WATER INFRASTRUCTURE AND RESILIENCE WIRe

EPSRC Centre for Doctoral Training

Understanding the impact of hydrants on transient-based leak detection methods

Charlie Whitelegg[1], Dr Richard Collins[1], Professor Joby Boxall[1], Scott Young[2]

[1]University of Sheffield

[2]Scottish Water

Scottish Water
Trusted to serve Scotland

University of Sheffield

UKRI Engineering and Physical Sciences Research Council

Background

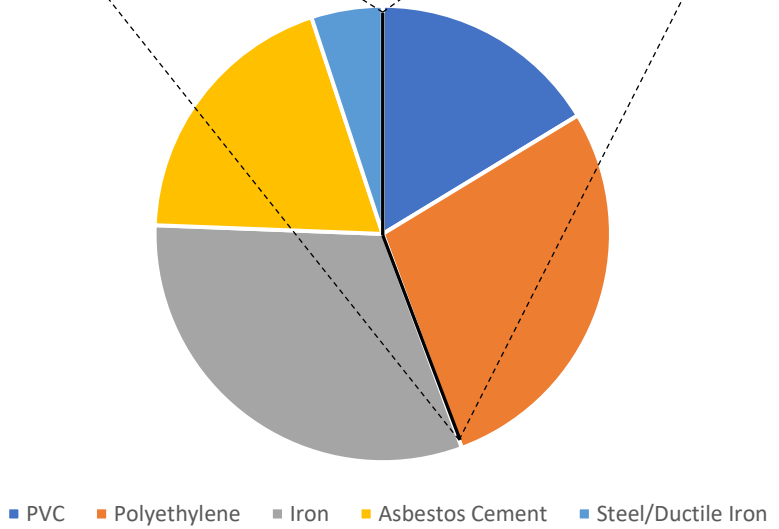
UK Water companies have agreed to halve leakage from 2017/18 levels by 2050 (Water UK,2018)

Elastic Pipelines

- *Iron*
- *Asbestos Cement (AC)*
- *Steel/Ductile iron*

Acoustic Methods

Listening stick (Cornwall live)

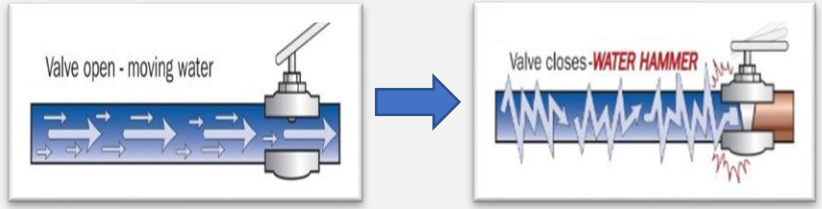


Utility data, collected between 2005 & 2018 (*Barton et al. 2019*)

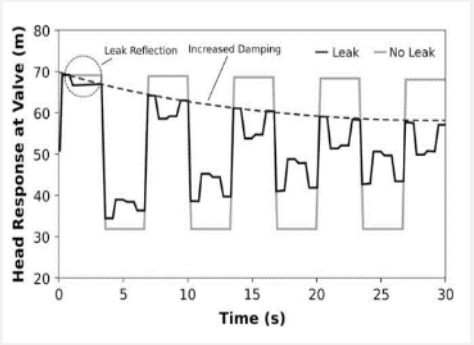
Viscoelastic Pipelines

- *Polyethylene (PE)*
- *PVC*

Transient Methods

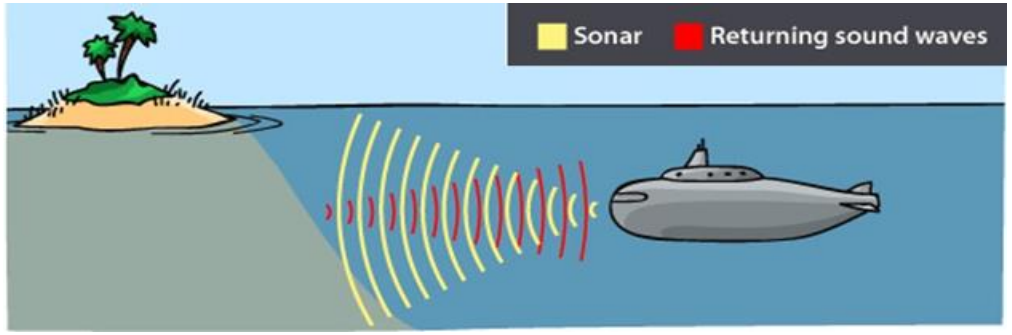


Water hammer - (Structure tech)



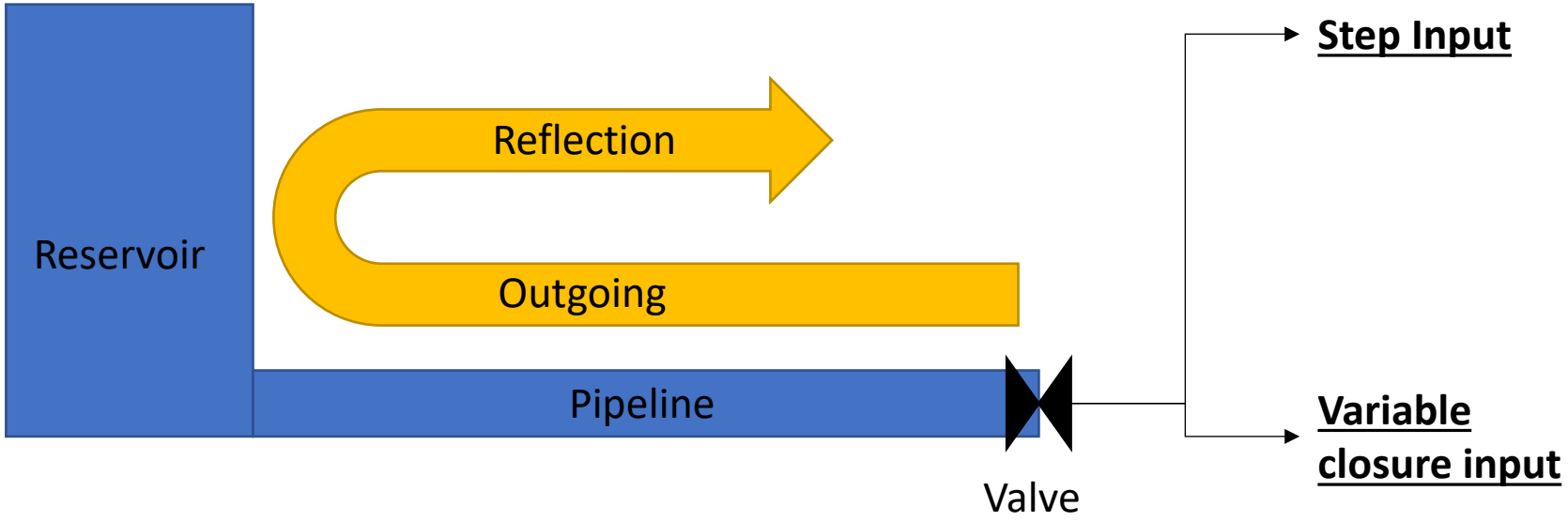
Colombo et al. (2009)

Transient Methods - Reflectometry

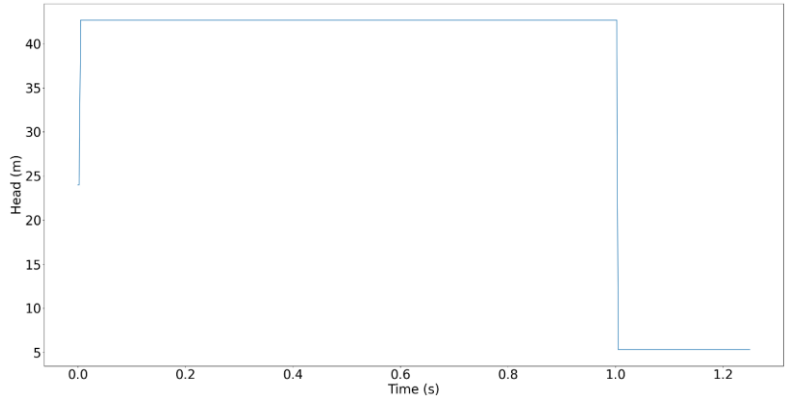


Simple in Concept

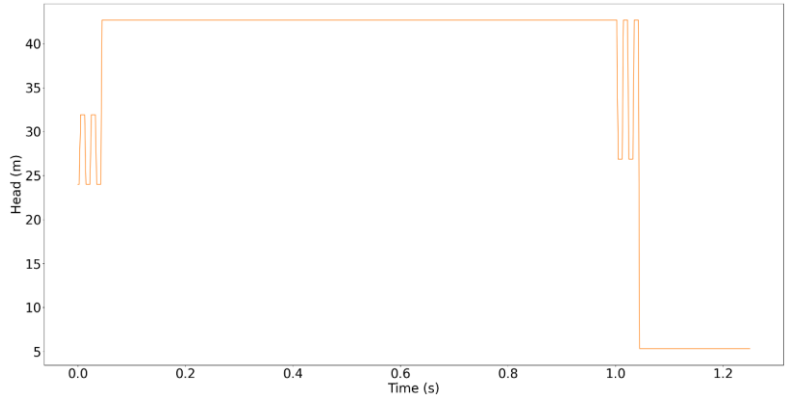
- Similar to sonar in submarines.
- Signal sent out = Signal from reflection



Step Input

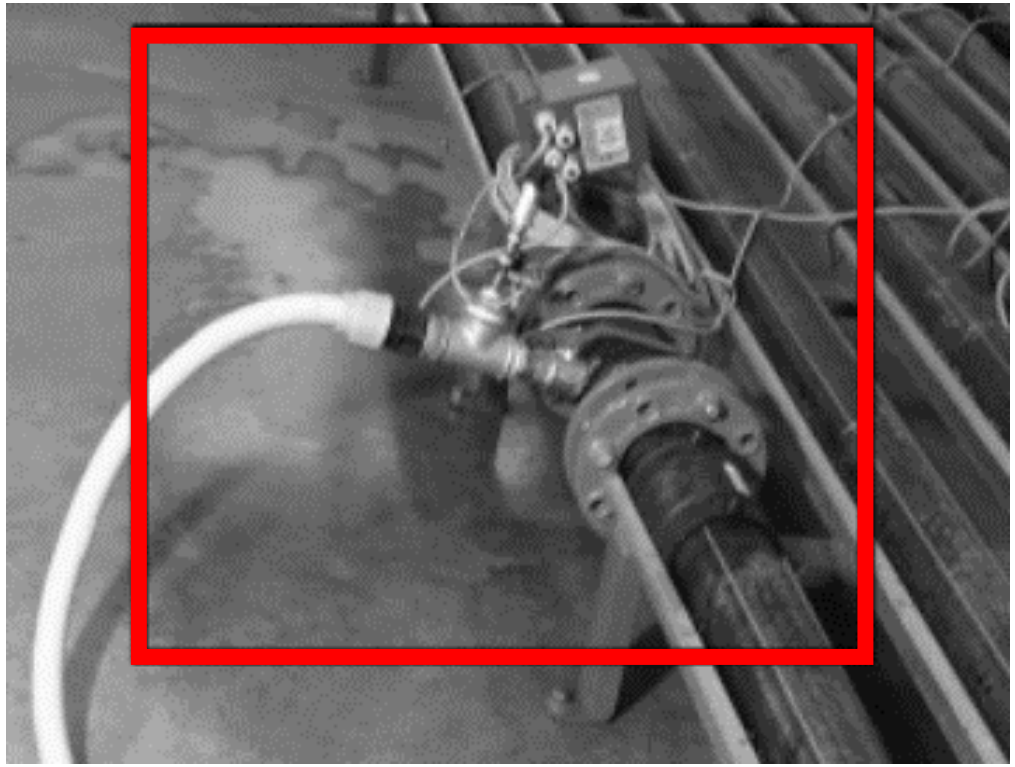


Variable closure input



Problem

Laboratory



Valve directly attached to pipe - Meniconi et al. (2011)

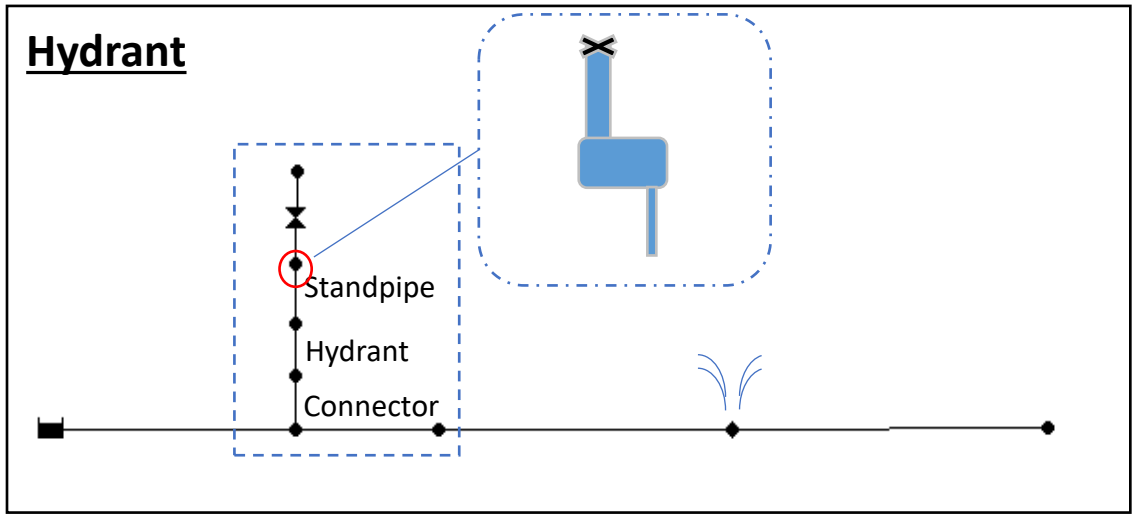
Field

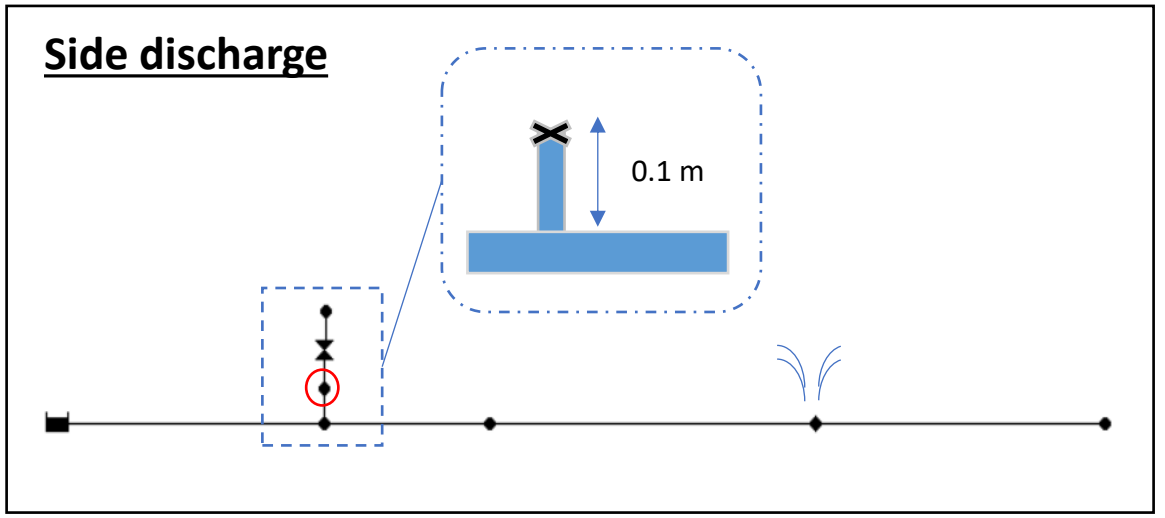
Valve at end of a hydrant - Shucksmith et al. (2012)

Signal is complicated by standpipe/hydrant/connector, with additional reflections

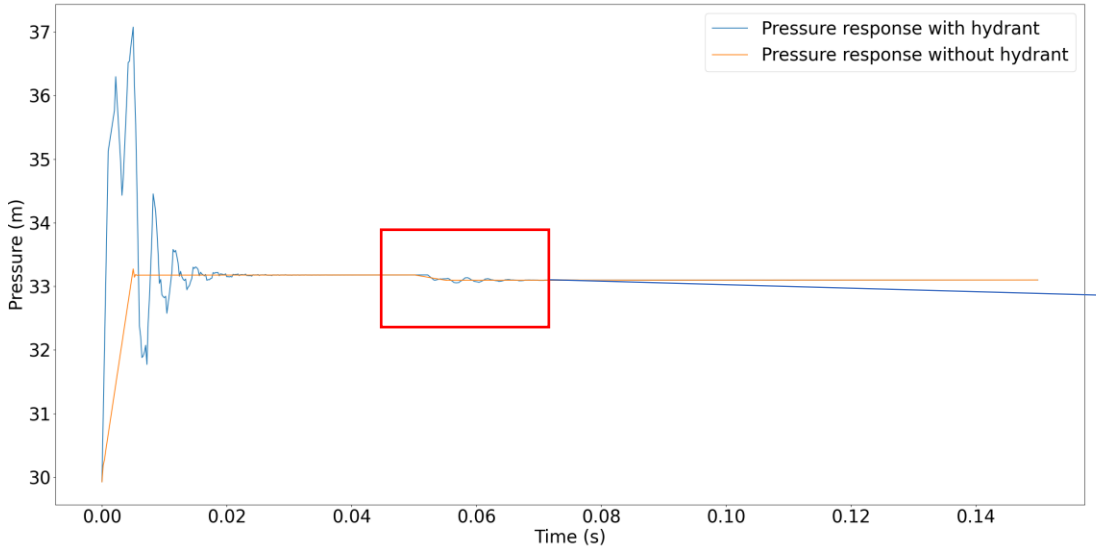
"It seems appropriate to discourage the use of hydrants as pressure wave insertion points" (Brunone et al. 2022)

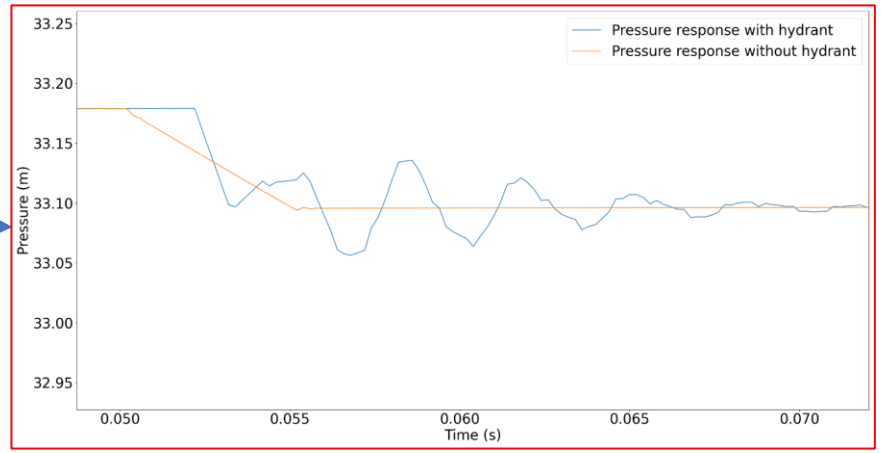
Hydrant vs. Side discharge





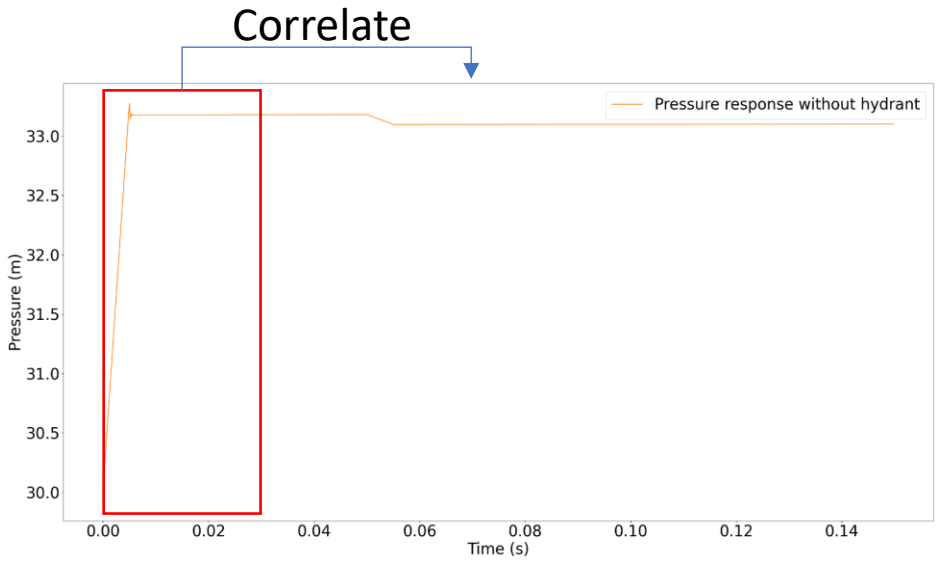
Modelled using TSNet (Xing & Sela, 2020)

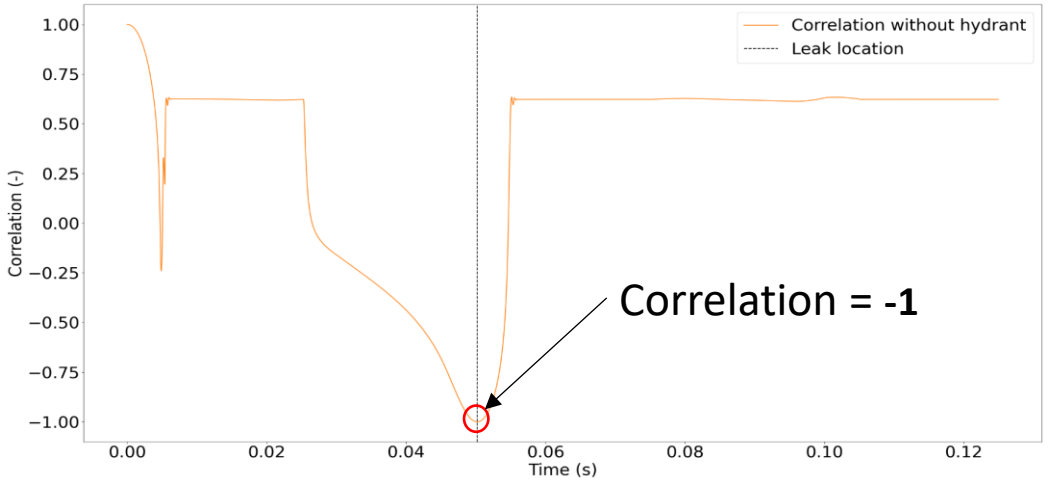


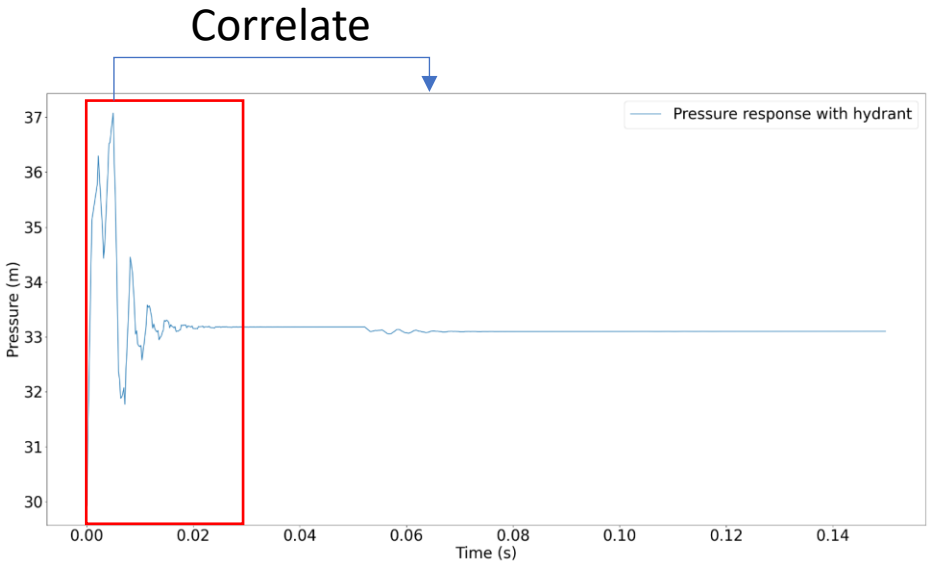


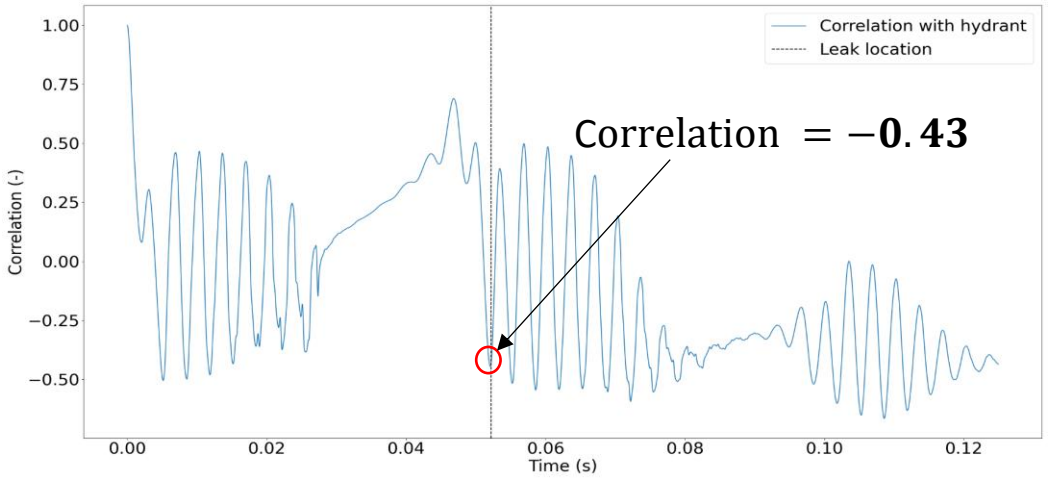
- Hydrants change the outgoing signal AND the reflected leak signal

Hydrant vs. Side discharge









1. Hydrant reduces correlation **strength**

2. Hydrant reduces localisation **accuracy**

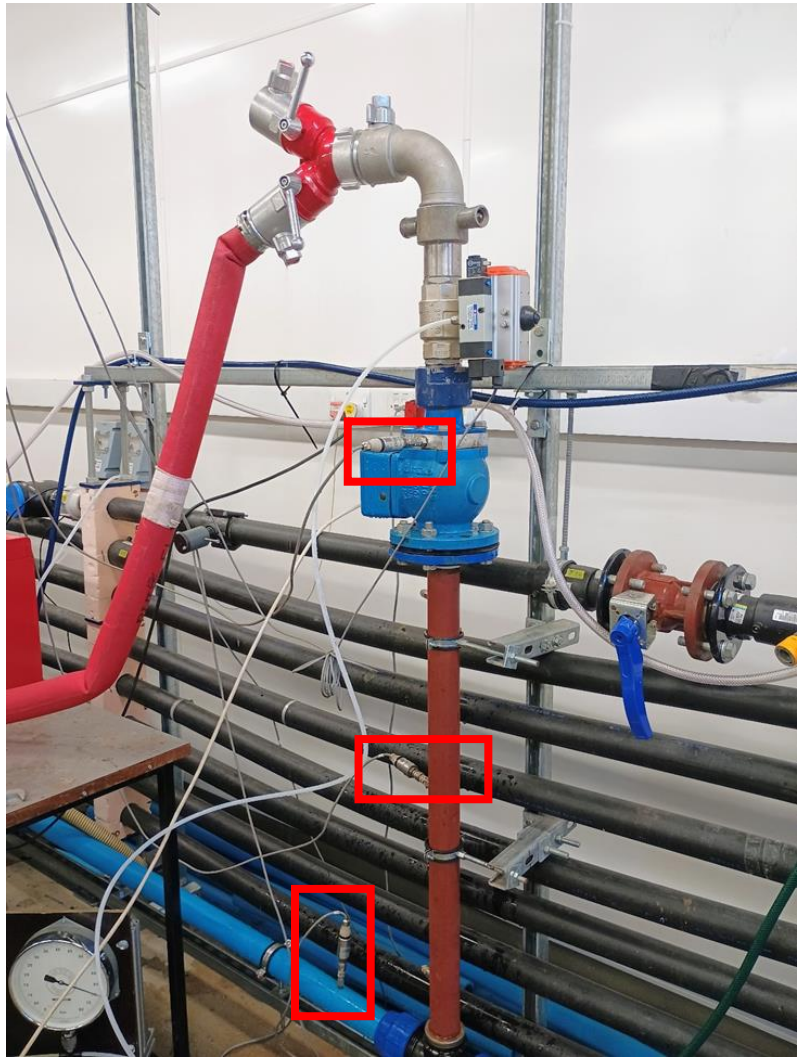
Solution?

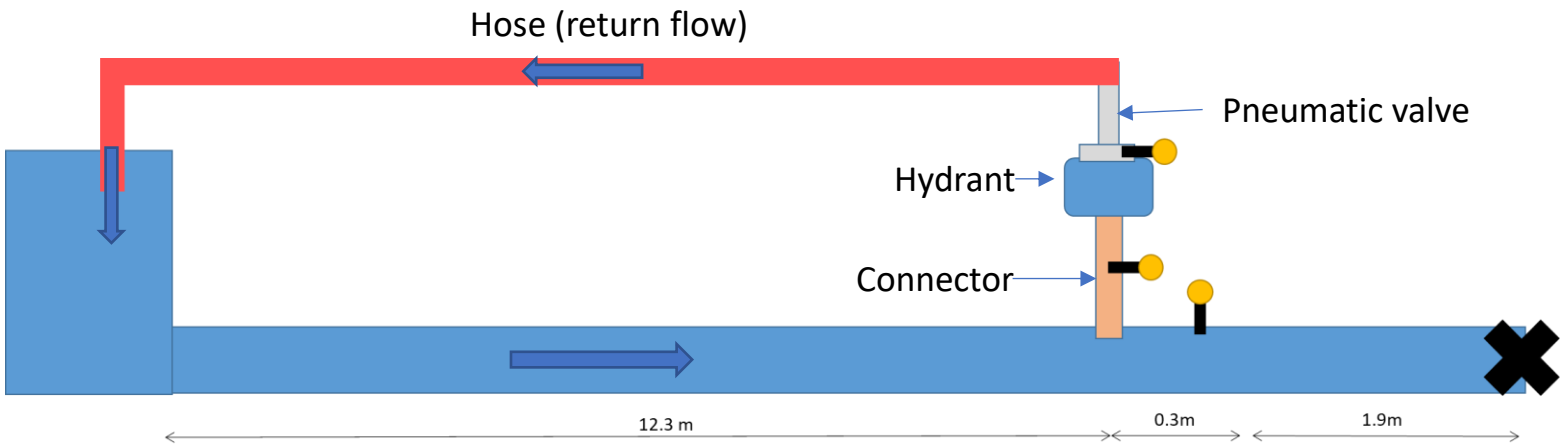
- If we can model the standpipe, hydrant and connector we can determine the expected reflection shape

- **Connector** properties can be calibrated leading to more accurate leak localisation (Whitelegg et al. 2024)

Q: Does changing the **hydrant** impact the transient wave?

Hydrant Testing - Method

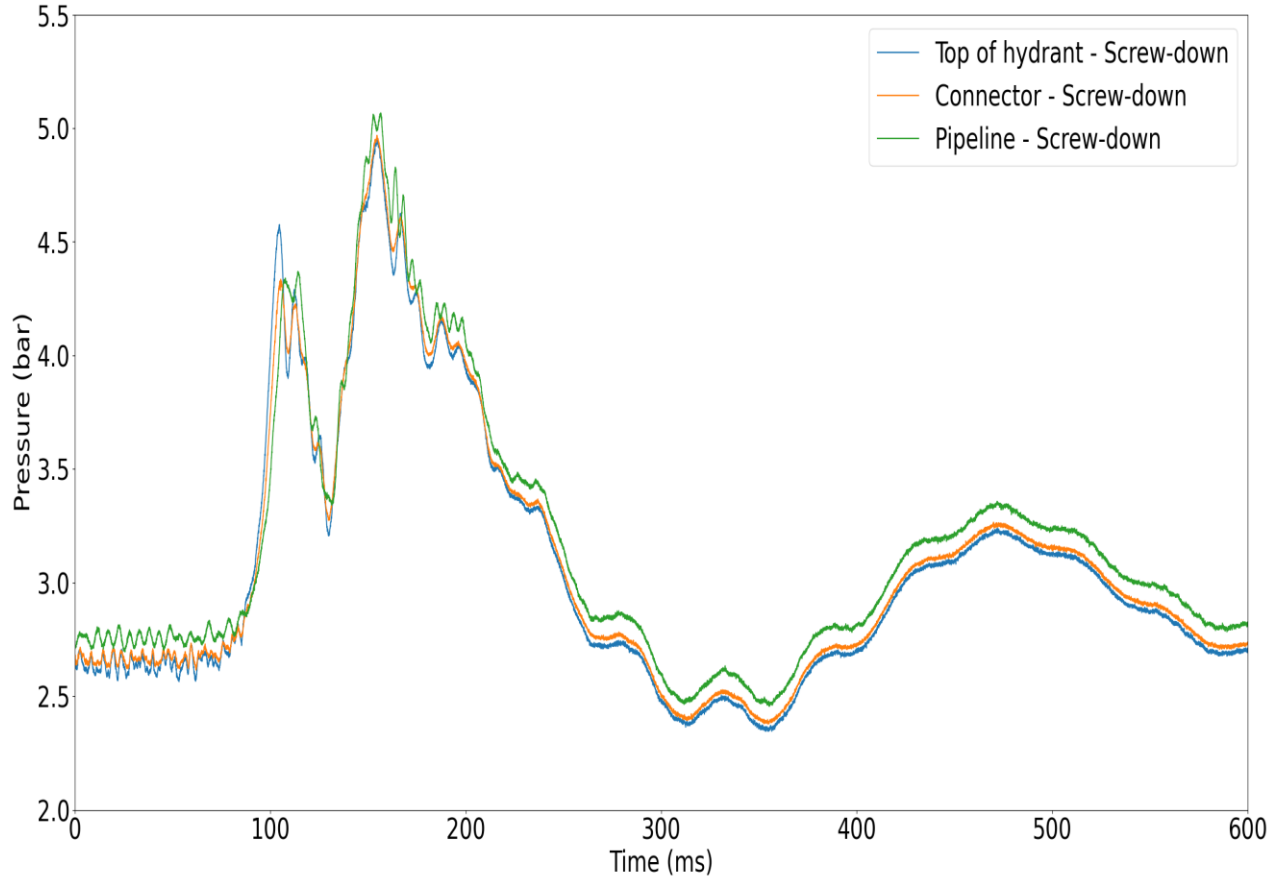




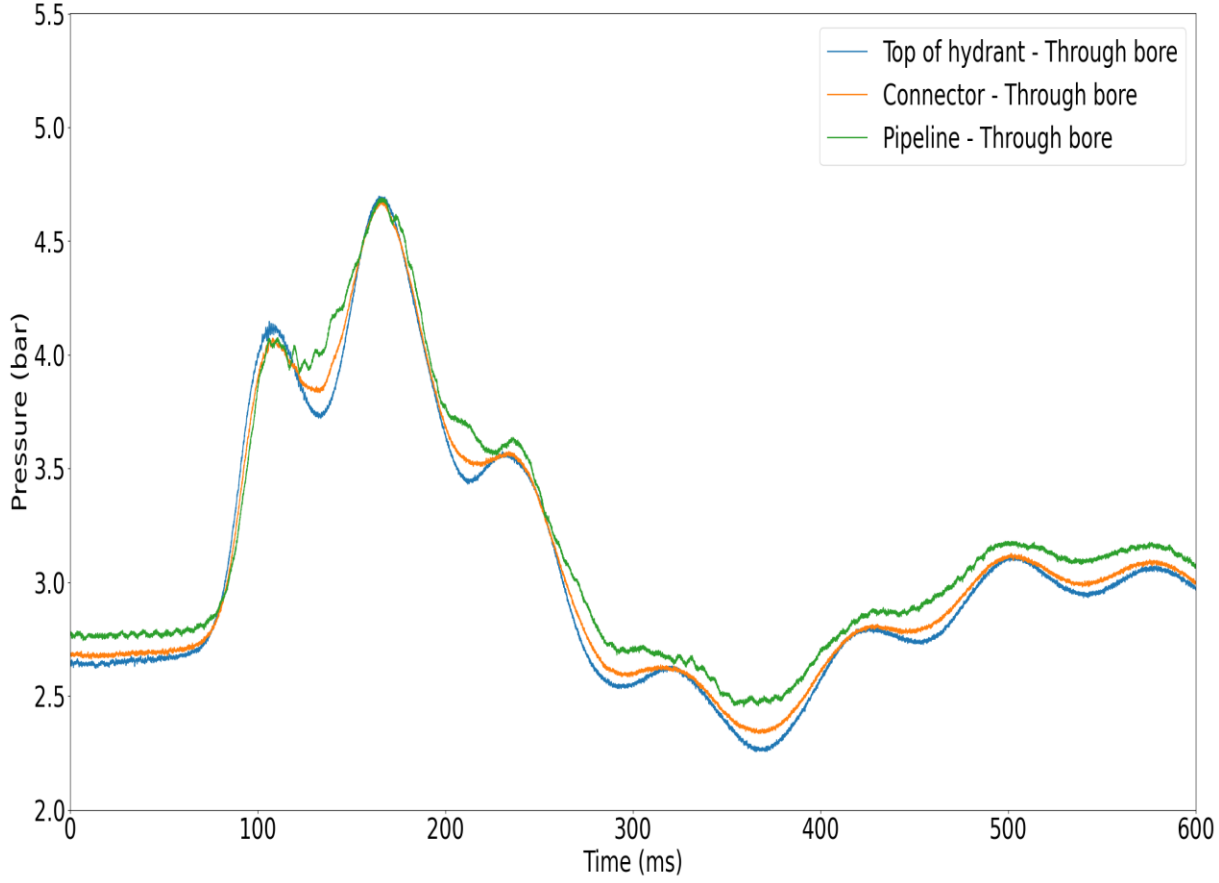
1. Control the flow so that 1.5 l/s of water is passing through hydrant
2. Generate transient using pneumatic air valve and record transient data
3. Repeat tests with different hydrants

Hydrant Testing – Results (1/2)

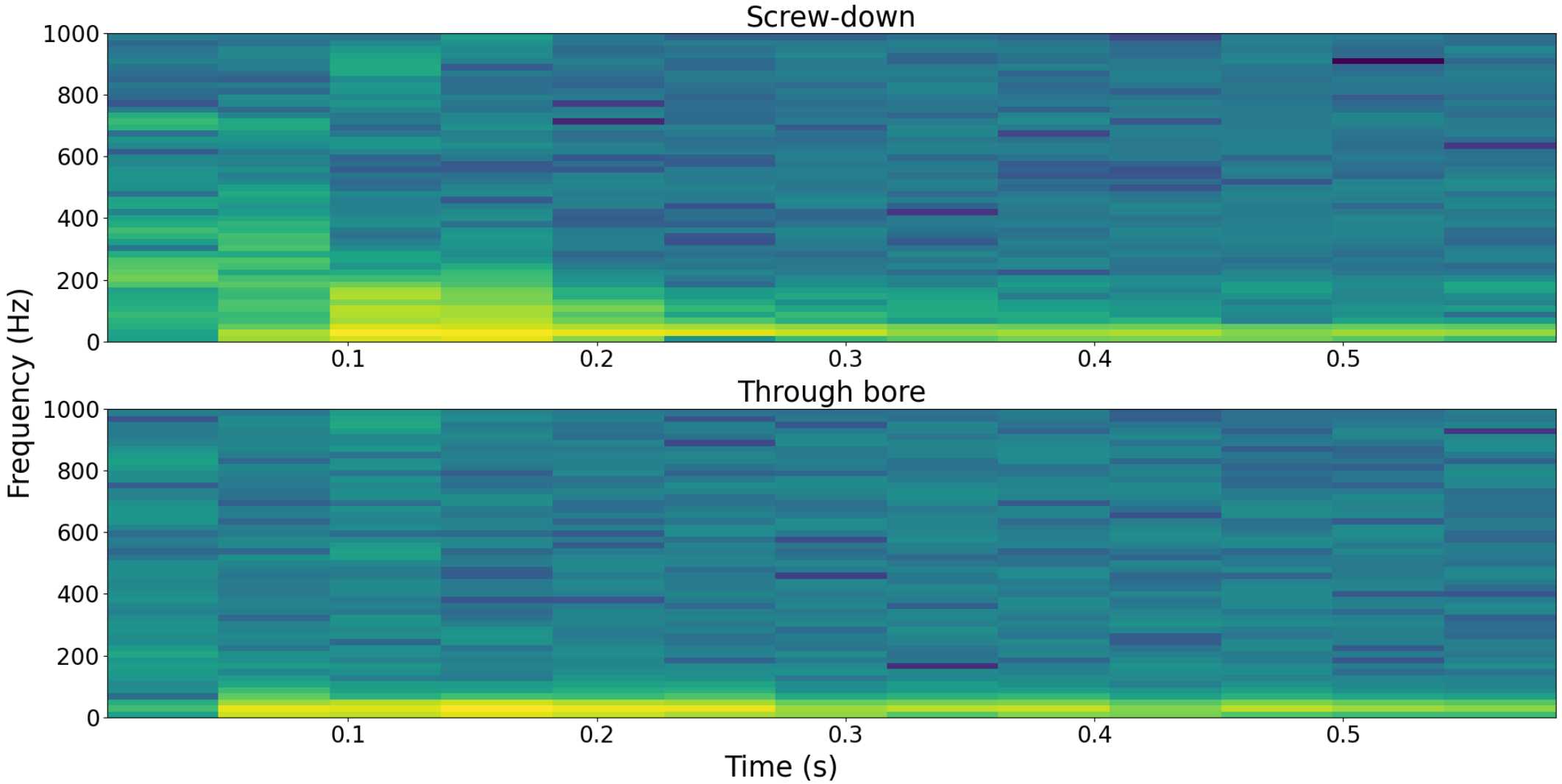
Screw-down Hydrant



Through Bore Hydrant



Hydrant Testing – Results (2/2)



Field Tests + Next Steps

Field Testing:

- A method has been developed which accounts for the variability of the reflected transient waves.

- Field testing has been conducted with Scottish Water.
  - A transient wave ≈ 1 bar has been injected, and a 0.9 l/s “leak” has been located over 400 m away.

Next Steps:

- Further testing is required to validate and develop the method.

Conclusions

1. Transient based leak detection can be successfully implemented if we know the expected reflection shape.

2. Field implementation requires either direct access points to the pipeline (e.g. UAP4W) or a method of accounting for the influence of hydrants.

3. Hydrants are currently the only practical induction points but are difficult to model. A method which automatically accounts for variability in reflection shapes is required.

Charlie Whitelegg
Dept of Civil and Structural Engineering
University of Sheffield
cwhitelegg1@sheffield.ac.uk

References

- Brunone, B., Maietta, F., Capponi, C., Keramat, A., & Meniconi, S. A review of physical experiments for leak detection in water pipes through transient tests for addressing future research. Journal of Hydraulic Research, (2022), 60(6). https://doi.org/10.1080/00221686.2022.2067086
- Shucksmith, J. D., Boxall, J. B., Staszewski, W. J., Seth, A., & Beck, S. B. M. (2012). Onsite leak location in a pipe network by cepstrum analysis of pressure transients. *Journal - American Water Works Association*, *104*(8), E457–E465. https://doi.org/10.5942/jawwa.2012.104.0108
- Meniconi, S., Brunone, B., Ferrante, M., & Massari, C. (2011). Transient tests for locating and sizing illegal branches in pipe systems. *Journal of Hydroinformatics*, *13*(3), 334–345. https://doi.org/10.2166/hydro.2011.012
- Xing, L., & Sela, L. (2020). Transient simulations in water distribution networks: TSNet python package. *Advances in Engineering Software (1992)*, *149*, 102884. https://doi.org/10.1016/j.advengsoft.2020.102884
- Andrew F. Colombo, Pedro Lee, Bryan W. Karney (2009). A selective literature review of transient-based leak detection methods, Journal of Hydro-environment Research, Volume 2, Issue 4, https://doi.org/10.1016/j.jher.2009.02.003.
- Whitelegg, C.; Collins, R.; Boxall, J.; Young, S. Characterizing the Impact of Hydrants on Transients. *Eng. Proc.* **2024**, *69*, 208. https://doi.org/10.3390/engproc2024069208