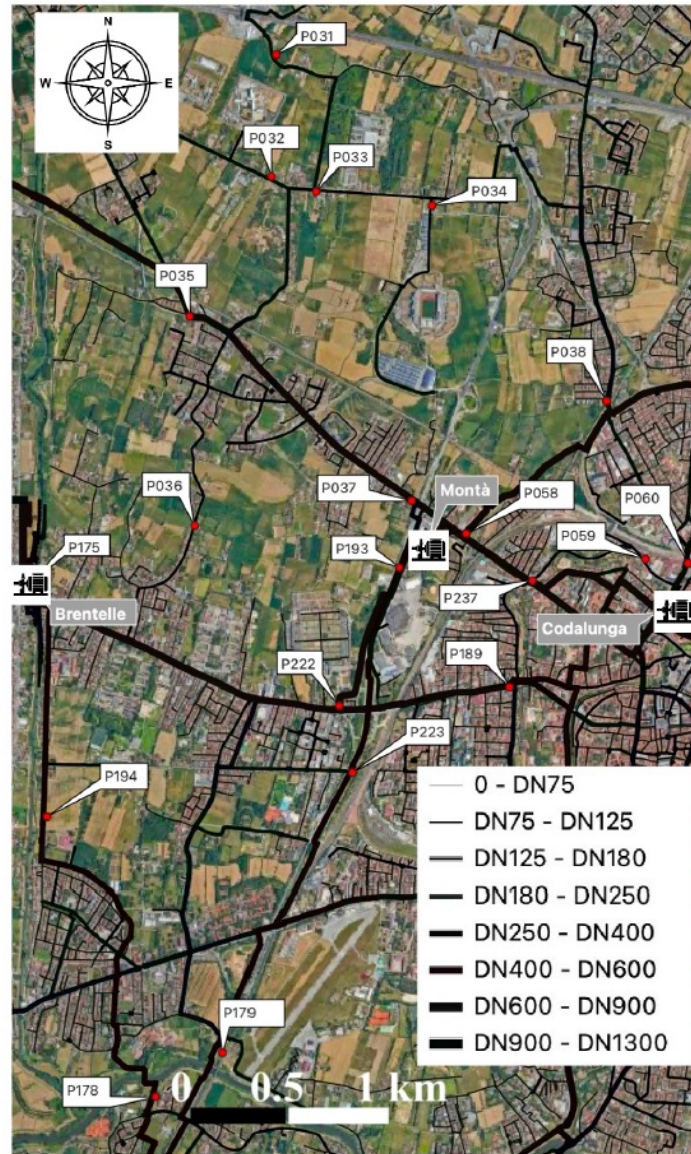


Administrative partitions (interconnected) of the Padua's WDN



REPAIRS ANALYSIS (STEP 1)

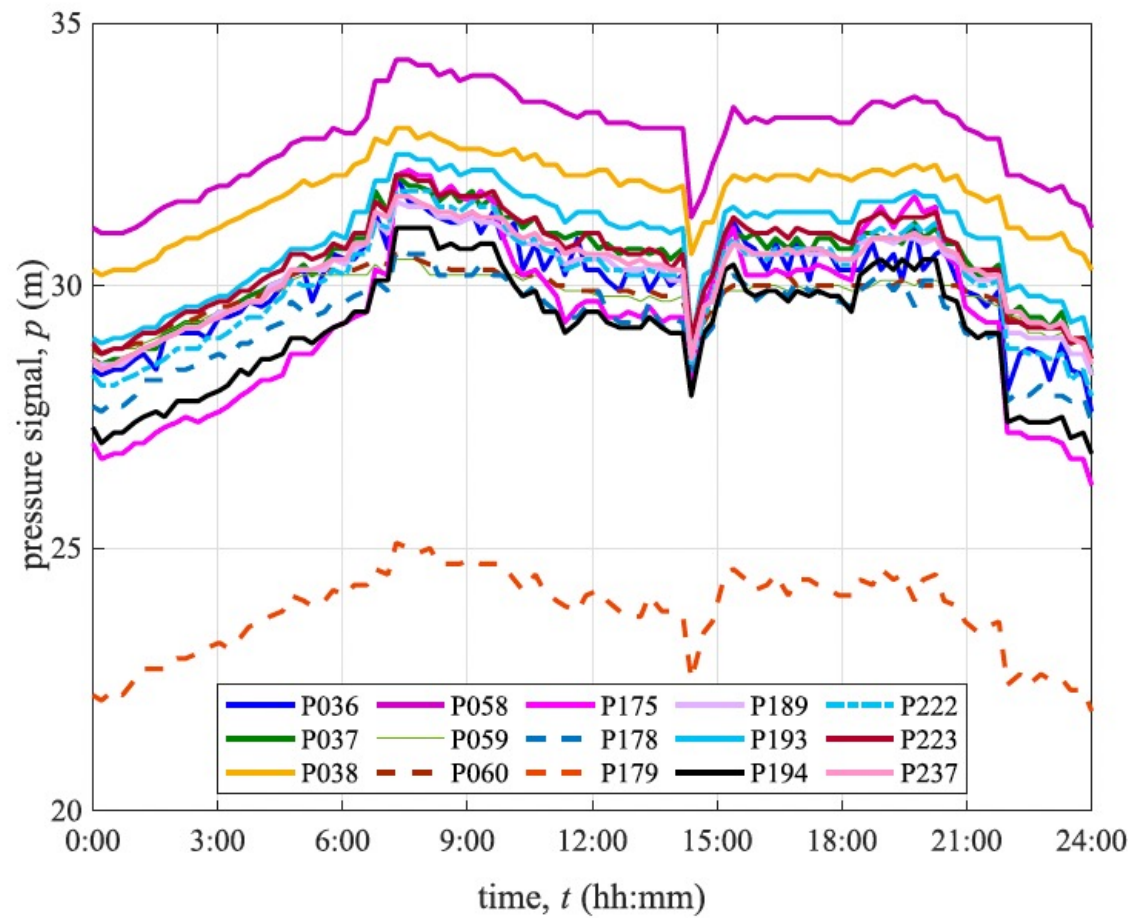




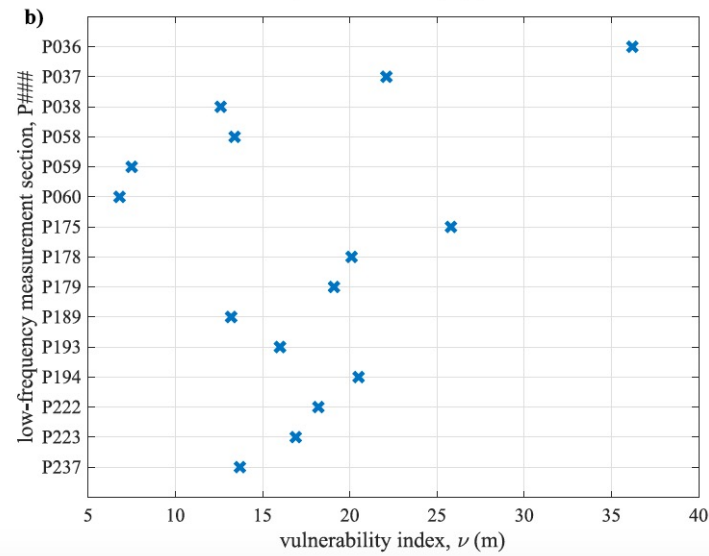
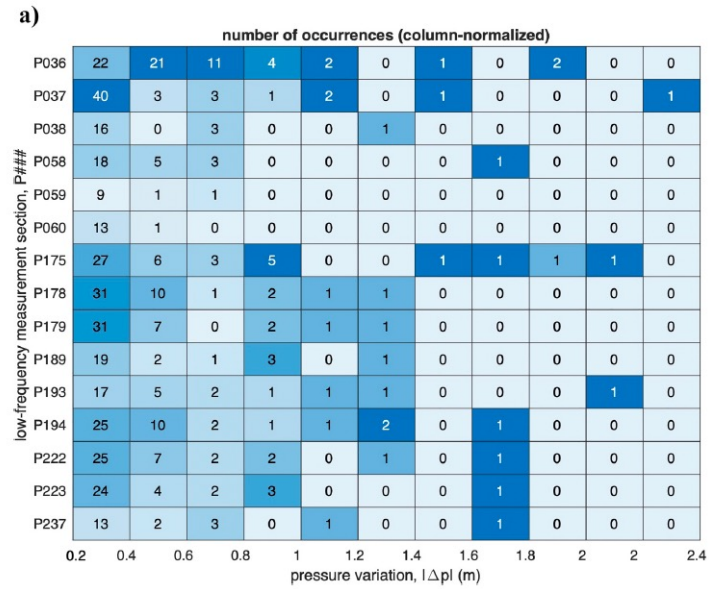
Partition #5

P indicates the low-frequency (LF) measurement section (15 min)

Low-frequency pressure measurements (typical midweek day)



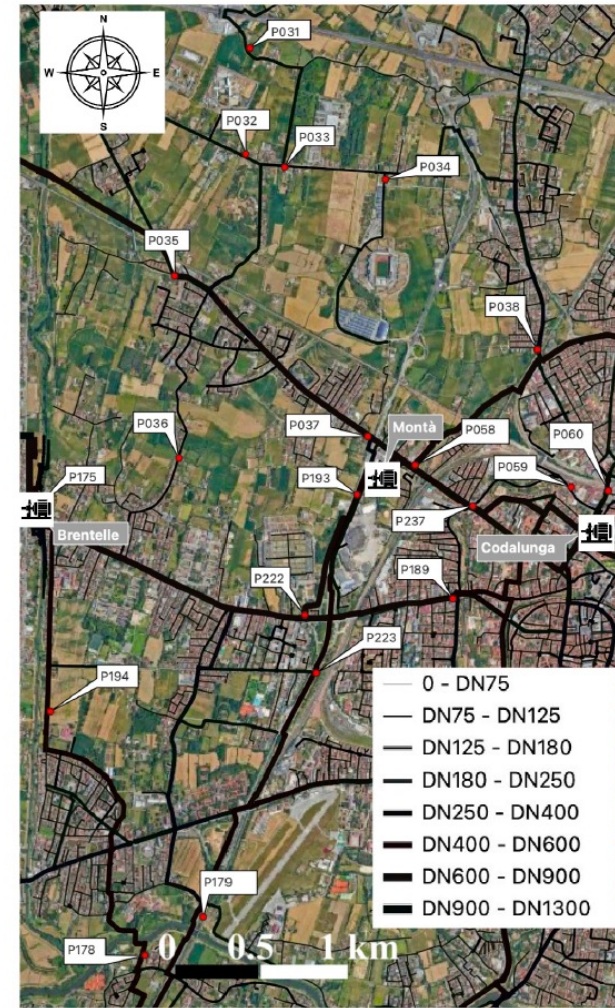
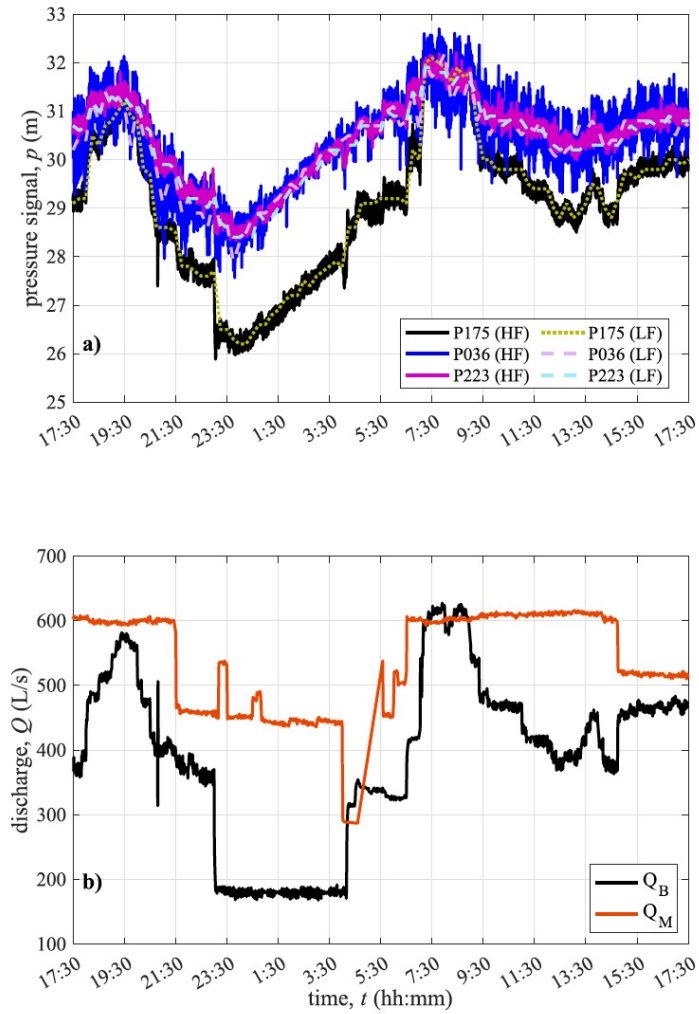
**Monitored area
3x3 km**

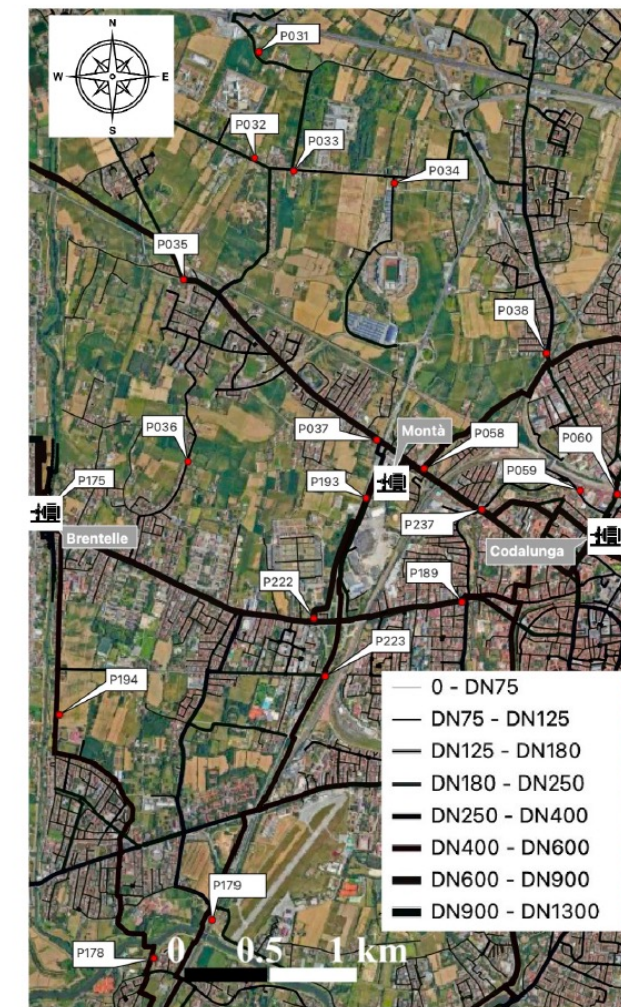
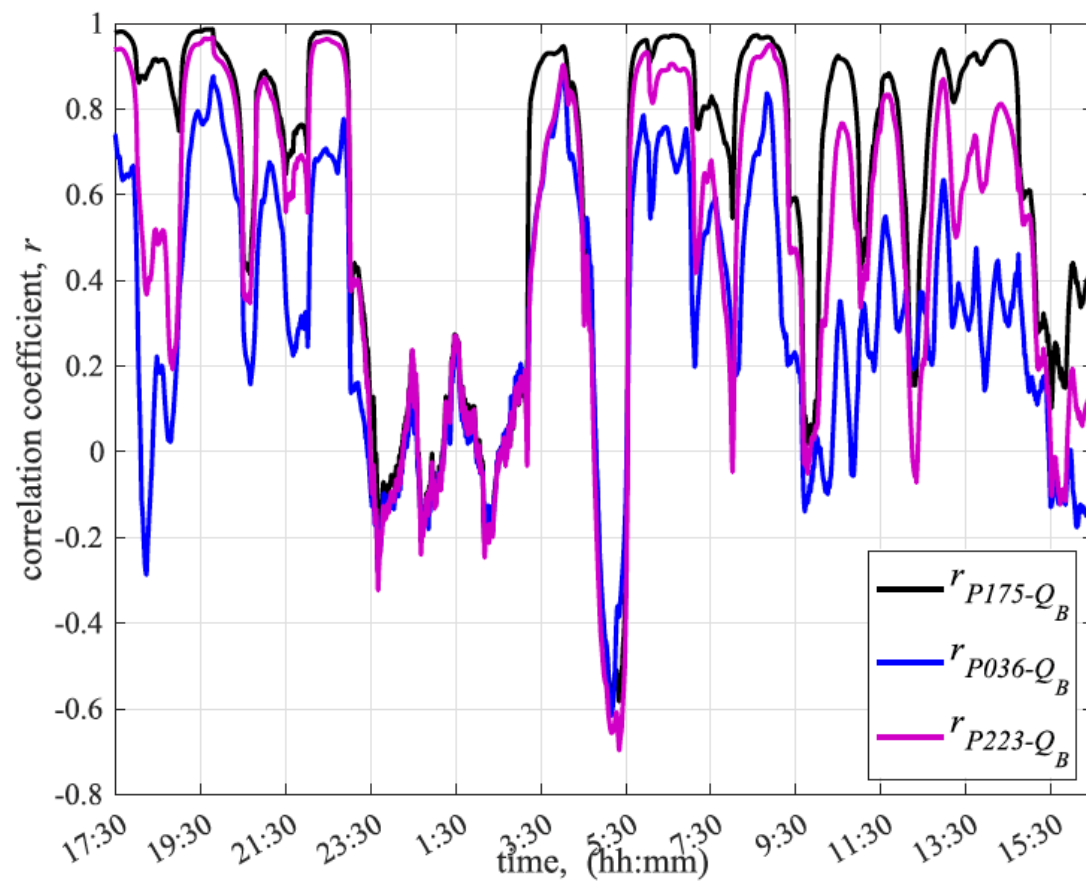


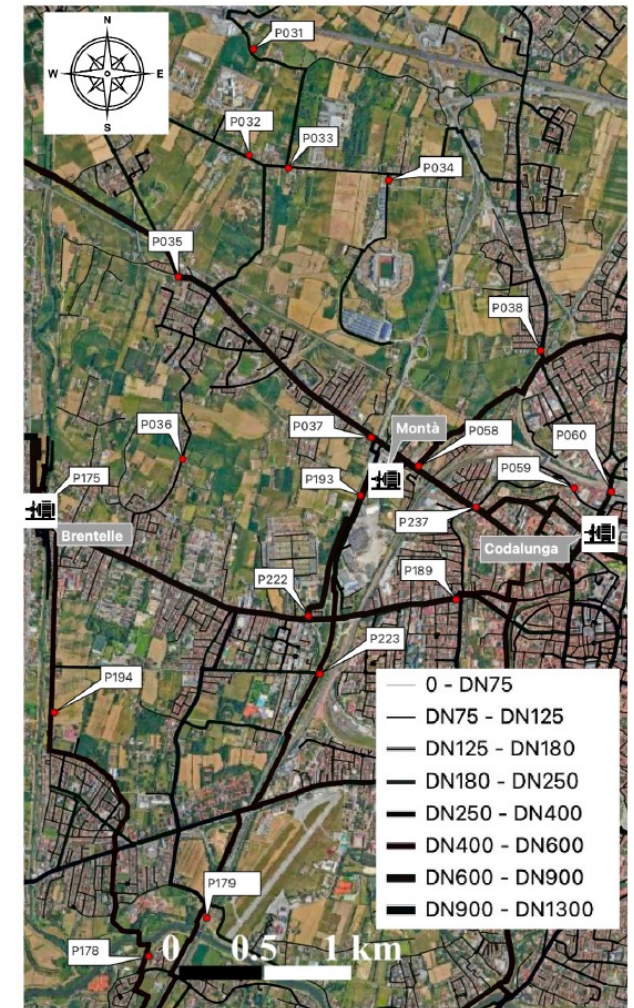
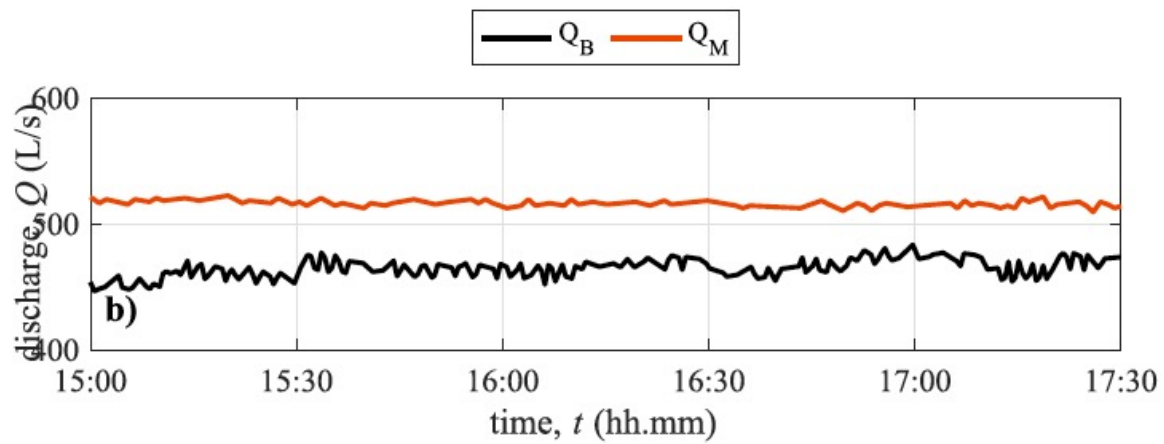
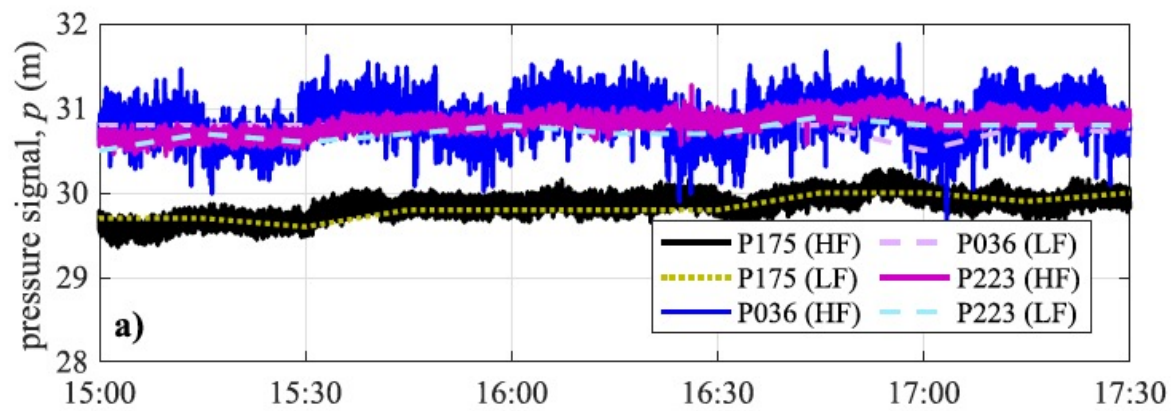
$$\nu = \sum_{i=1}^n |\Delta p_i| f_i$$

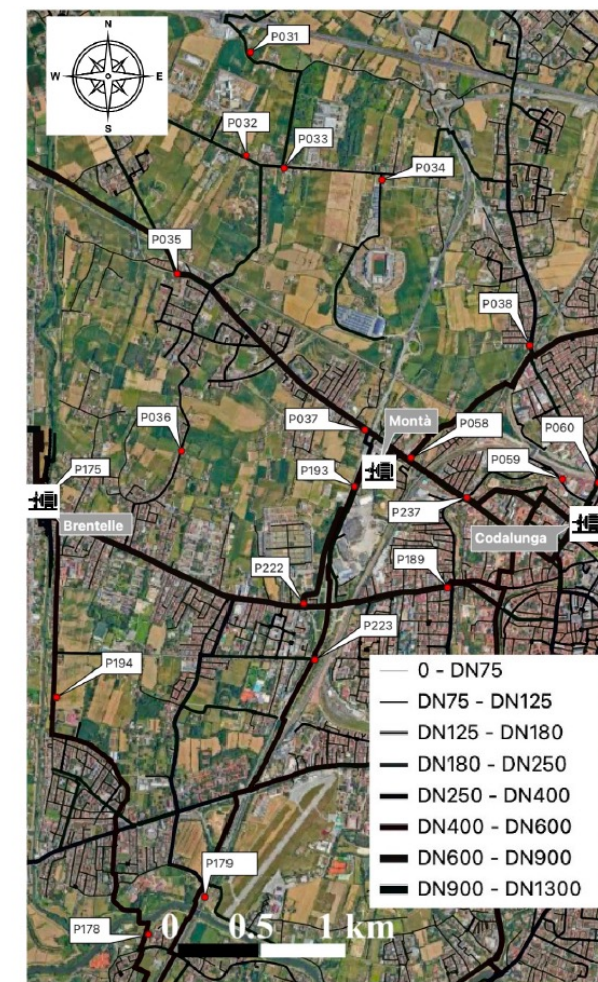
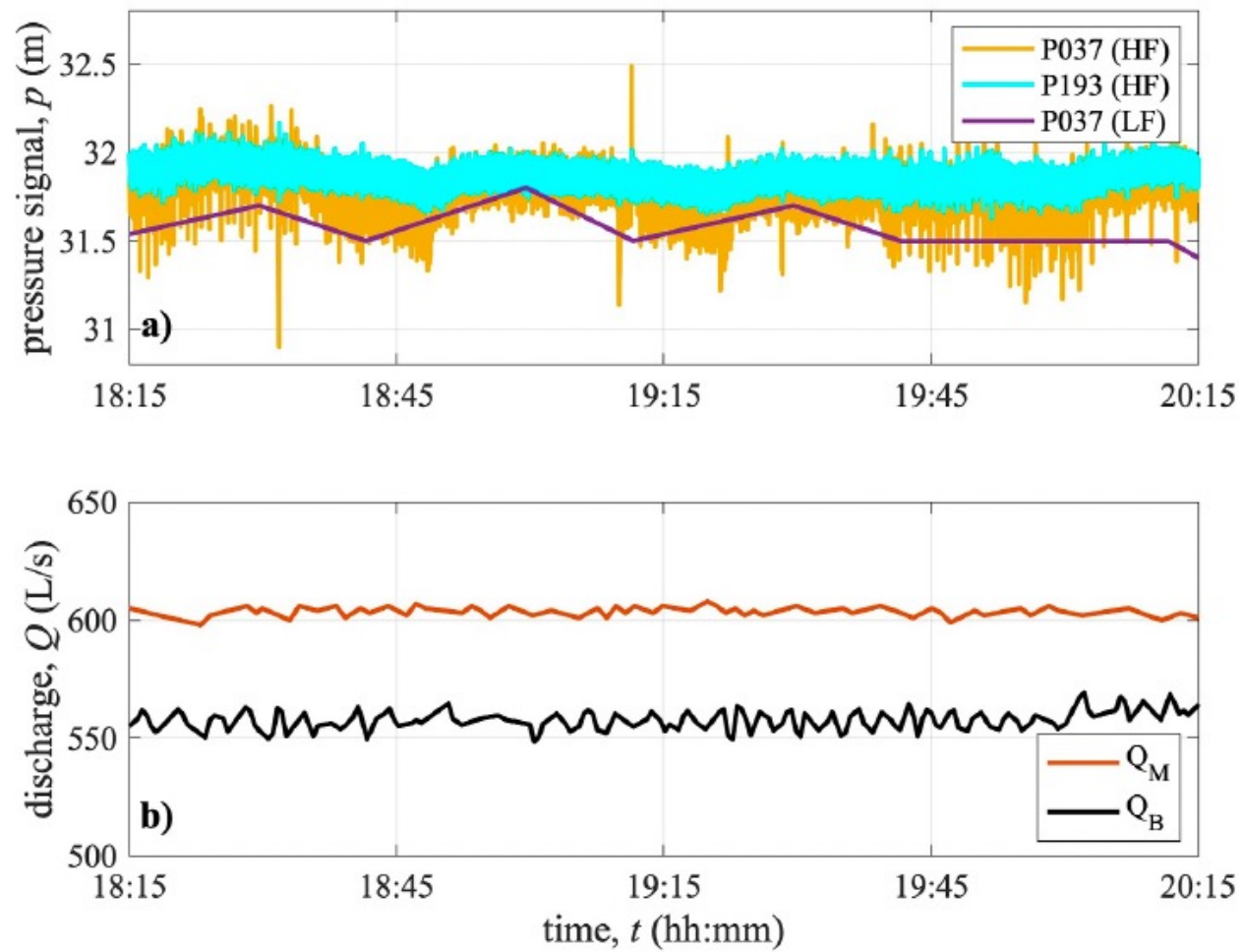
n = number of measurements per day

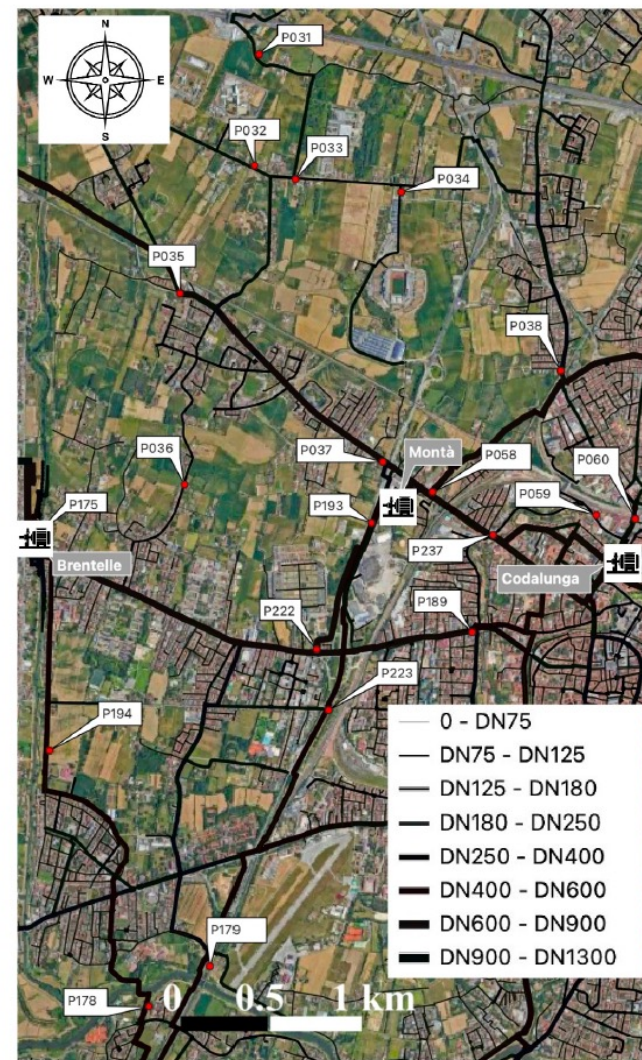
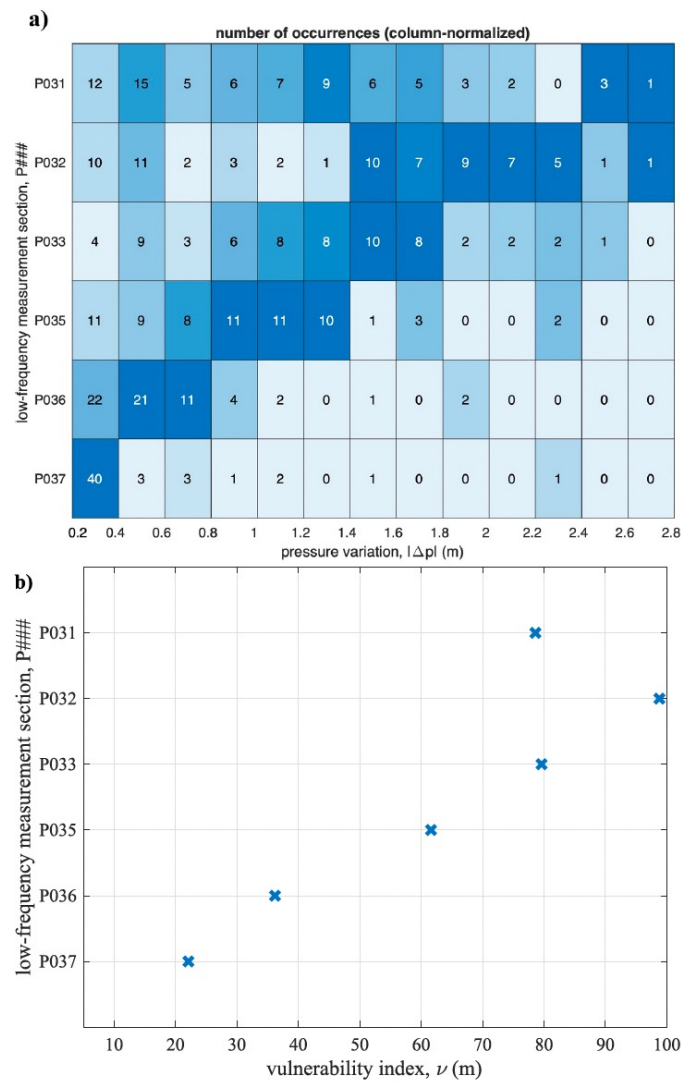
High-frequency (2,048 Hz) pressure measurements

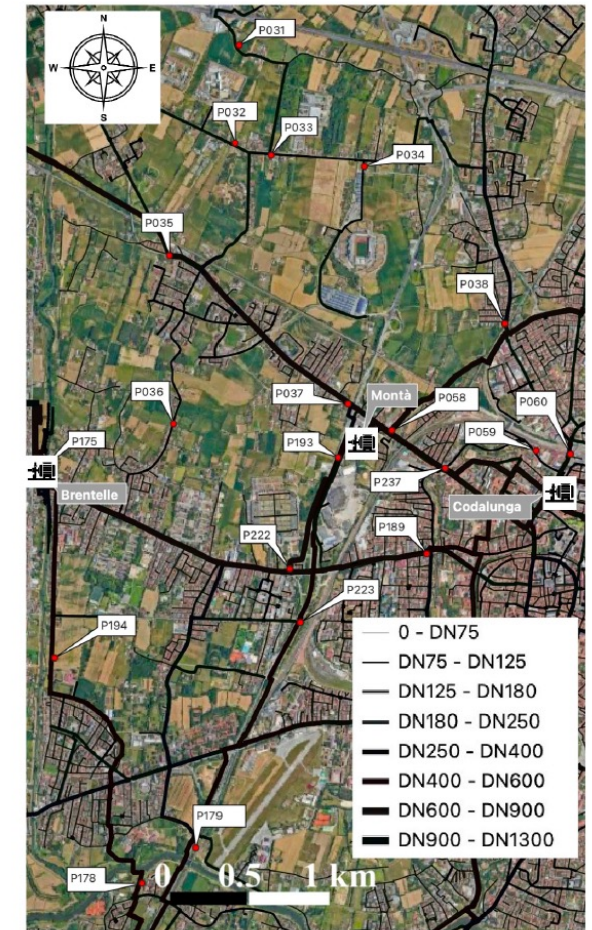
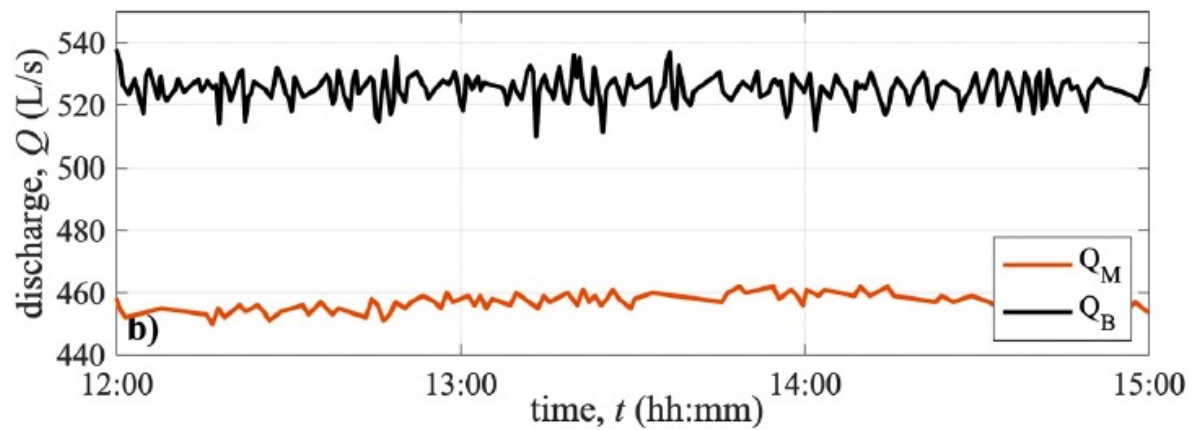
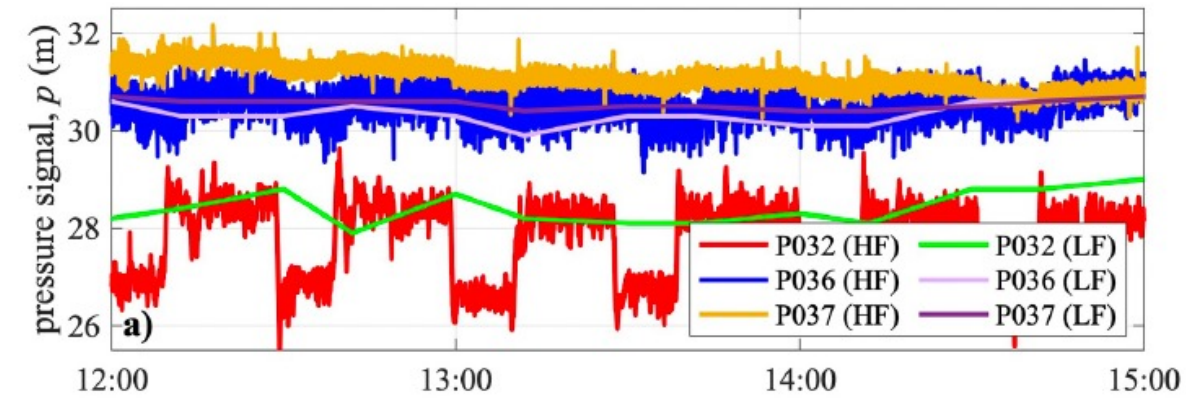




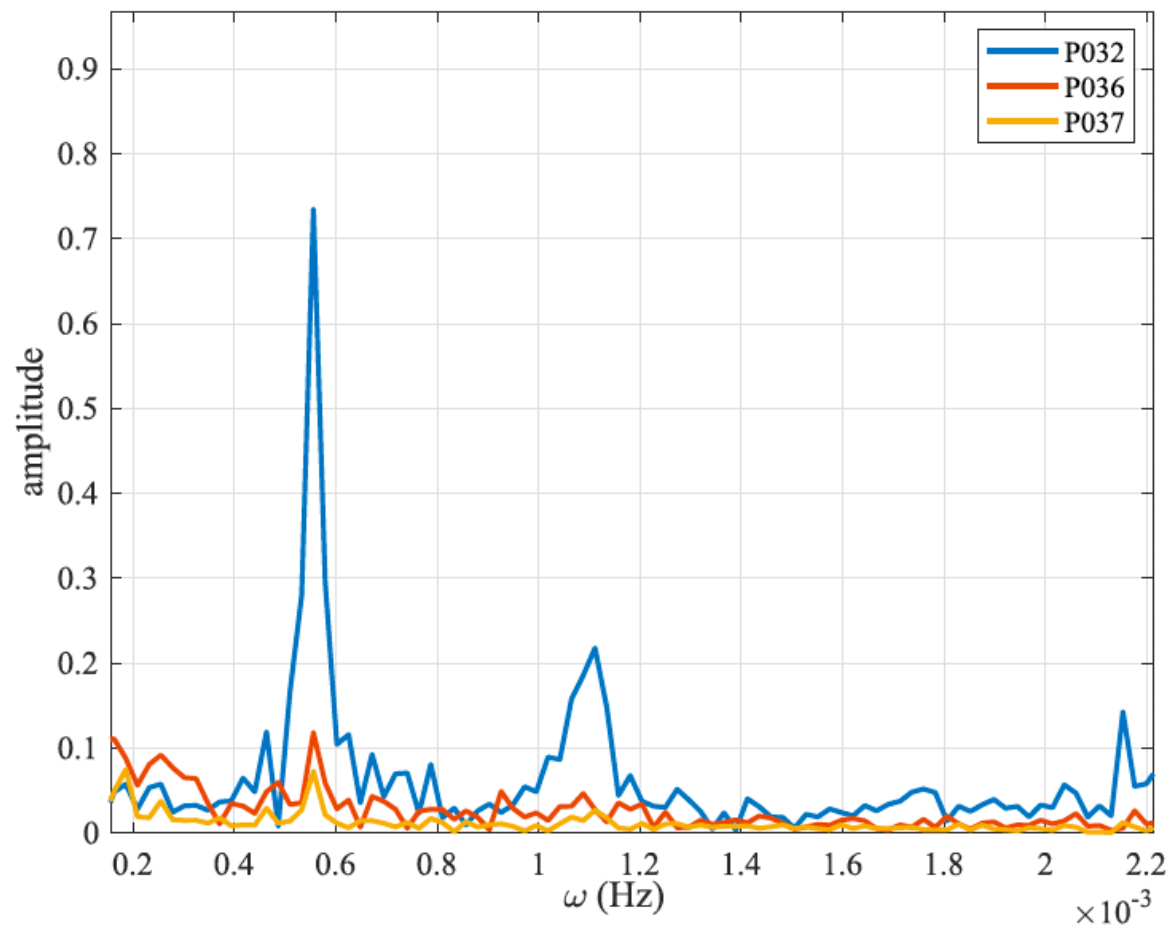




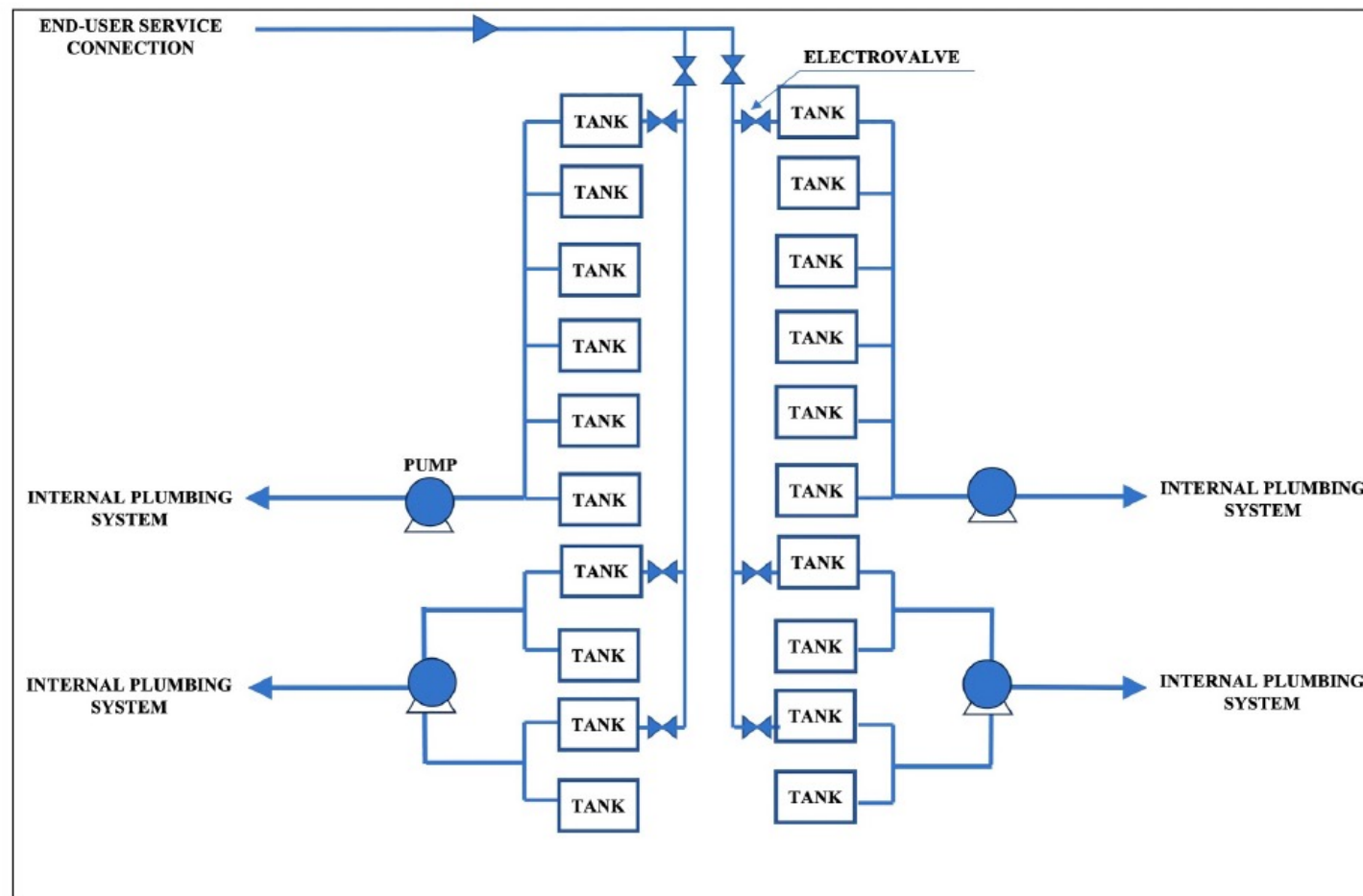




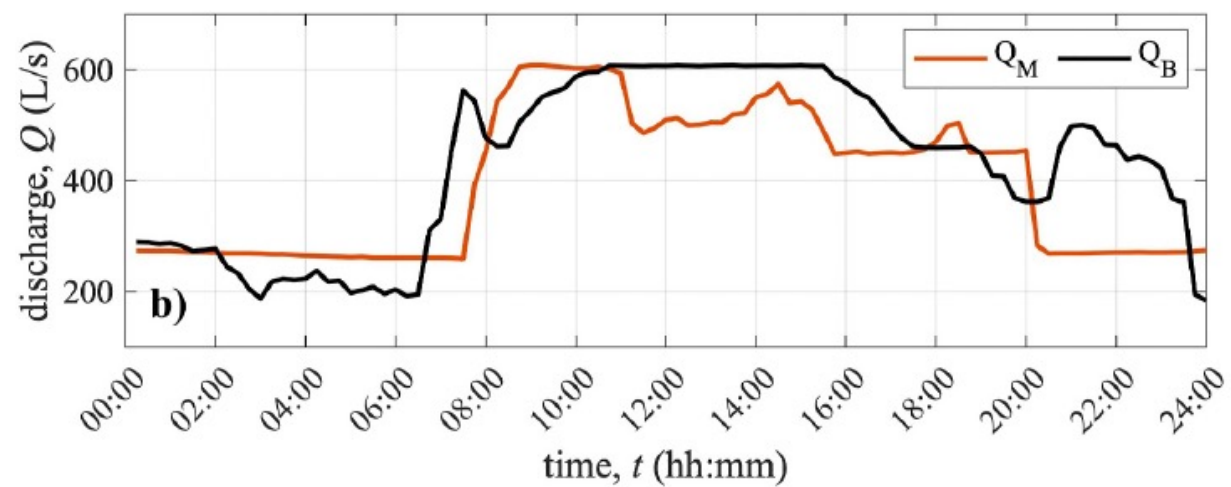
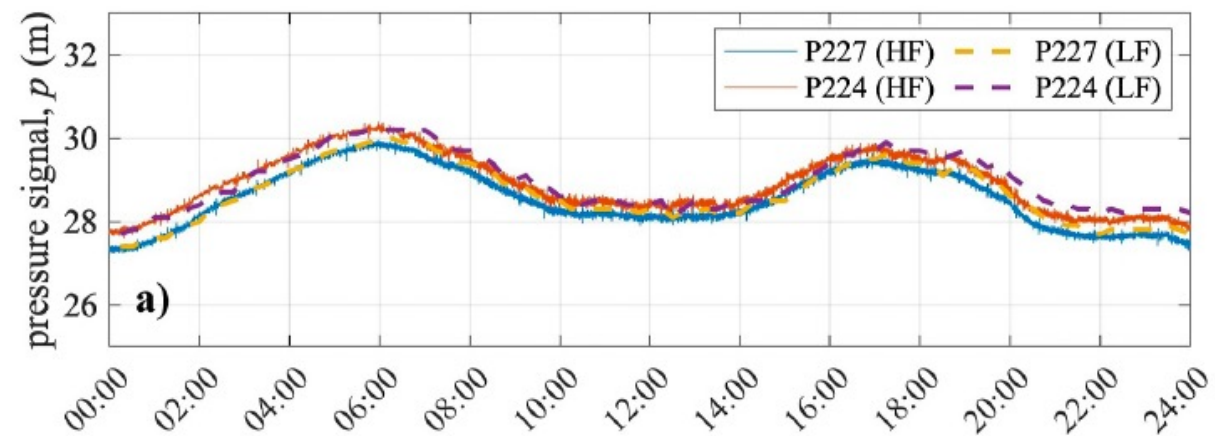
Note: frequency of pressure variations at **P032**: about **30 min**



$\omega = 5.56 \cdot 10^{-4}$ Hz,
(about 30 min)



Note: a unique connection between the user and WDN



***(Some)* Conclusions**

A methodology based on the joint use of LF and HF pressure measurements is proposed as a proaction for leakage reduction
(no numerical model is used nor the path of the single pressure waves is followed)

The existing LF measurement system of the water company is highlighted

Large volumes of withdrawals do not necessarily imply severe transients

The relevance of end-users transients *could* depends on several factors:

Entity of the demand and functioning conditions (*initial conditions*)

Characteristics of the end-user: entity of demand, behavior, and modality of connection
(*boundary conditions*)



THE GLOBAL LEAKAGE SUMMIT

15th Global Leakage Summit

2 - 3 September 2026, London

Bruno Brunone, Silvia Meniconi, and Caterina Capponi
University of Perugia, ITALY

Lorenzo Tirello and Andrea Rubin
AcegasApsAmga (Hera Group), ITALY

Thank you a lot for your attention!

bruno.brunone@unipg.it

