Evaluation of Leakages Effects in the Water Supply System of Moratalla (Spain)

A. Vigueras-Rodríguez, A. Casanova & Juan T. García

Hydraulic, Maritime and Environmental Engineering (Hidr@m)
Department of Civil Engineering — Universidad Politécnica de Cartagena — Spain

Universidad Politécnica de Cartagena

Introduction

- One of the risk management requirements is the assessment of the effect of each kind of possible failure.
- In water supply systems, the most common failures are the pipe leakages.
- Leakages usually can affect the service, leading to reductions in service pressures, and causing the loss of water and energy resources.
- Infrequently, leakages can worsen water quality by aspirating air or solid particles in negative pressure zones.
- Water scarcity in Southern Spain increases the relevance of reducing water leakages.

Water Supply System of Moratalla

- Moratalla is a municipality located at Murcian Region in Spain.
  - ≈ 8200 inhabitants.
  - $\approx$ 955 km^2.
  - Important changes in elevations from around 550 m to 2000 m a.s.l.
- Center of Moratalla
  - $\approx$ 6000 inhabitants
  - Elevation varies from 550 m to 710 m

Figure 1: Location of Moratalla in southeastern Spain.

- Main characteristics of the Water Supply System of the center of Moratalla
  - Water consumption is around 1300 m^3/day.
  - Hydraulic retention time varies up to 30 h.
  - It is usually operated by dividing it into two hydraulic sectors.
  - Model is compound of 300 pipes summing 19 km of length and with diameters between 32 mm and 300 mm.

Epanet-Octave Library

- Mainly a GNU Octave wrapper enabling user to call the EPANET Toolkit C functions within GNU Octave.
- Vector oriented used of the functions.
- A few extra functions.
- Easy scripting and analysis of EPANET simulations.
- Free software (licensed under the GPL 3.0).
- Under early development ("beta"), feedback is welcome.

Leakage pattern

A leakage pattern is defined for each of the 300 pipes in Moratalla's water supply system. That leakage pattern is defined as an orifice whose diameter length is 1/10 of the pipe diameter (D).

$$Q_l = C_d \cdot \frac{\pi D^2}{4 \cdot 100} \sqrt{2gp}$$

Where $C_d \approx 0.60$ is the discharge coefficient, and p(m) is the pressure in the pipe.

Simulation of the leakage pattern event on each pipe

1. Selection of a pipe.
   1.1 Simulation of the leakage pattern at 1st node of the pipe (at any time in an average week).
   1.2 Analysis of effects of the leak (determination of average and extreme effects).
   1.3 Simulation of the leakage pattern at 2nd node of the pipe.
   1.4 Analysis of effects of the leak.
   1.5 Calculus of the variables that compound the pipe index (Q_a, $Q_{l,\max}$, Q_{bmp}, $I_{p<0}$).
2. If all pipes have not been considered yet come back to step 1, otherwise go on.
3. Estimation of the weighted index for each pipe
4. Categorising of the pipes.

Weighted index

The following effects of the leakage are estimated:

- Losses of water
  - Q_a Average water losses.
  - $Q_{l,\text{máx}}$ Maximum water losses.
- Service deterioration
  - Q_{bmp} Water consumption that is being supplied below regulated minimum pressure or not supplied.
- Water quality deterioration
  - At this stage, qualitatively estimated by the presence of steady negative pressures around orifice (air and or solids entrance).

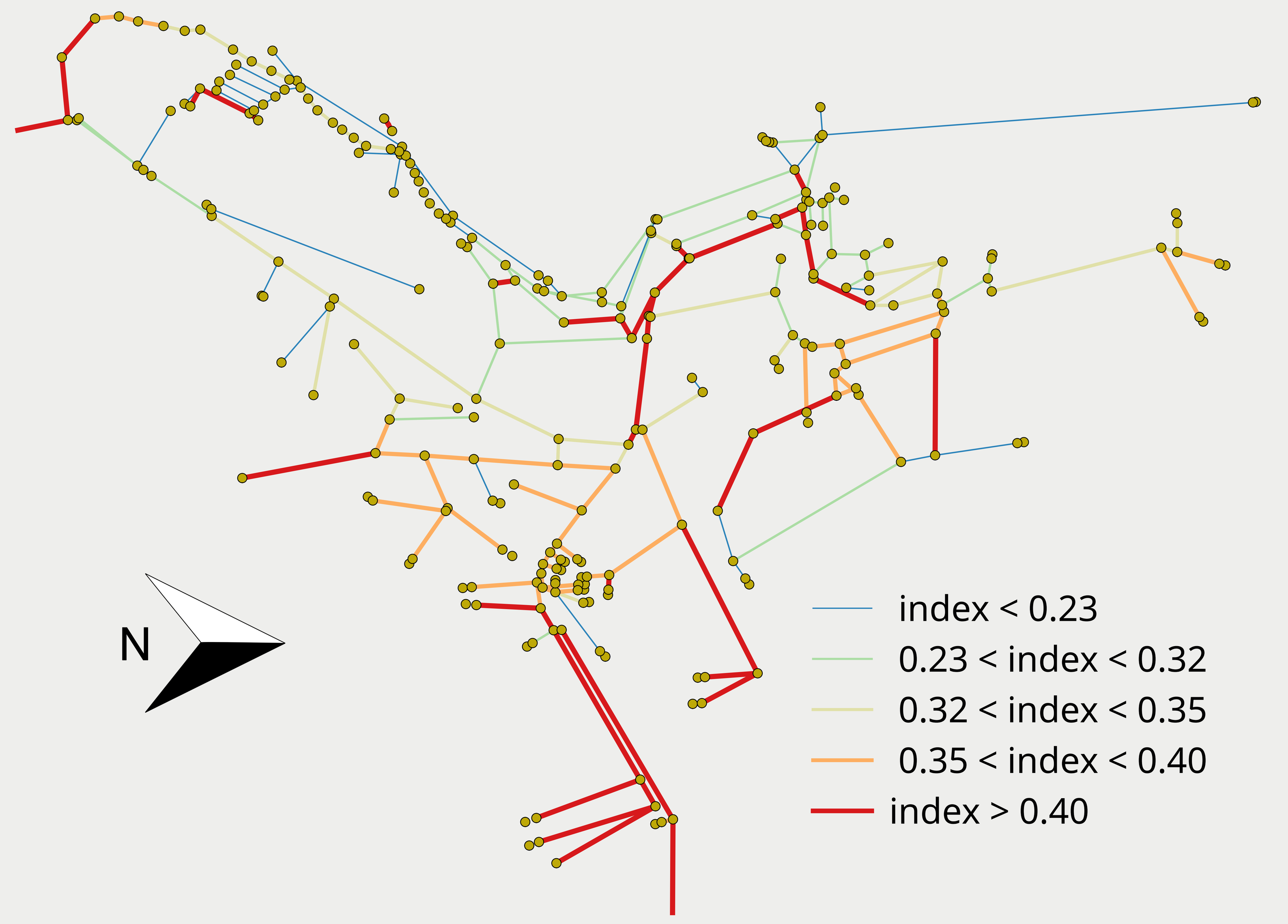

Figure 2: Pipe categorisation attending to the weighted index from the pipes in which a leakage would lead to worse effects (greater index), to the pipes with less important effects (fewer index).

Conclusions

- A procedure for categorising the pipes attending to the effect a hypothetical. leakage would have is proposed.
- Maintenance and replacement of pipes can be prioritised from such type of classification.
- Weighting factors can be modified to adapt to the different importance of water losses for each region.

Open problems

- Including different leakage patterns.
- Assigning probabilities for each leakage pattern depending on each pipe's material and including some kind of pipe age factor.
- Extending the weighting coefficient by including more variables like:
  - Pipe material. In many Spanish water supply systems, Asbestos fibre cement pipes are being progressively replaced.
  - Improving the estimation of the water quality deterioration (quantifying and/or including dynamic effects).
  - Difficulty to find the orifice (distances between manholes, ...).

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Contact Information: Antonio Vigueras-Rodríguez   Phone: +34 968 32 7071   Email: avigueras.rodriguez@upct.es