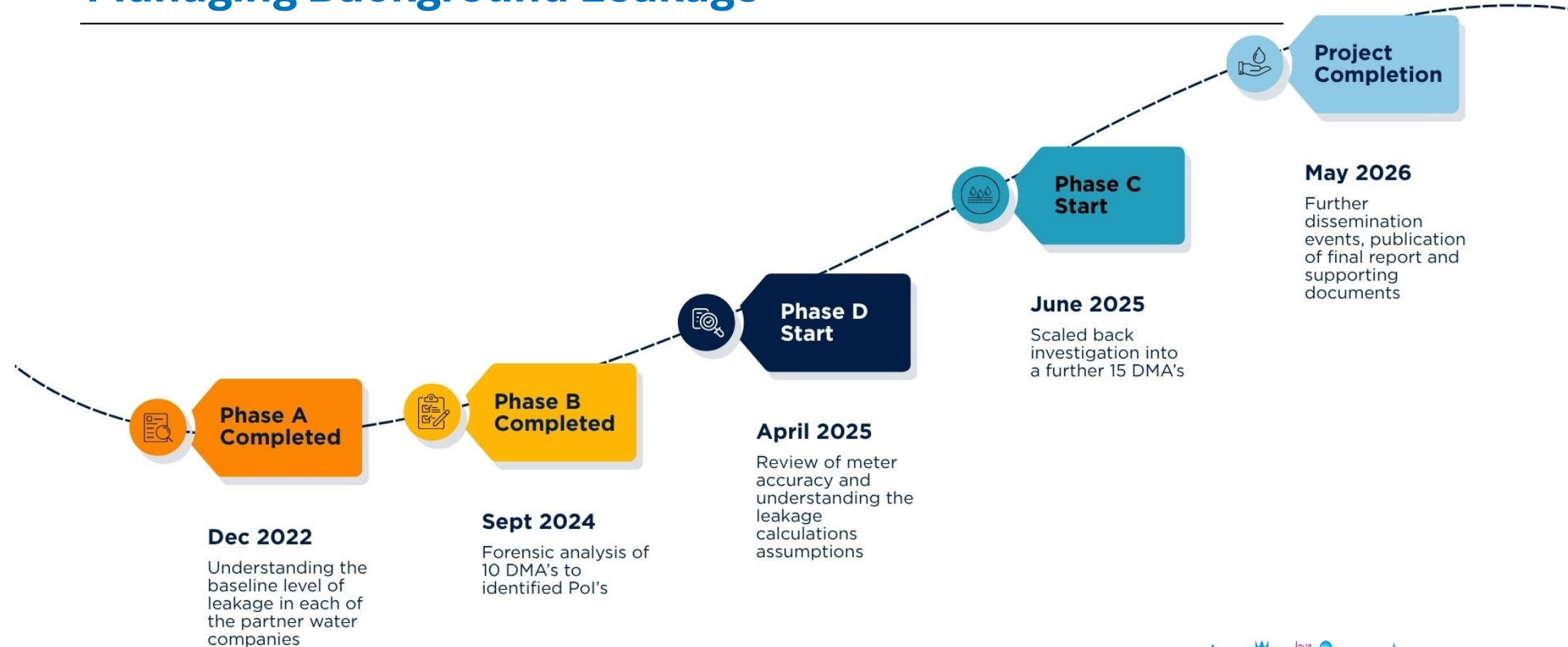


Delving Deeper into Background Losses Assessment

Stuart Trow
Director, Trow Consulting, UK



Ofwat Water Breakthrough Challenge: Transform 2 Stream Managing Background Leakage

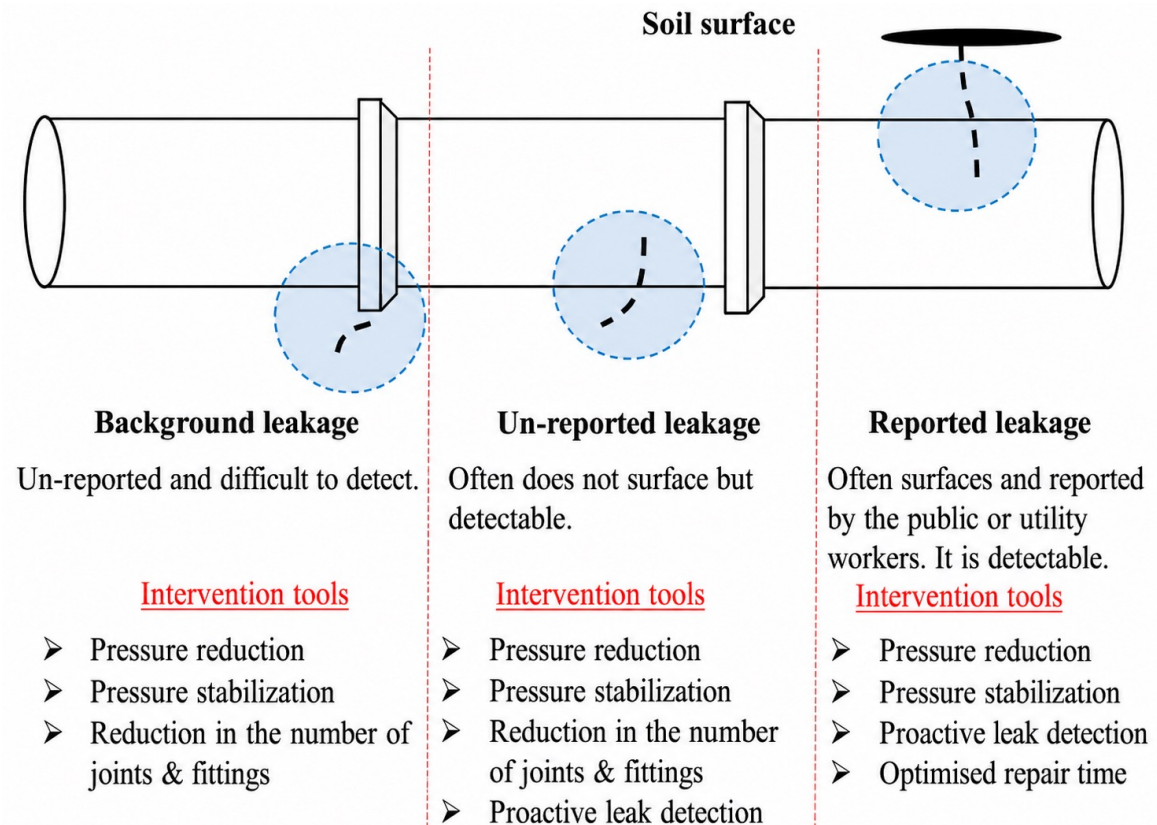


The 3 types of leakage

Reported leakage: Due to bursts and leaks that become self-evident, because the water comes to the surface and/ or because they result in a loss of supply to customers.

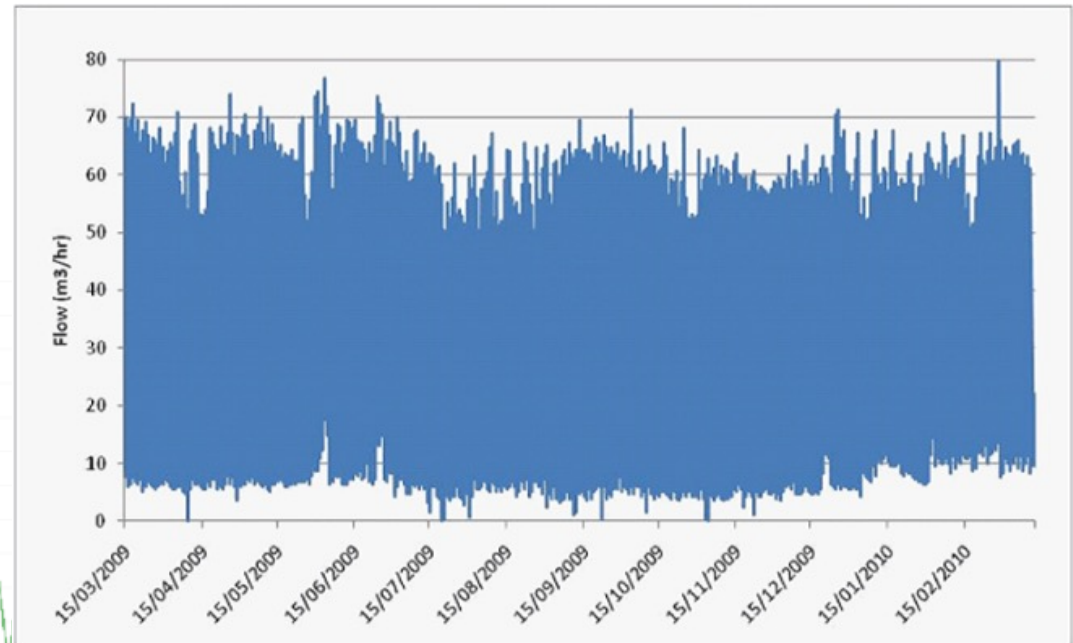
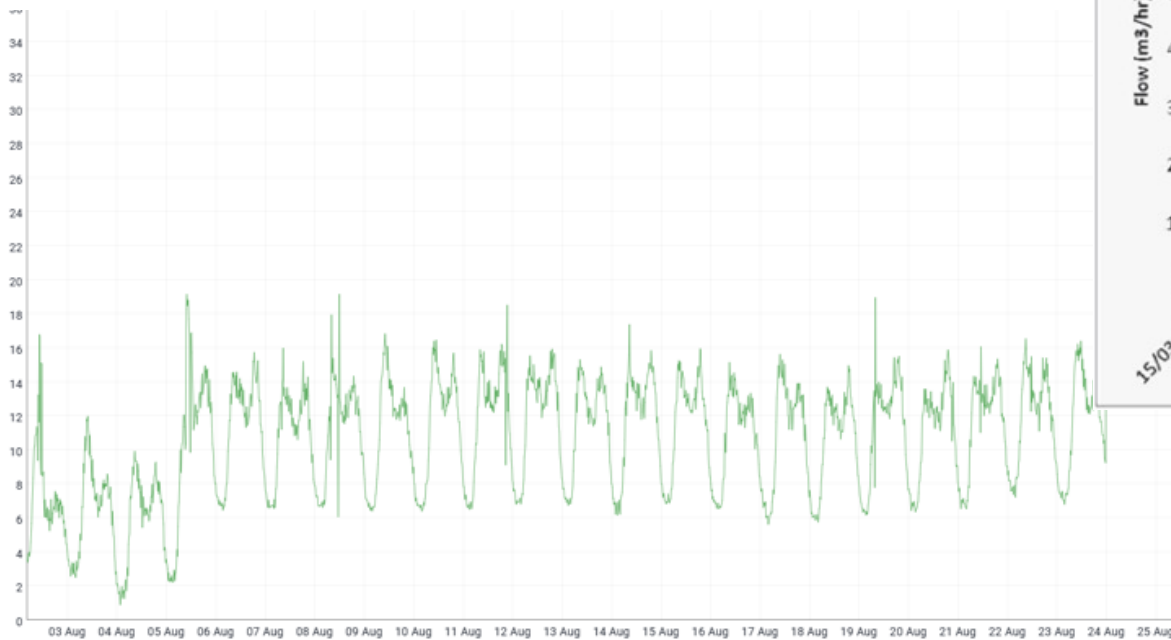
Unreported leakage: Resulting from bursts and leaks that are found by proactive find and fix activity

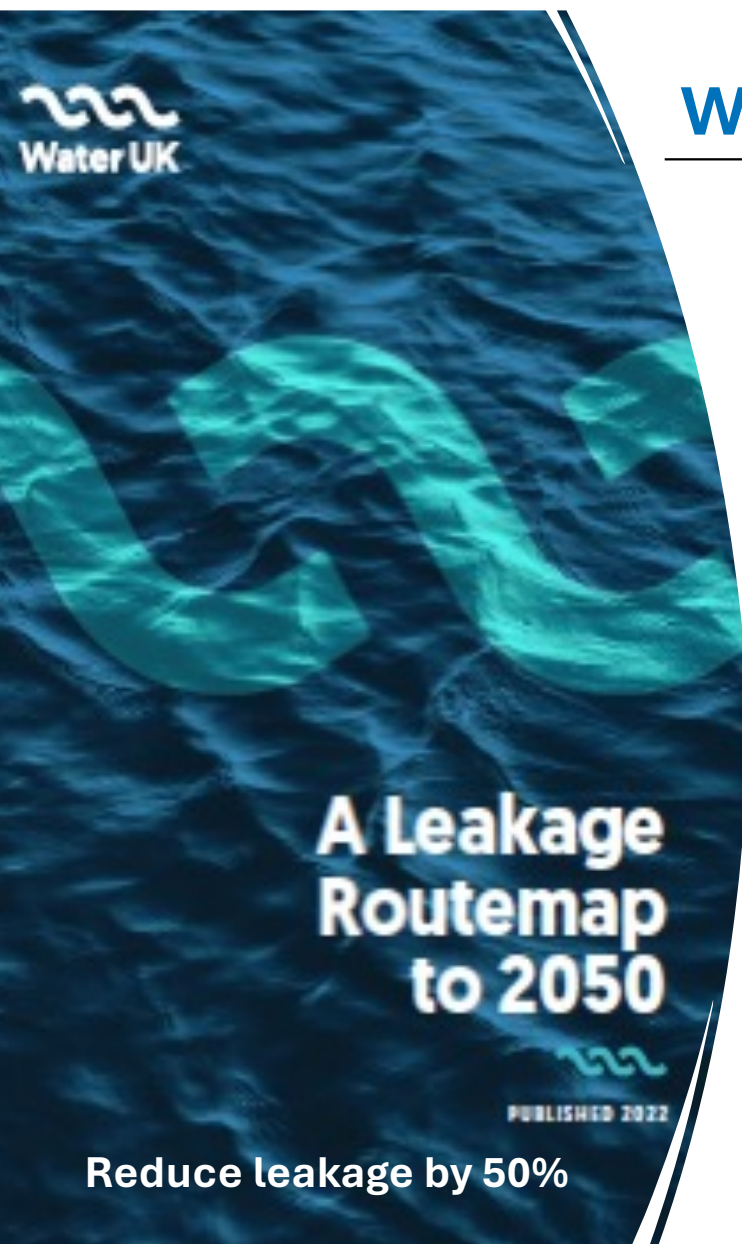
Background leakage is that proportion of total leakage that is left after the volume from reported and unreported leakage is accounted for.



DMA Flow Profile

- Every DMA for each of the 5 water companies
- Adjustments to avoid negative leakage estimates
- 20th percentile MNF over 3 years

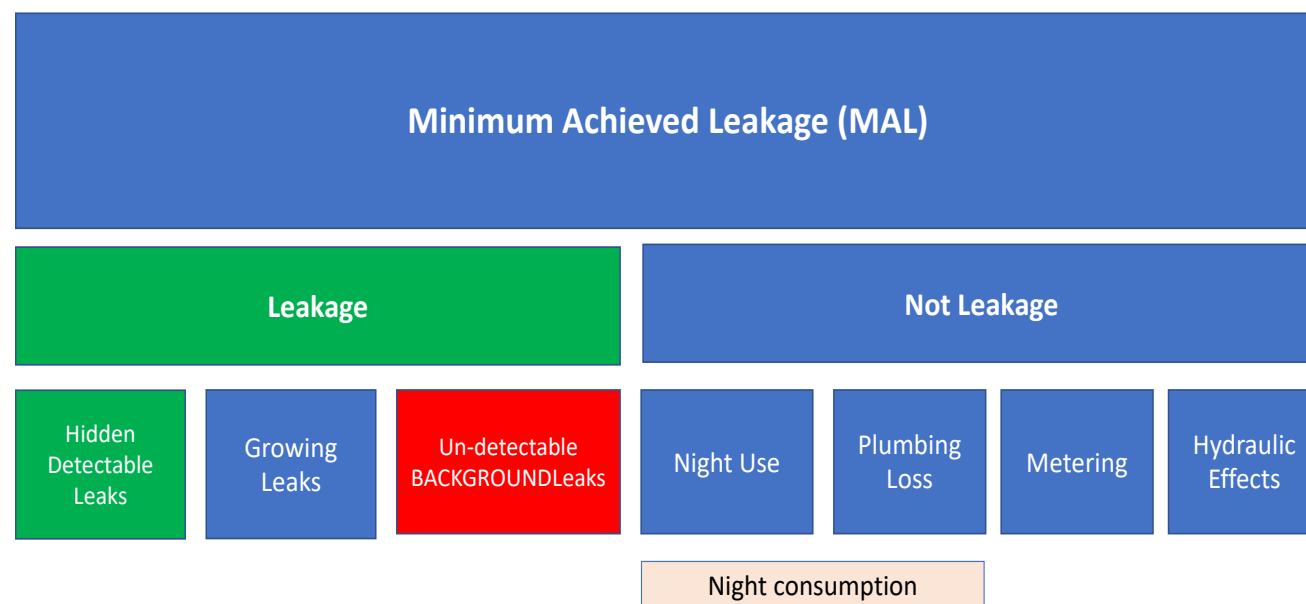




Water UK Routemap Definition

Background leakage:

This is the level where leakage cannot be reduced further, using current detection technology. This can be altered by replacing pipes in the network, but also by reducing pressure in the network. It can also change due to new technological innovations that make detection more effective.





Water Breakthrough Challenge
Transform Stream

Managing Background Leakage

Stage A Report

Draft

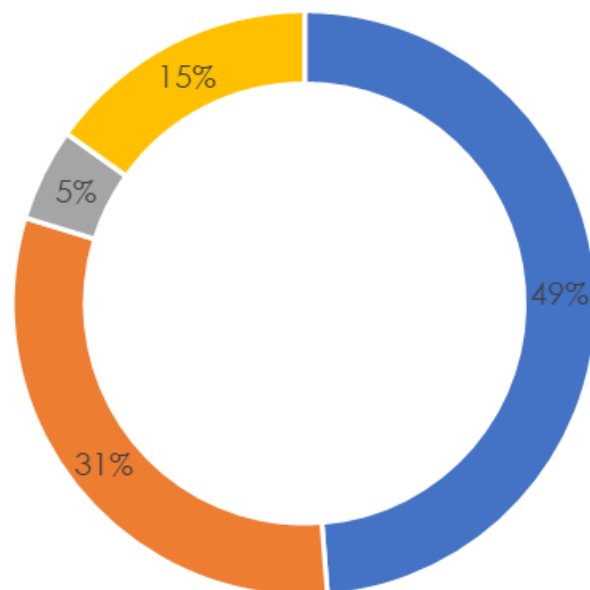
Date: 06/01/2023

Issue: Draft v.1.0



Phase A Report

31 Page Report sets out work carried out in Stage 1 at end of 2022



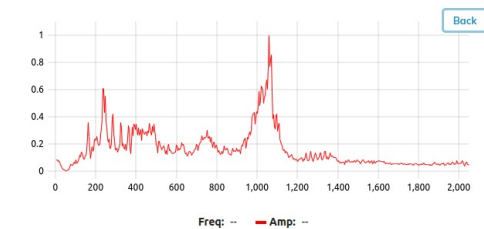
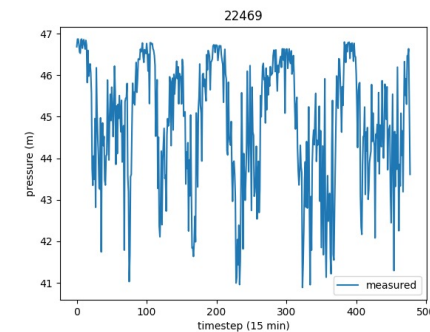
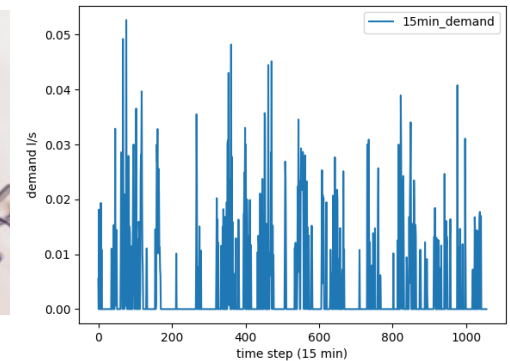
- Background leakage in DMAs: 49%
- Unreported DMA Leakage: 31%
- Reported DMA leakage: 5%
- Trunk main and service reservoir leakage: 15%

Figure 1: Proportions of leakage components in the companies as a whole

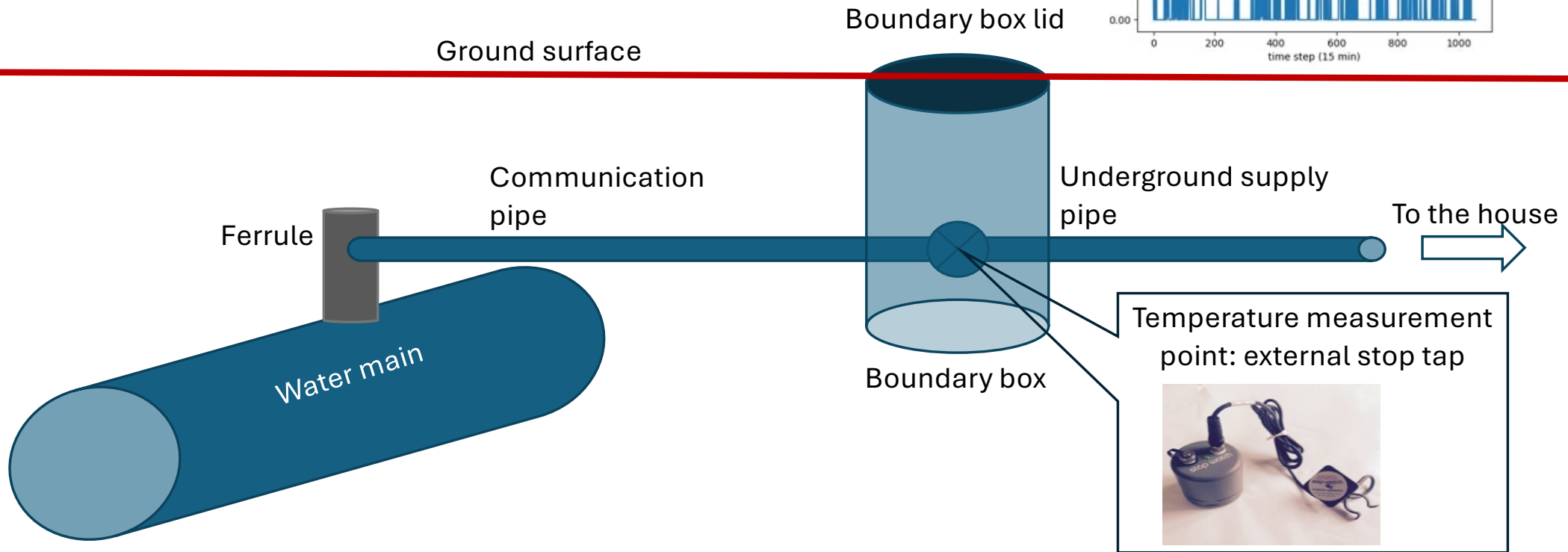


Phases B and C DMA surveys

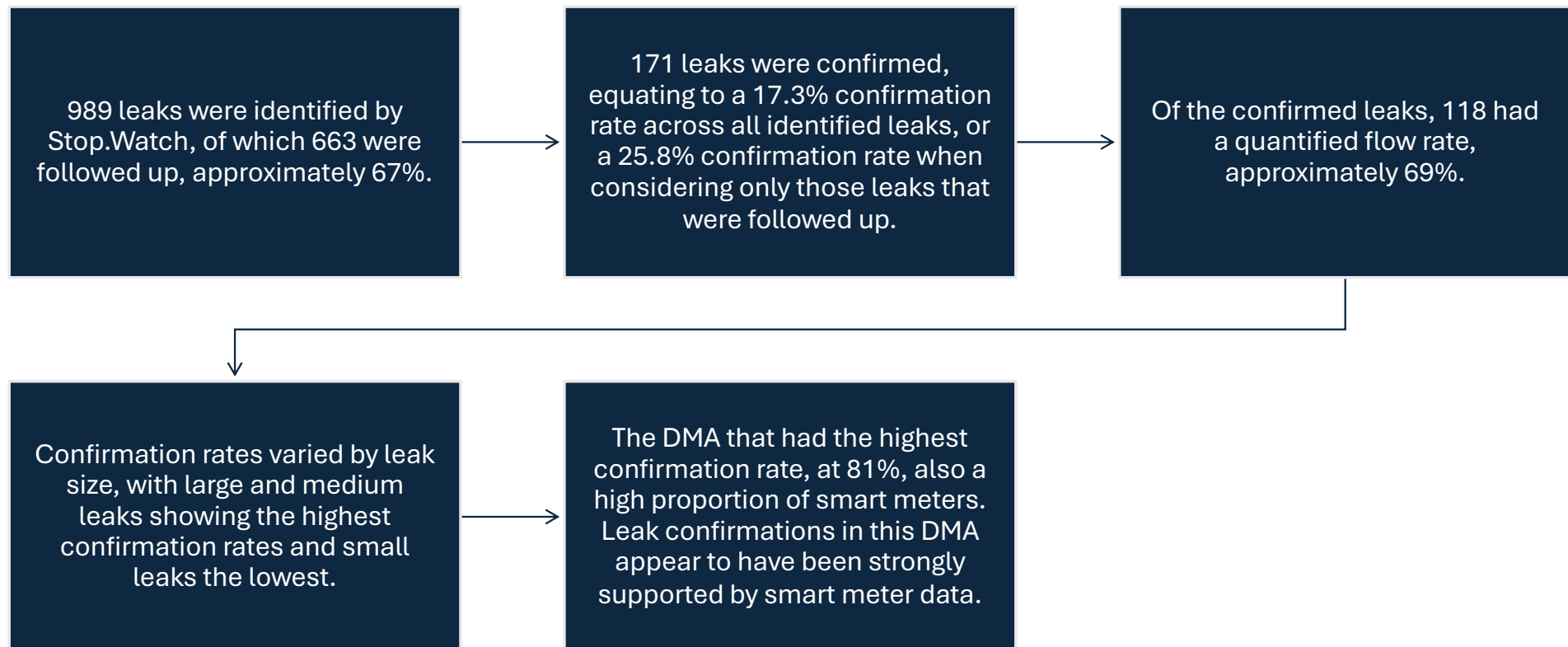
- All connections network model of each DMA
- Actual consumption profiles @ 1 min resolution based on Stop.Watch
- Modelled consumption profile for connections not logged
- Fitting pressure loggers to every available hydrant: 20 to 25 per DMA; 15-minute values
- Transient 100Hz Pressure Logging 24/7 using HWM LX Loggers that have been newly developed for this Project
- Installing acoustic loggers at high density sending nightflow acoustic readings
- Combining data sets to identify areas of interest



Stop.Watch Deployment



Customer Side Leaks Found



New techniques developed

- New, simple mass balance technique - the 'Sheffield Method'
- Enhanced analysis of data from acoustic loggers
- All connections, network modelling of flow and pressure data
- 100Hz pressure logging and remote analysis for an extended duration
- Emerging technique to predict DMA demand profile from high frequency pressure data



Managing Background Leakage
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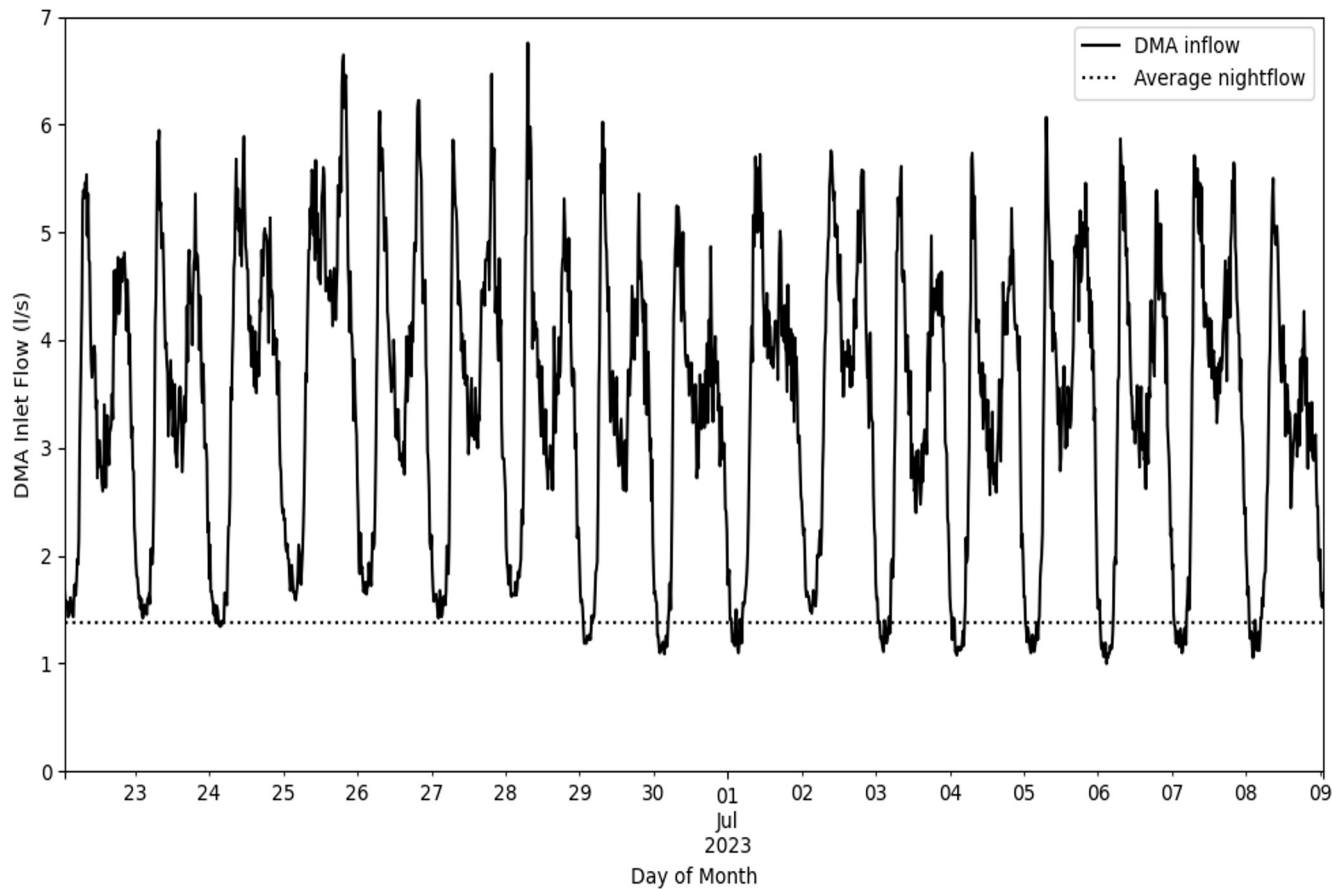


The Sheffield Method for Calculating DMA Leakage

The Value of Smart Metering to Determine Network Leakage

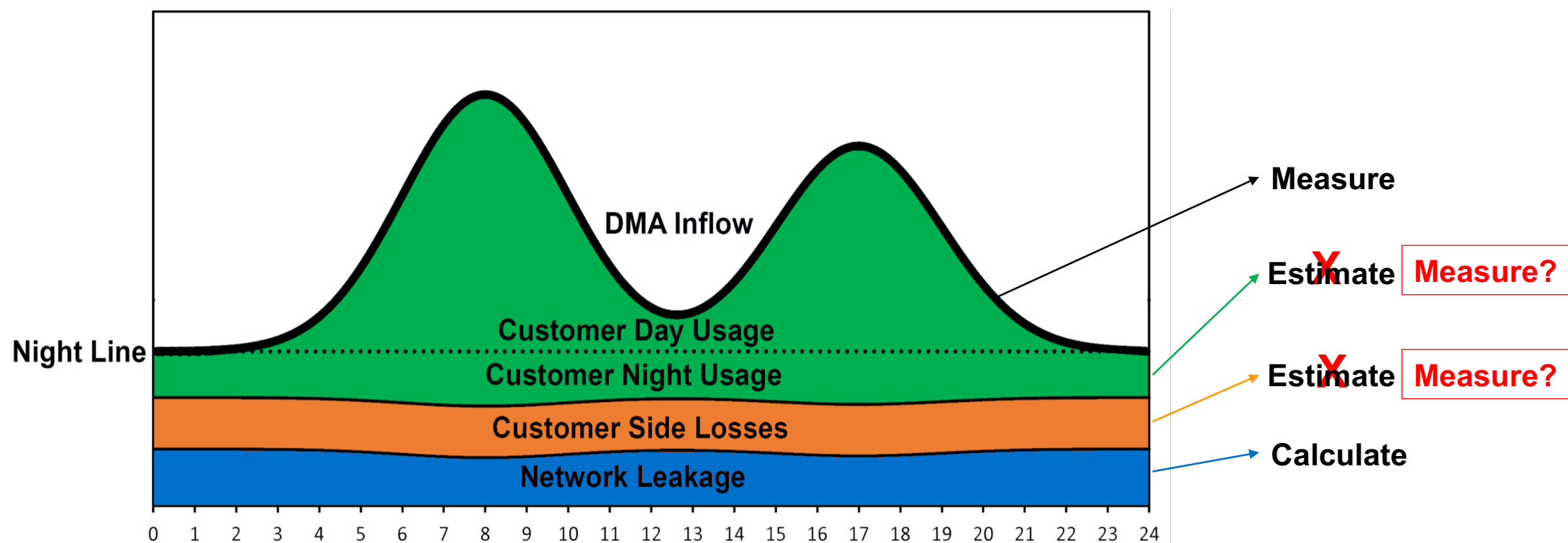


DMA Inlet Data

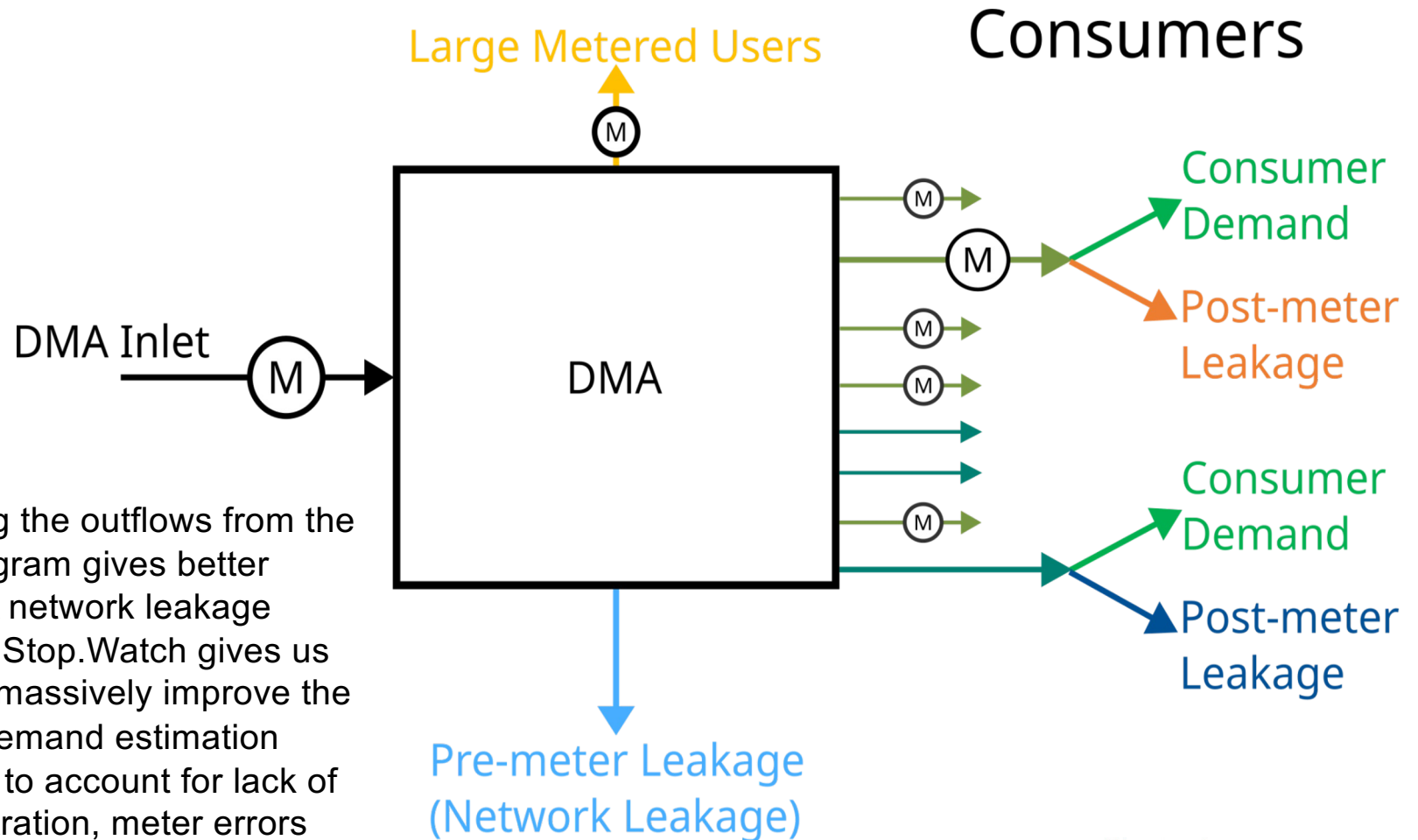


Average Nightflow = 1.38 l/s
What is leakage?

Quantifying Leakage Flow Components

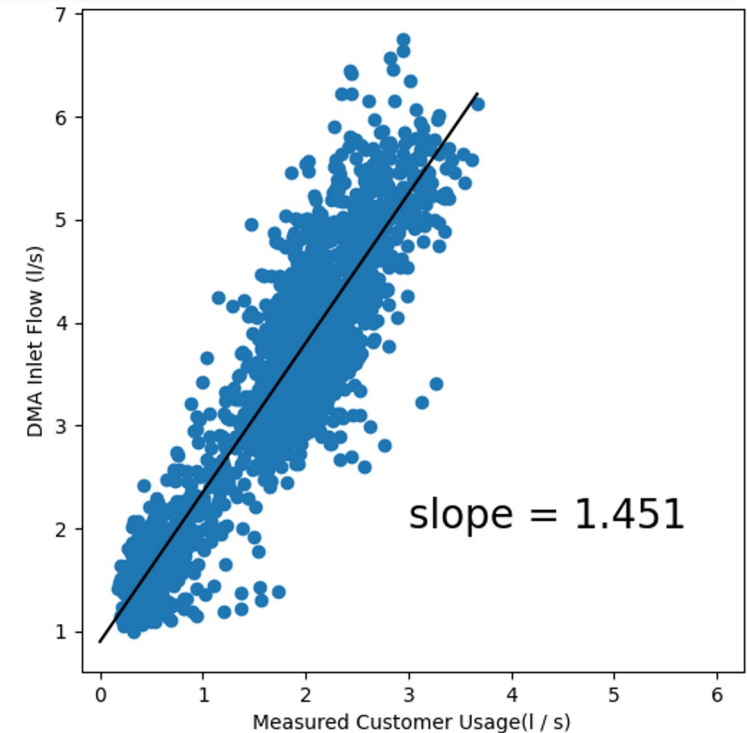
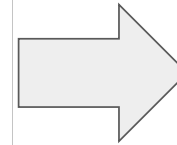
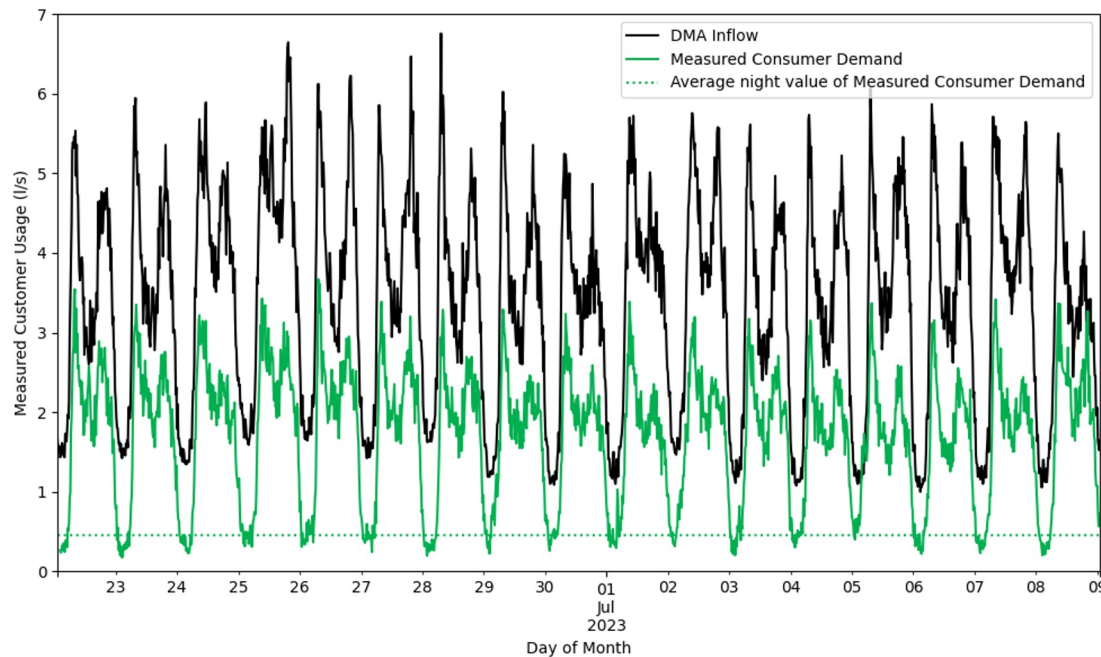


DMA Mass Balance



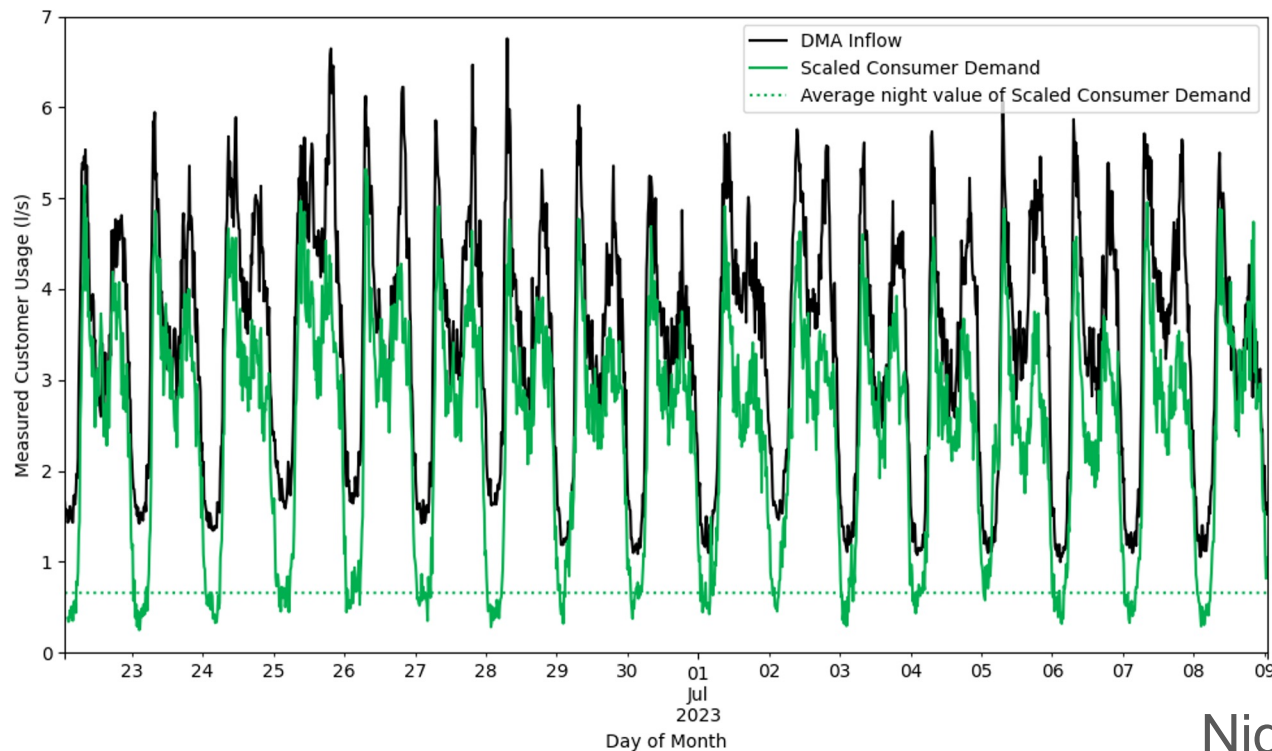
- Actually measuring the outflows from the Mass Balance diagram gives better estimation of DMA network leakage
- Smart meters and Stop.Watch gives us the opportunity to massively improve the uncertainty from demand estimation
- Provides a means to account for lack of 100% meter penetration, meter errors etc.

Scaling Consumer Demands



- Shape is similar, scale is wrong
- Not 100% coverage
- Meter errors
- But if penetration is sufficient then the shape should be similar

Best Estimate of Consumer Usage



Scaled Demand =
Measured Demand x 1.45

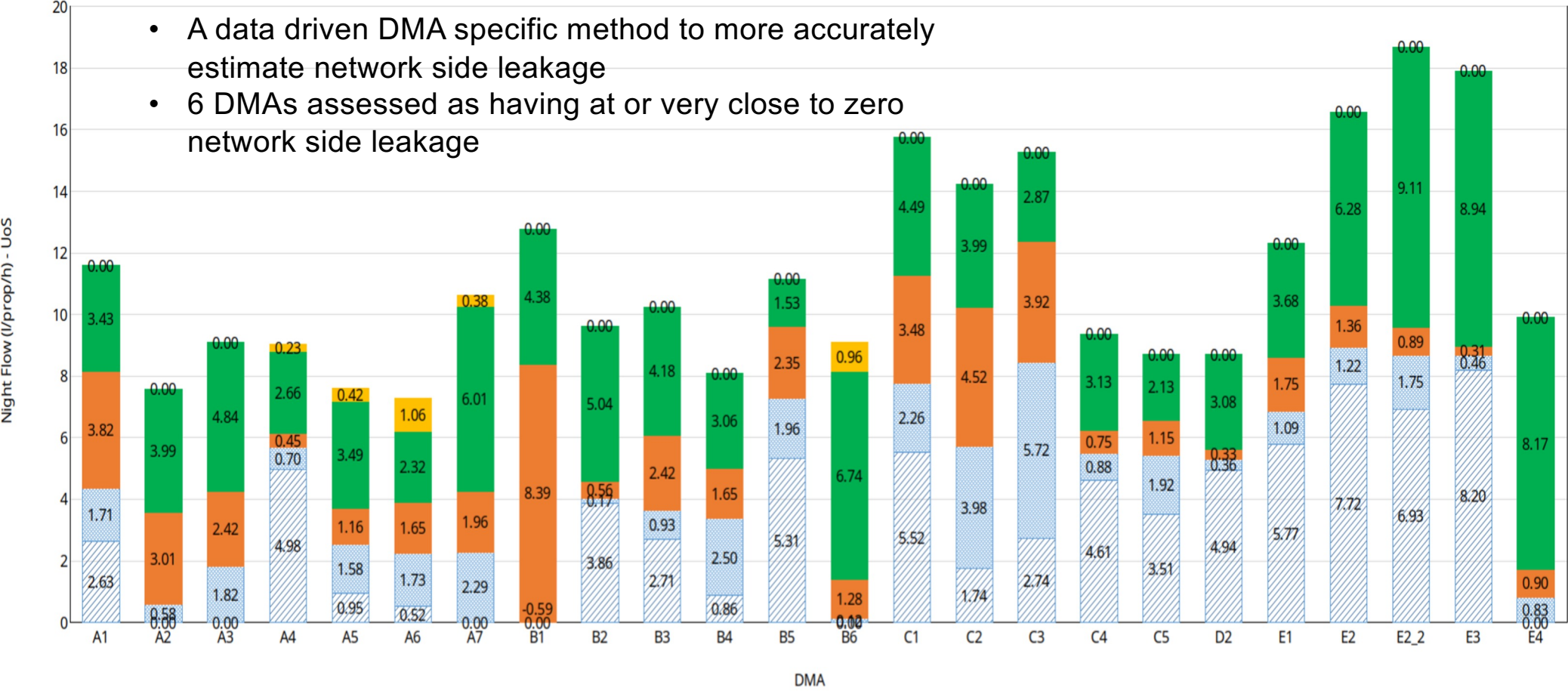
Difference between the
DMA inlet and scaled
consumer demand is the
continuous flow in the
network

Night-time customer usage = 0.72 l/s

Components of the Night Flow (l/prop/hr)

Possible Network Side Leakage (l/prop/h) Possible Customer Side Leakage (l/prop/h) Measured Customer-Side Leakage (l/prop/h) Scaled, Factored Customer Night Use (l/prop/h) Measured Large User Night (l/prop/h)

- A data driven DMA specific method to more accurately estimate network side leakage
- 6 DMAs assessed as having at or very close to zero network side leakage



NOTE D1 removed for clarity

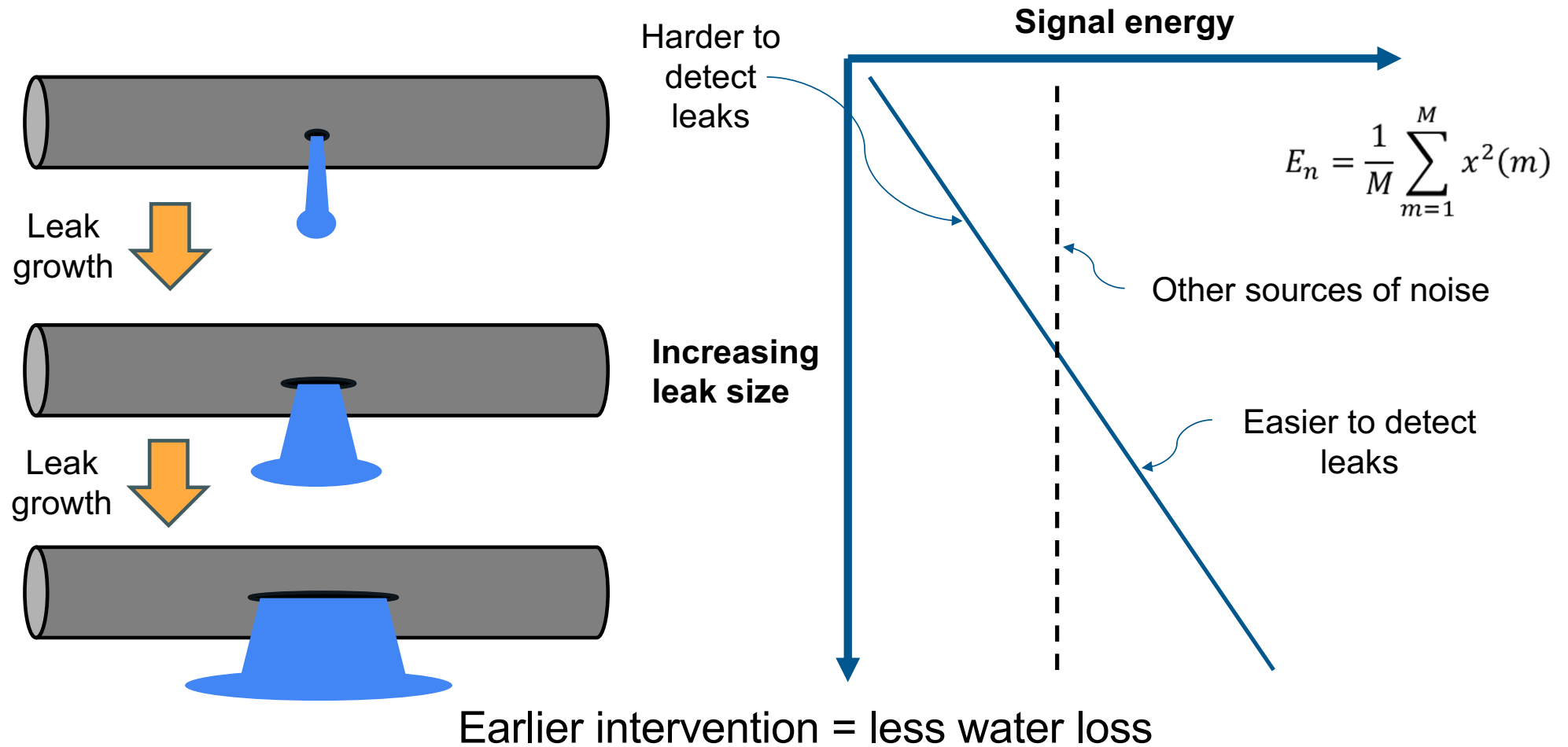
Managing Background Leakage
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Ofwat

Acoustic leak detection: The dual feature method

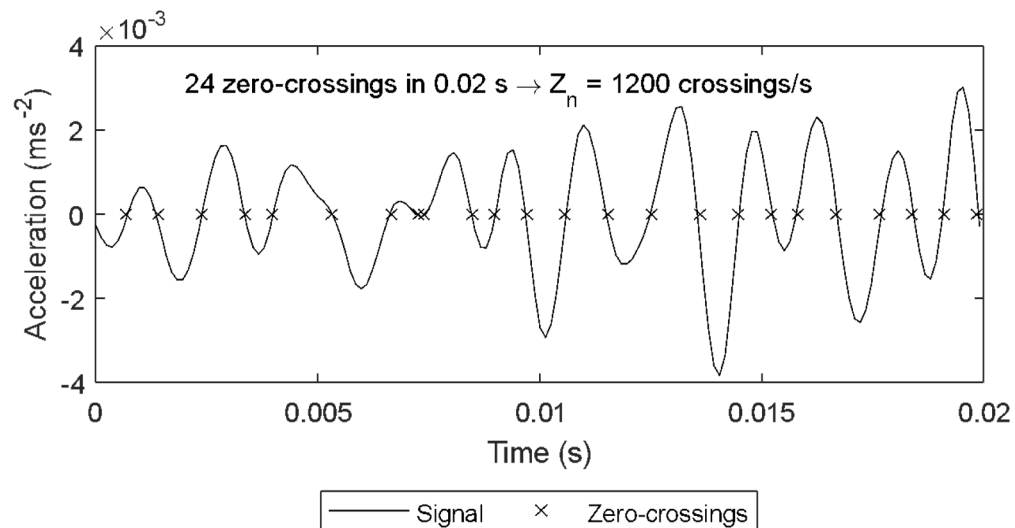


Detecting small leaks against background noise



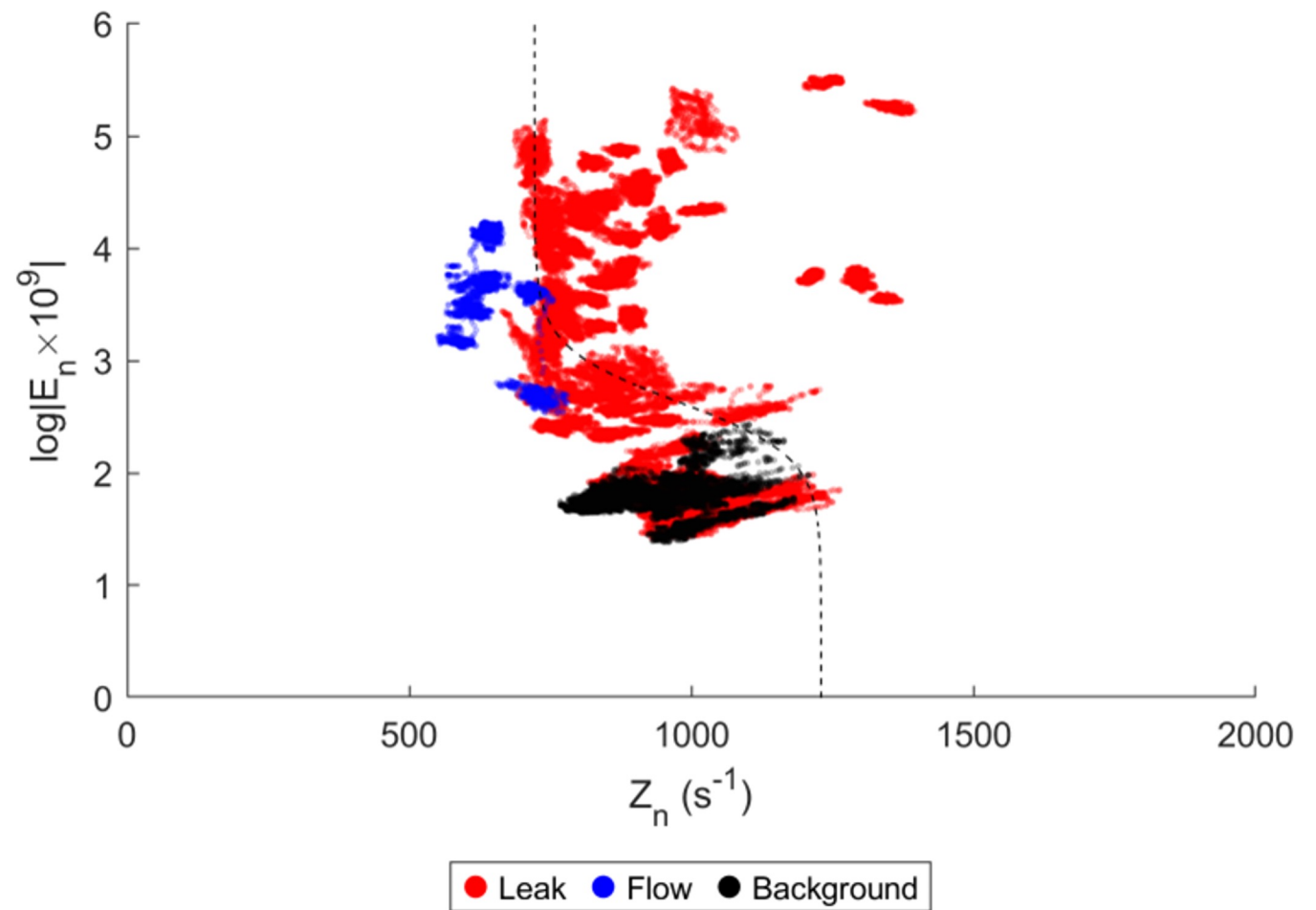
Zero-Crossing Rate

$$Z_n = \frac{f_s}{2M} \sum_{m=2}^M |\text{sgn}(x(m)) - \text{sgn}(x(m-1))|$$

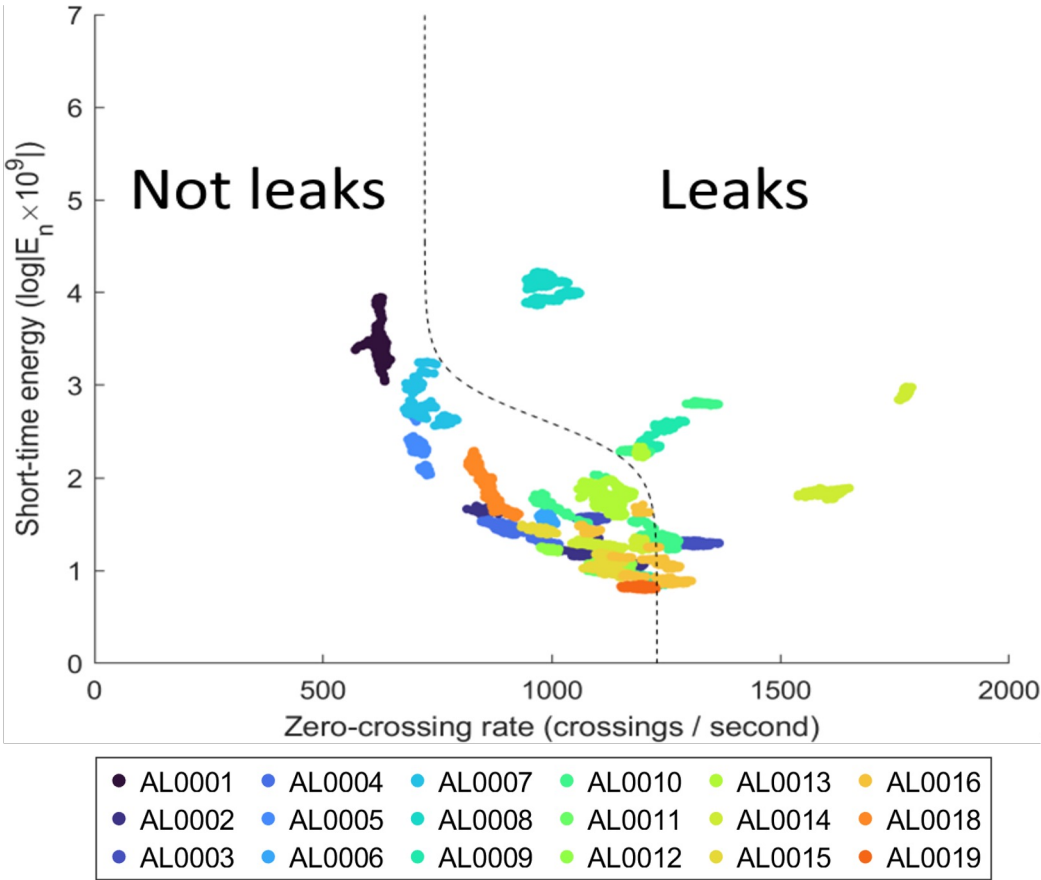


- Simple signal feature indicative of the dominant frequency component
- Data-driven research has shown Z_n can be useful for leak identification
- Large sets of labelled leak data typically not available
- Physics-based understanding of parameters needed to interpret signals

Laboratory data



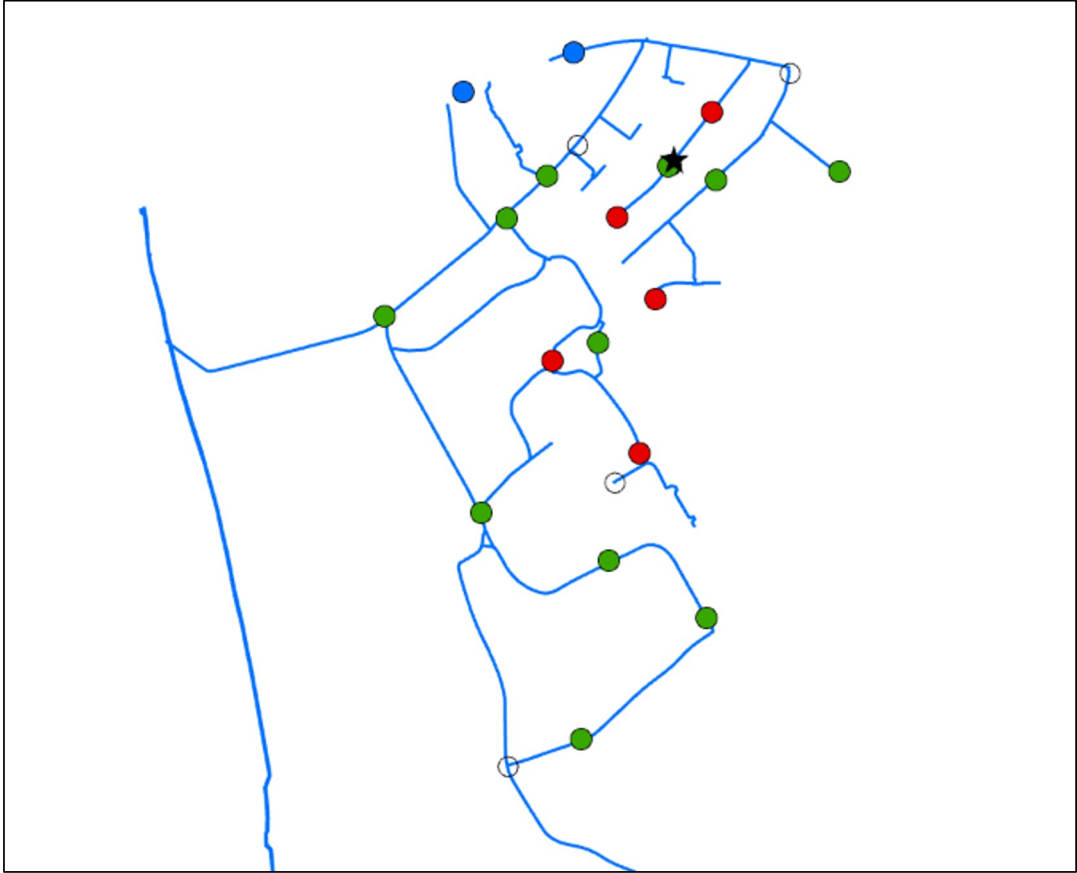
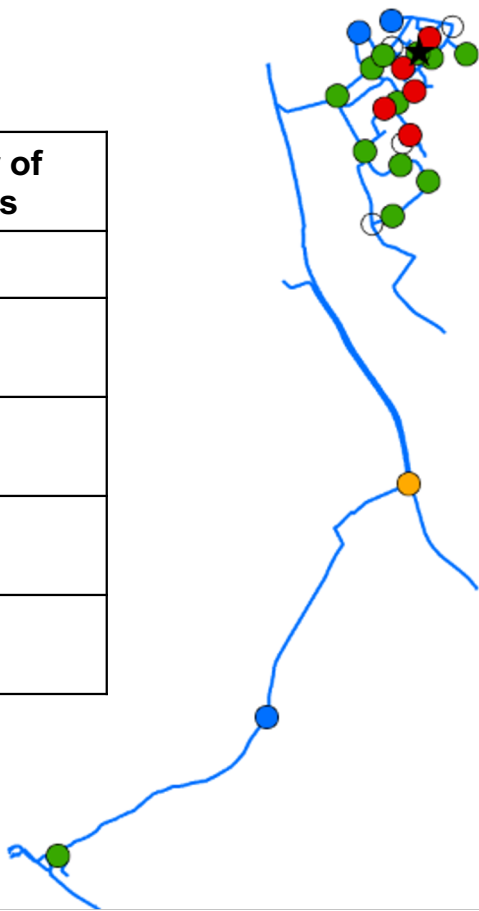
Leak classification



Wilcoxon signed-rank test result:	Median distance from leak threshold of all recordings for the logger:	
	≥ 0	< 0
Reject null hypothesis	Leak, high confidence	No leak, high confidence
Accept null hypothesis	Leak, low confidence	No leak, low confidence

NetE2.2

Classification	Number of loggers
No stable data	4
No leak, high confidence	13
No leak, low confidence	3
Leak, low confidence	1
Leak, high confidence	5



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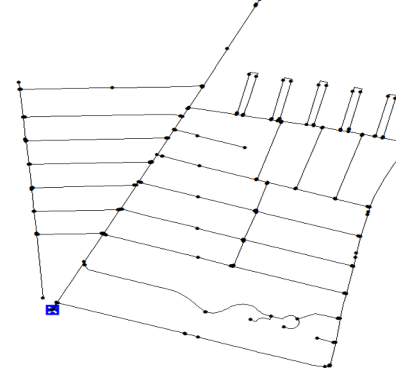
Hydraulic Analysis



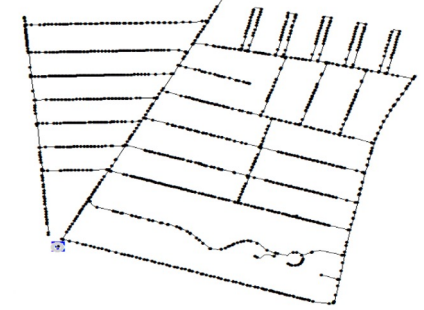
Finding existing (background) leakage

- use high resolution data driven modelling (a digital twin)
- individual property water consumption data
- all-connection models for deeper insight
- inverse modelling to search the locations, size and number of leaks

Standard, top-down, lumped model



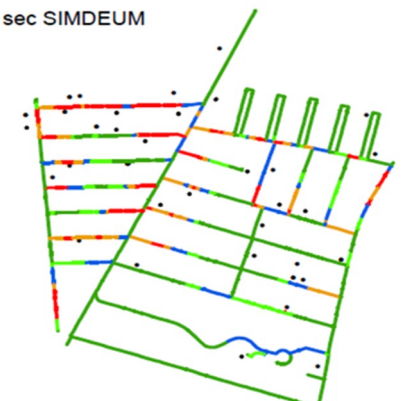
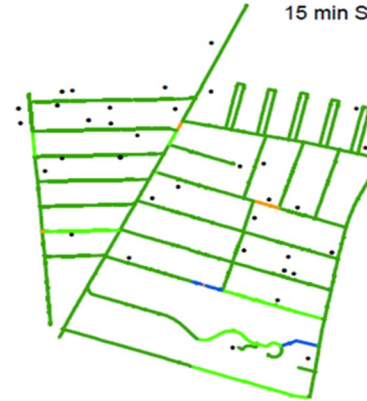
All connections model



Number of flow reversals

15 min Standard

1 sec SIMDEUM



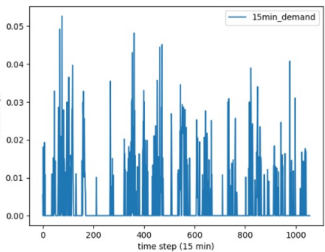
2nd International Joint Conference on Water Distribution
Systems Analysis & Computing and Control in the Water Industry
Valencia (Spain), 18-22 July 2022
doi: <https://doi.org/10.4995/WDSA-CCWI2022.2022.14084>

THE IMPACT OF DRINKING WATER NETWORK MODEL SPATIAL AND TEMPORAL SCALE ON HYDRAULIC METRICS INDICATING DISCOLOURATION RISK

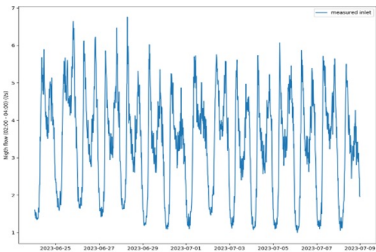
Reinar Løkk¹, Mirjam Blokker², Joby Boxall³, Michele Romano⁴, Anna Provost⁵ and Stewart Husband⁶

DOI 10.4995/WDSA-CCWI2022.2022.14084

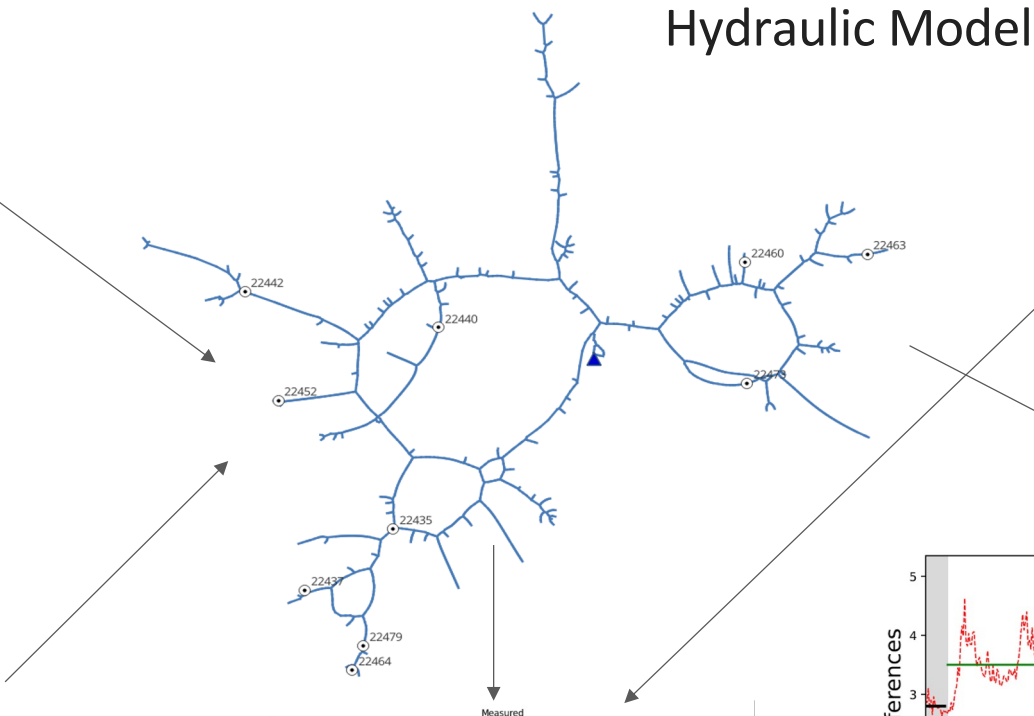
Inverse hydraulic all connections modelling



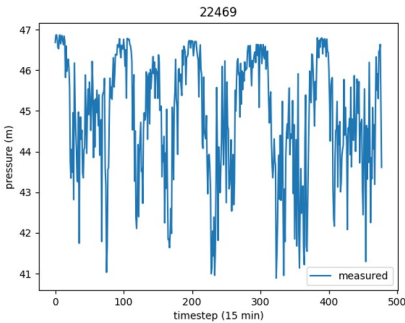
Customer Usage Data



DMA Inflow Data



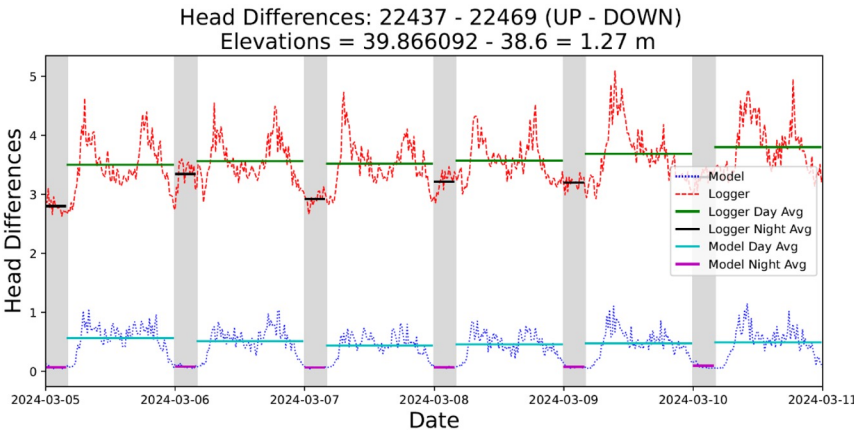
Hydraulic Model



Pressure Data, 10 locations



Network Connectivity



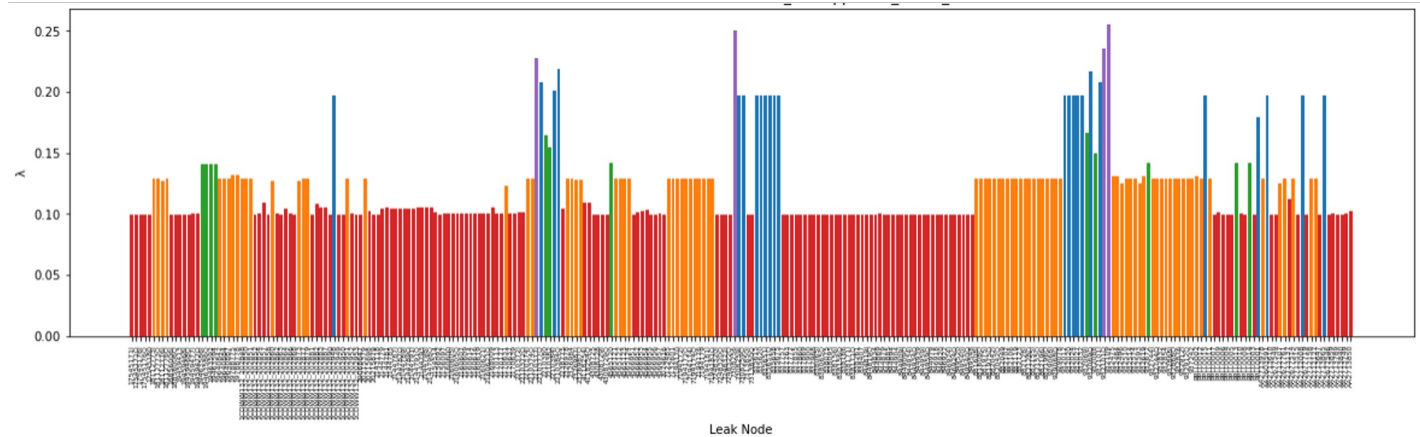
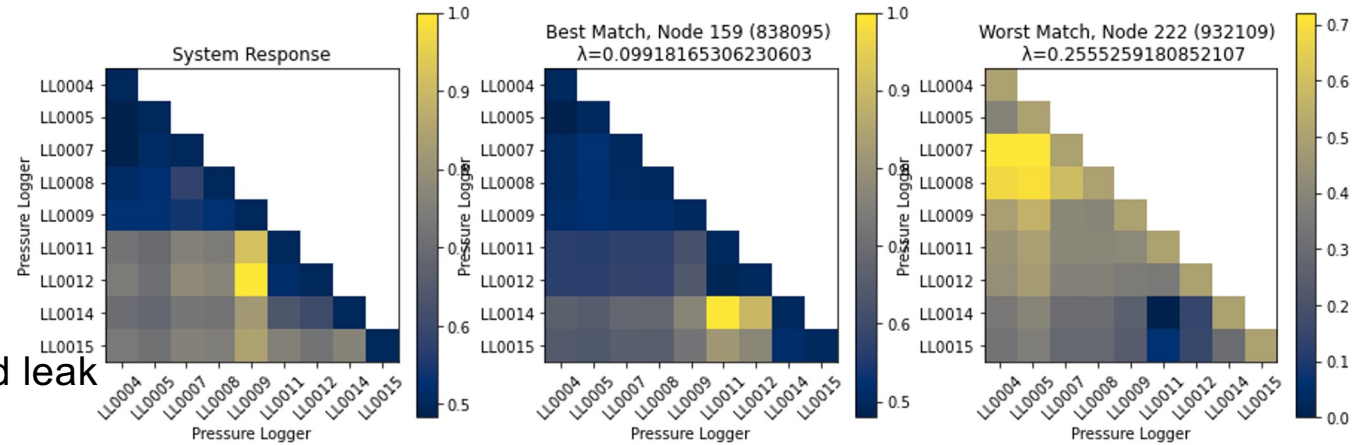
Network Headloss Analysis

Net A4: Hydraulic Analysis

- Total No. of Address: 842
- Pressure Loggers: 11 (9 used)
- Stopwatch Coverage: 39.1 %

- Lowest Likelihood
- Low Likelihood
- Medium Likelihood
- High Likelihood
- Highest Likelihood
- Inlet
- Pipes

Confirmed leak



Hydraulic Analysis Summary

Method:

- attempts to determine discrepancies in the head losses between modelled and field measurements
- avoids the need for ground levels
- Hypothesis that inclusion of actual consumer demands and coincident pressure measurements would increase accuracy/precision

Results were varied:

- In some networks areas were highlighted that corresponded to acoustic Pol's and found leaks
- Areas of DMAs highlighted tend to be large
- Other networks no correlations were found
- Assessing viability of method was challenging due to difficulties in getting “ground truth”
- Needs more accurate pressure loggers to detect smaller leaks

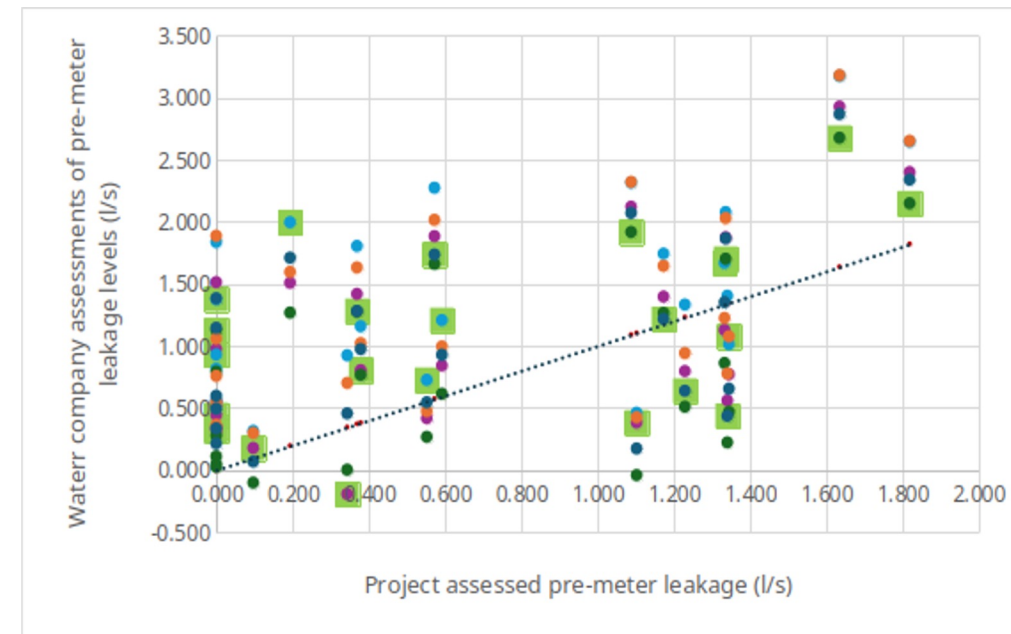


Phase B and C Conclusions

- **Different levels of customer night usage.** in both absolute (0.49 to 2.82 l/s)) and per household terms (1.53 to 9.11 l/prop/hr).
- **Different levels of measured customer side leakage.**
 - Measurements of the post-boundary leakage varied considerably amount between the DMAs, from 0.31 to 8.39 l/prop/hr.
 - Differences in the number of leaks and the characterised sizes of the leaks detected, with large leaks making the most significant contribution to overall customer side leakage.
- **Different levels of network leakage.** Network leakage varied significantly between DMAs. Several DMAs were found where our estimate of network leakage is near zero, but there were also DMAs where the estimated network leakage was higher than expected.
- **Nightline level.** On its own, nightline level is not a good predictor of the actual network leakage. Variations in DMA specific customer usage, and variations in customer side leakage from water utility estimations could incorrectly influence a DMAs priority for leakage action.

Phase D - Leakage Reporting

- In the DMAs surveyed water companies tended to **over-estimate distribution leakage** because they under-estimated customer-side continuous flows using their standard allowances.
- There is a **significant scatter of values**: company total leakage estimates for their own DMAs range between 41% and 238% of the project assessment using the same flow data.
- There is significant variability in the company-level estimates of **customer-side leakage** between water companies. The range in estimates is 28 litres per property per day. The range of plumbing loss estimates equates to 14 litres per property per day.
- The analysis of the sample of **smart meter data** indicates that customer-side leak flow rates are very skewed, with small numbers of very high flow rate leaks having a significant impact on average flow rates



Key Findings. The project has cast doubt on:

- The concept of Background Leakage. Is it really all about small leaks below a detectable threshold ?
 - We have shown that 6 of the DMAs have close to zero network side leakage i.e. that 'background leakage' or the 'minimum achievable leakage' on the water company assets is zero with current methods.
- The values for Background Leakage given in the UK Managing Leakage reports
- The split between Network and Customer side leakage.
 - The method reveals DMAs with significantly greater network side leakage than is identified using averages and fixed multipliers that are common throughout existing methods.
- The whole basis of using DMA night flows to estimate leakage without DMA specific customer consumption data.



Key Recommendations

- Water companies should adopt a **data driven approach** to estimating and managing leakage in DMAs avoiding company level estimates and assumptions.
- The current definition of Background Leakage does not apply at a DMA level. Whilst there will always be a minimum achievable level of leakage for larger zones, companies should adopt a **zero-based** approach to DMA network leakage
- **Sample sizes** for estimates plumbing loss, night use, and customer side leakage should be sufficiently large to ensure they include a representative number of large value.
- Where companies are proposing to reduce background leakage in DMAs by **asset replacement** they should be sure of the components of the night flow by undertaking surveys and analysis first.
- Programmes for installing **Smart meters** should be coordinated with DMA leakage analysis ideally giving priority to DMAs that exhibit high night flows.



Project Reports

Reports to be published in November after the Water UK Leakage Conference

Executive Summary

Phase A report

- Desk study of DMA data that confirms MAL is about 50% of DMA leakage

Phases B and C results report

- The results of 25 DMA surveys

Phase D report

- A statistical analysis of the data

Methodology report

- Sets out the methodology employed in the field surveys

Current Knowledge report

- Summarises the current knowledge on Background Leakage

Thankyou

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