Beyond leakage management:

How to decide where and how many detectors for leaks in DMA

JaoShyan Chen
Taiwan Water Corporation

Outline

1. Introduction
2. Review
3. Approach
4. Application and Discussion
5. Conclusion

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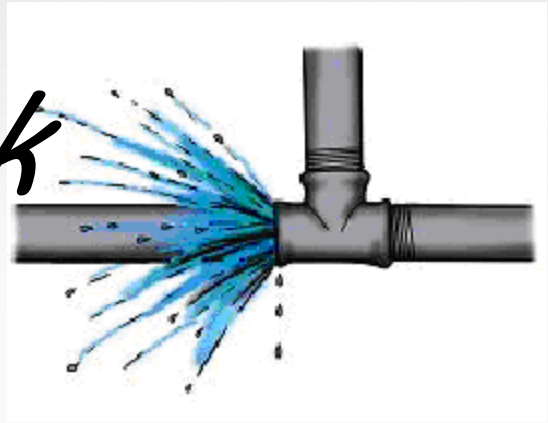
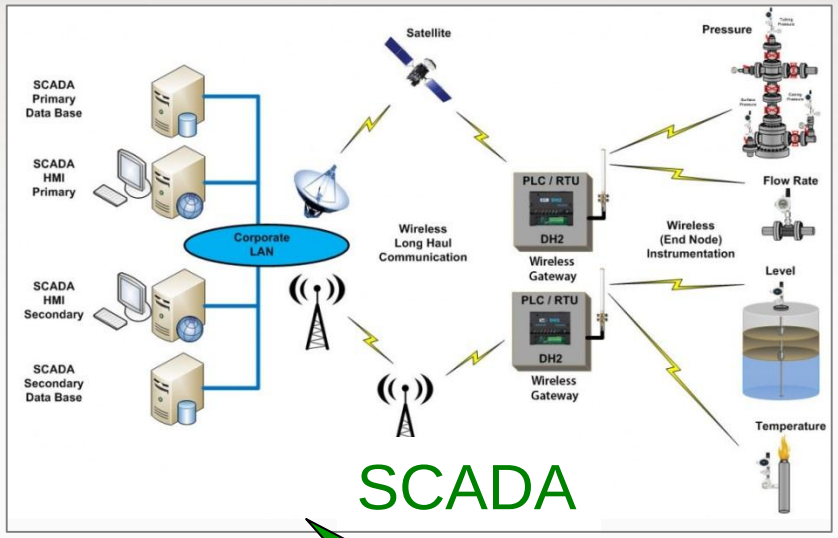
1. Introduction- leak problems

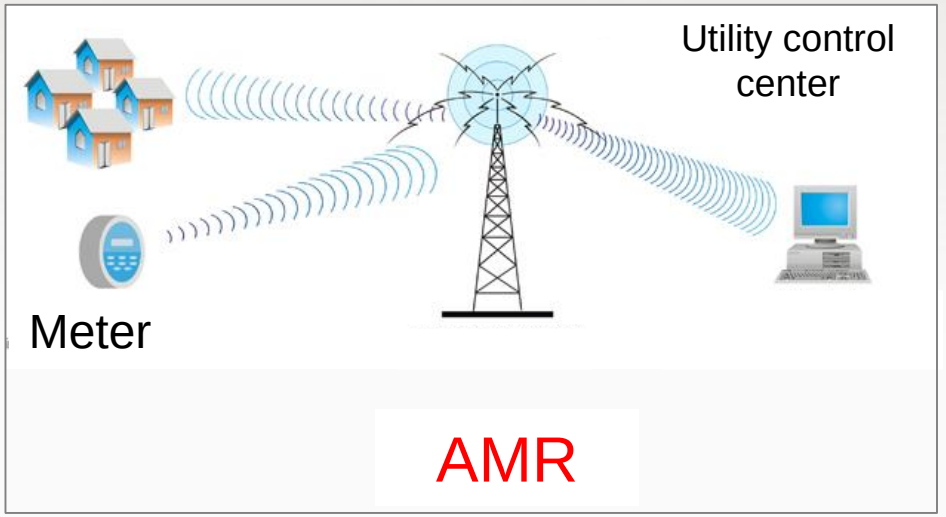


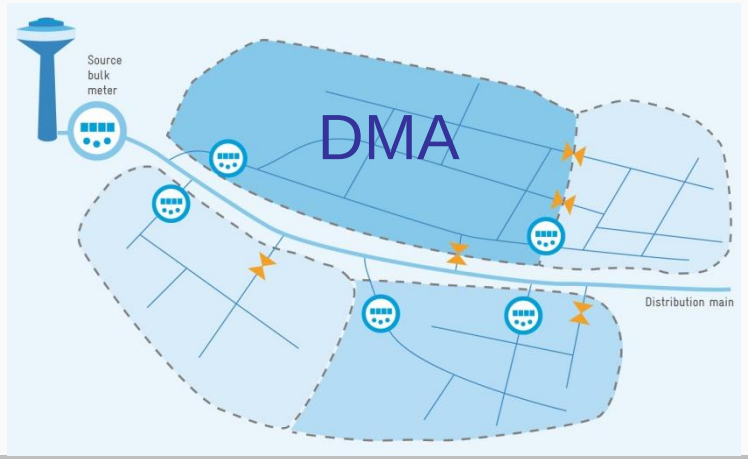
Some figures in Taiwan (2015)

- 25% NRW
- US$720,000 loss per day
- 17% water loss

1. Introduction- leak detection







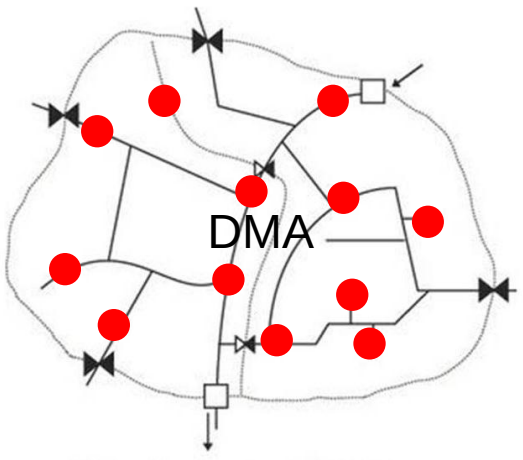
1. Introduction- leak location

Conventional techniques	Suggested techniques
✓ground microphone	✓pressure/ flow monitoring devices
✓ listening stick	✓algorithms/ simulation based on real-life data
✓ground penetrating radar	
✓ leak noise correlation	
✓ noise loggers	

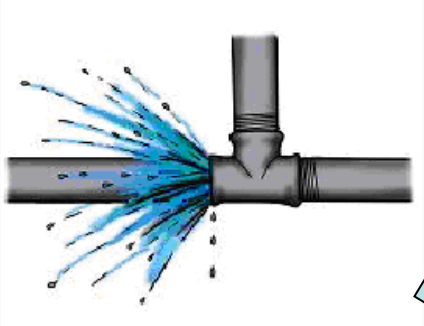
Expensive device +
Professional staff

1. Introduction- objectives

More sensors



Precisely pinpoint leak

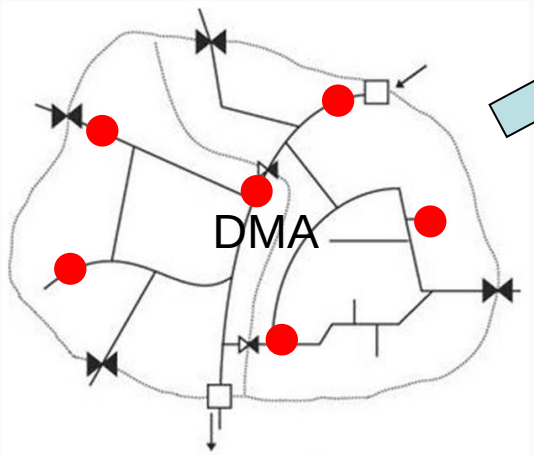


Huge cost

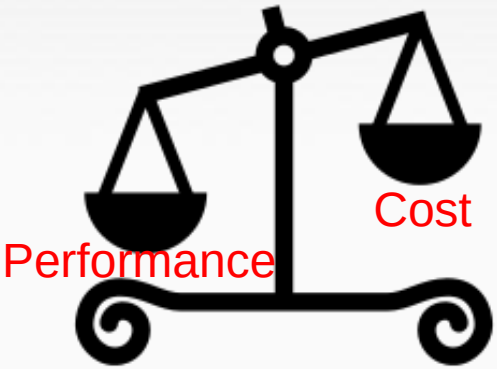
1. Introduction- objectives

Limited budget

A constrained number of sensors



Trade off



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2. Review

Previous Studies

- ✓ Fault sensitivity matrix
- ✓ Algorithm of sensitivity matrix
  - Artificial Intelligence
  - Artificial Neural Network
  - Fuzzy Logic
  - Support Vector Machine

This Study

- ✓ Simple understanding
- ✓ Easy practice

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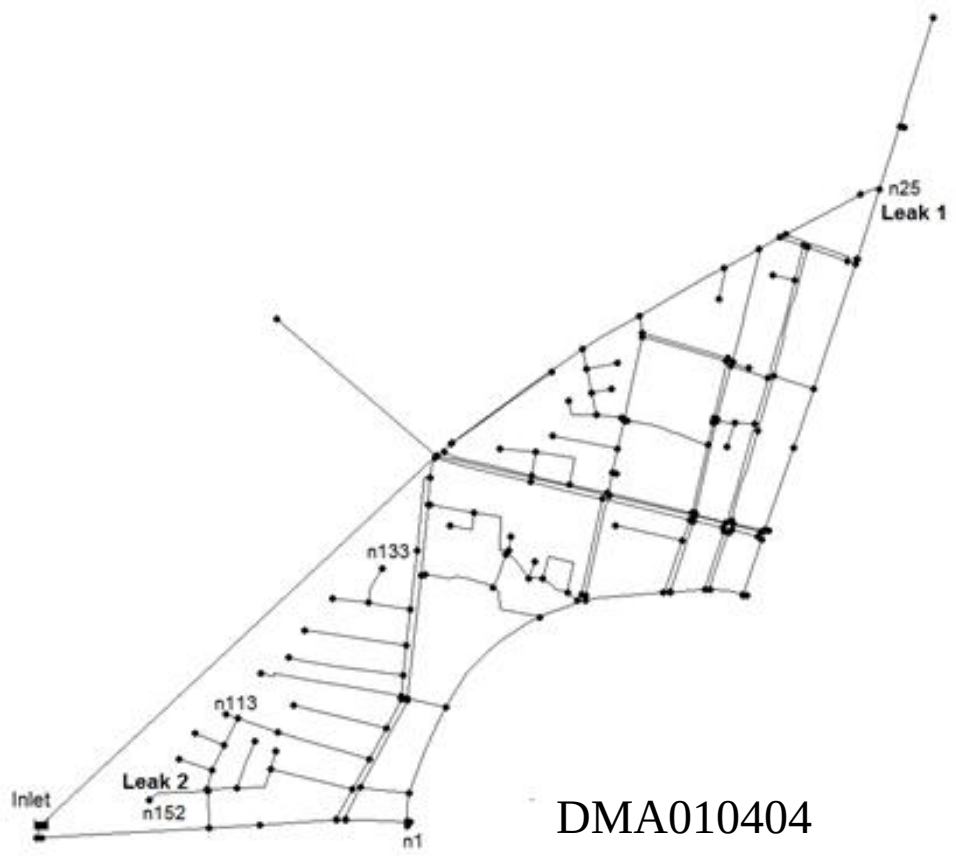
3. Approach

3.1 Case Study Description

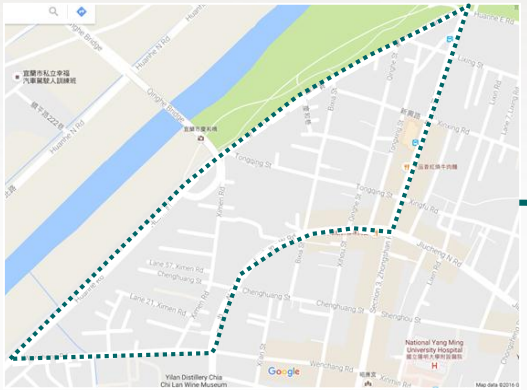


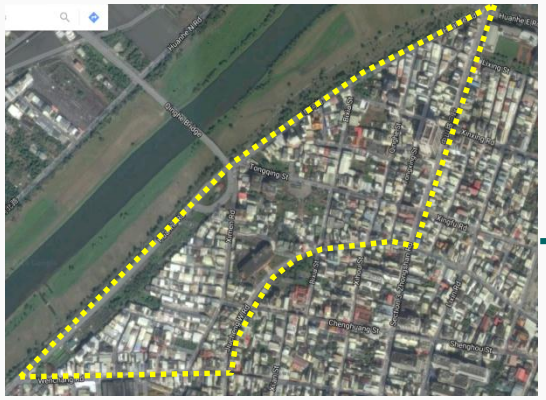
DMA010404

- Area: 6km2
- Network length: 98 km
- Population: 8,800
- Demand: 2,000 CMD
- 171 nodes, 205 pipes
- 1 inlet, 0 outlet

3.2 Model Development and Calibration

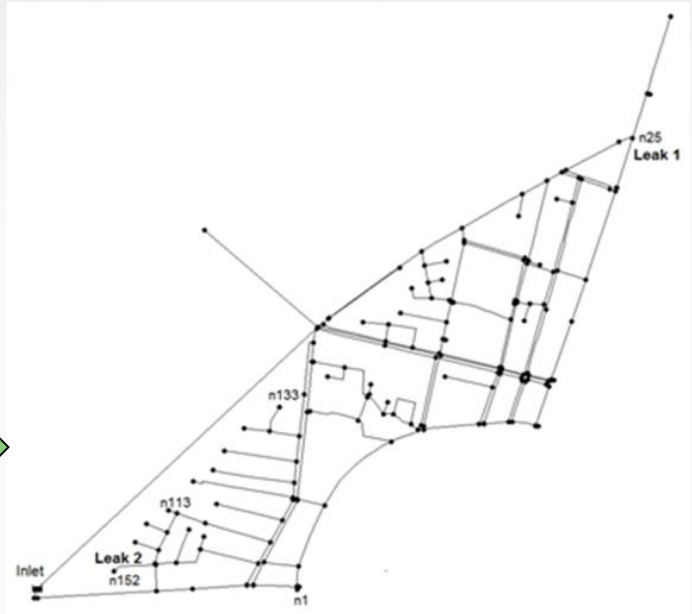
Real World





15 days flow data

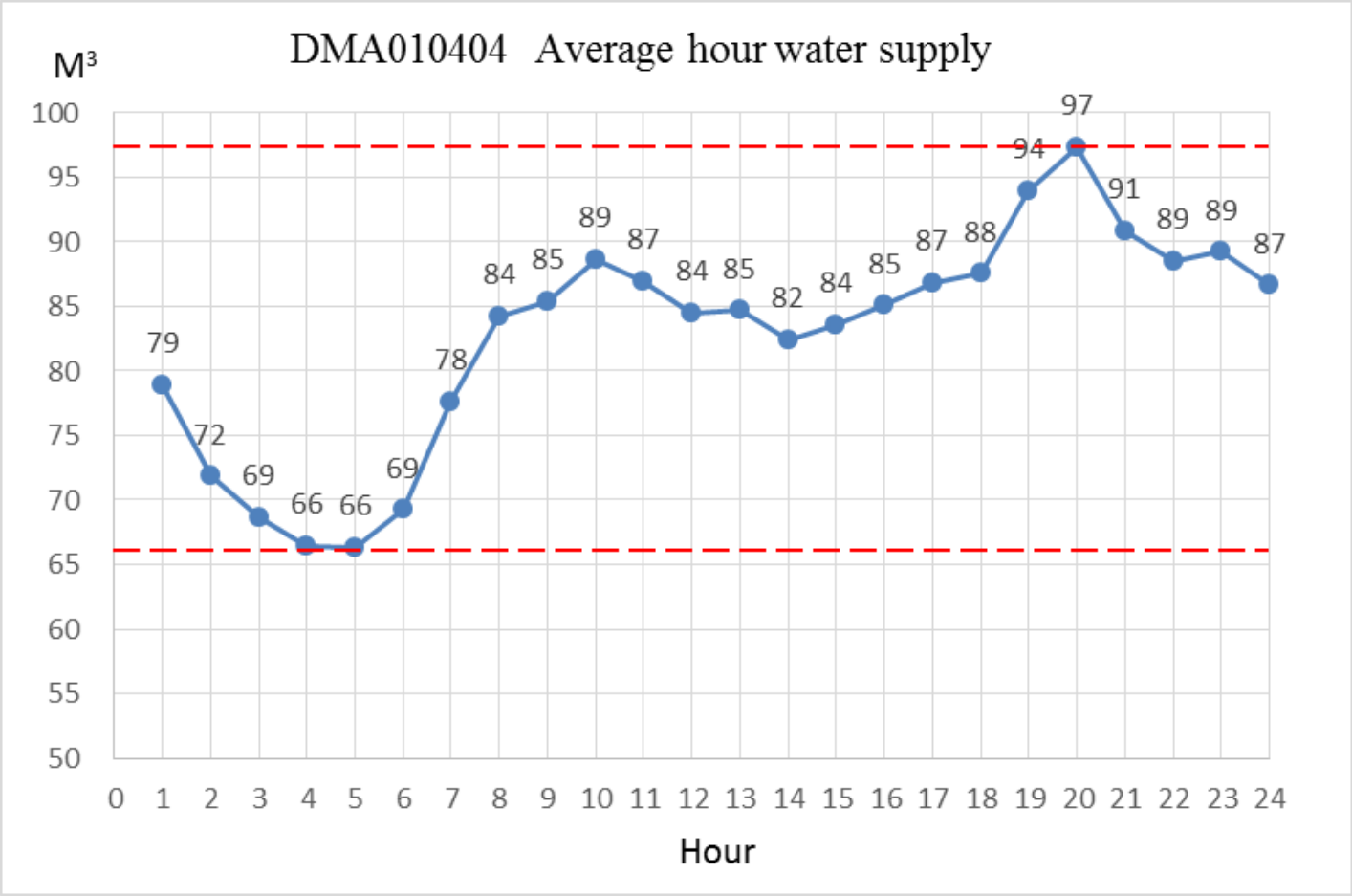
Model development



- ✓ EPANET hydraulic simulation
- ✓ Node demand = Base demand X Demand Coefficients

3.2 Model Development and Calibration

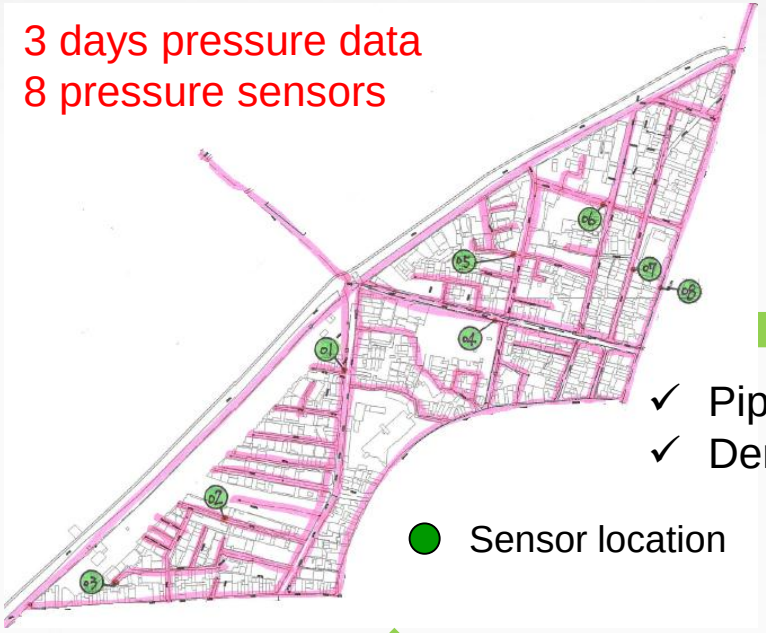
A pattern time step of 24 hours



3.2 Model Development and Calibration

Data collected

3 days pressure data
8 pressure sensors

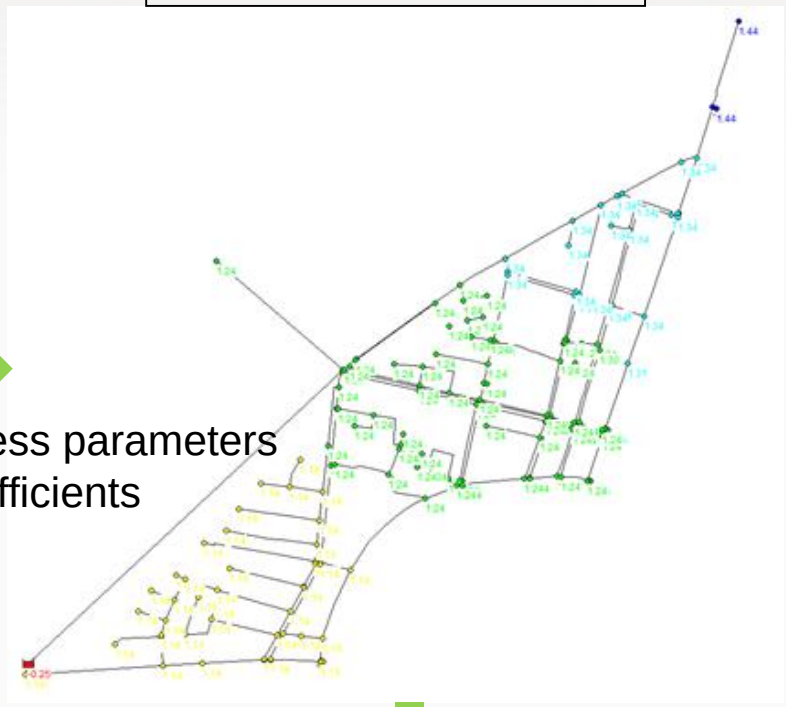


Sensor location

Modify

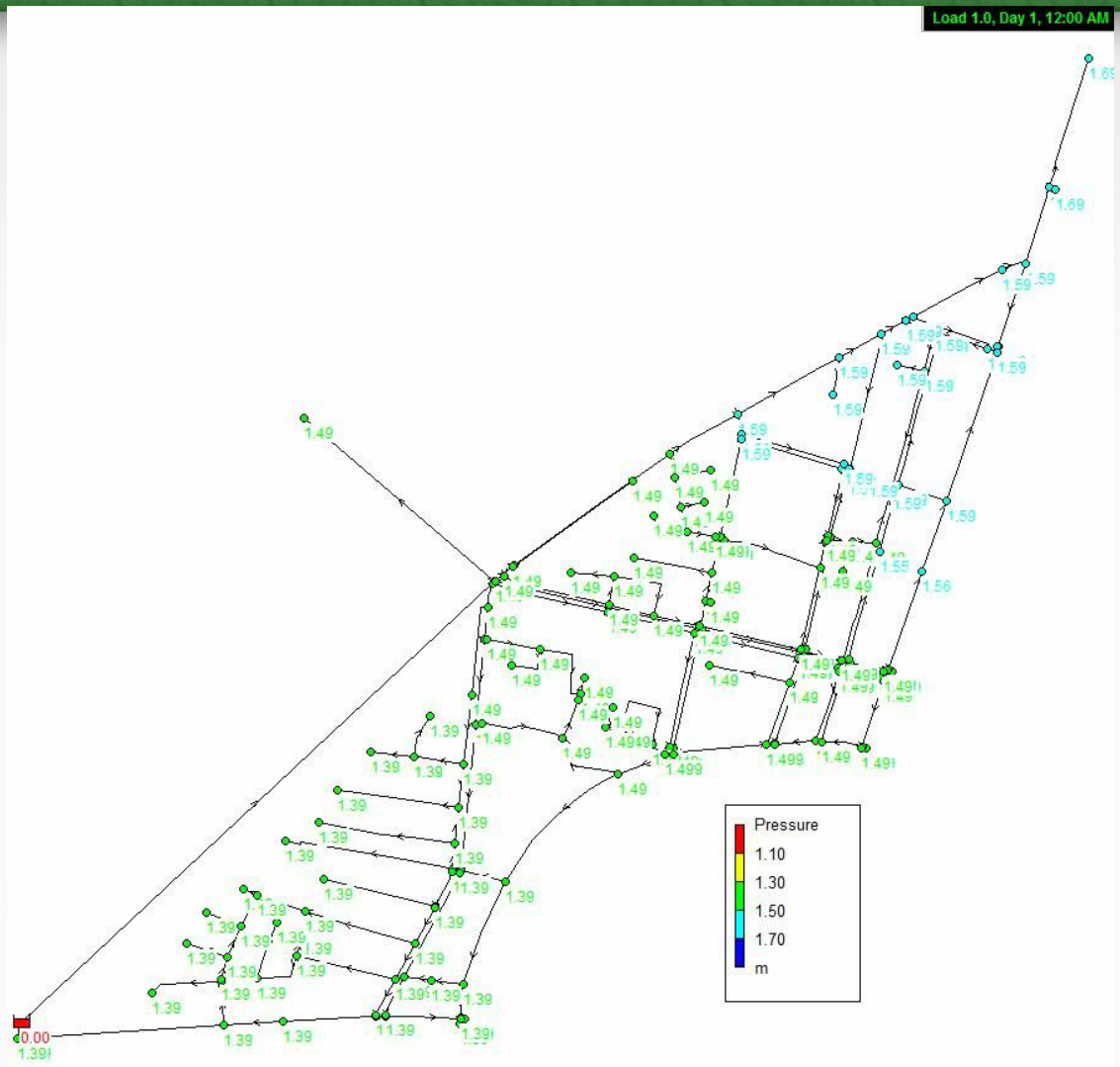
- ✓ Pipe roughness parameters
- ✓ Demand coefficients

Model calibration



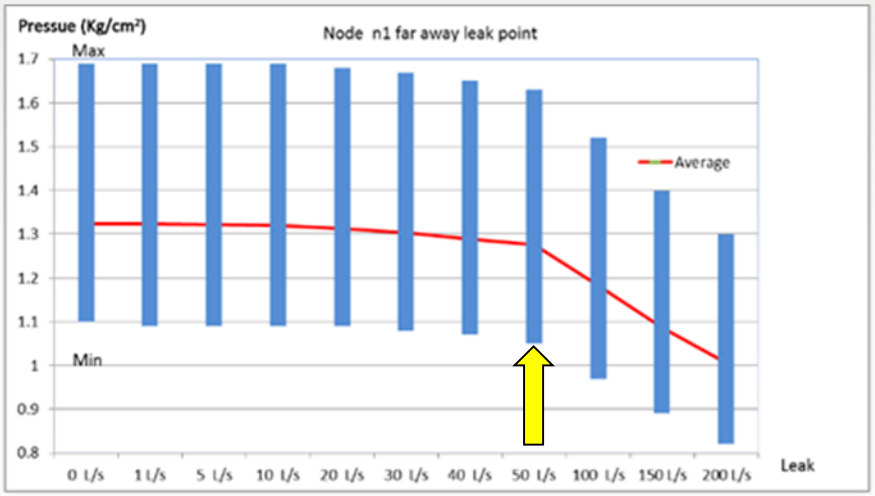
Field pattern ≅ Model simulation

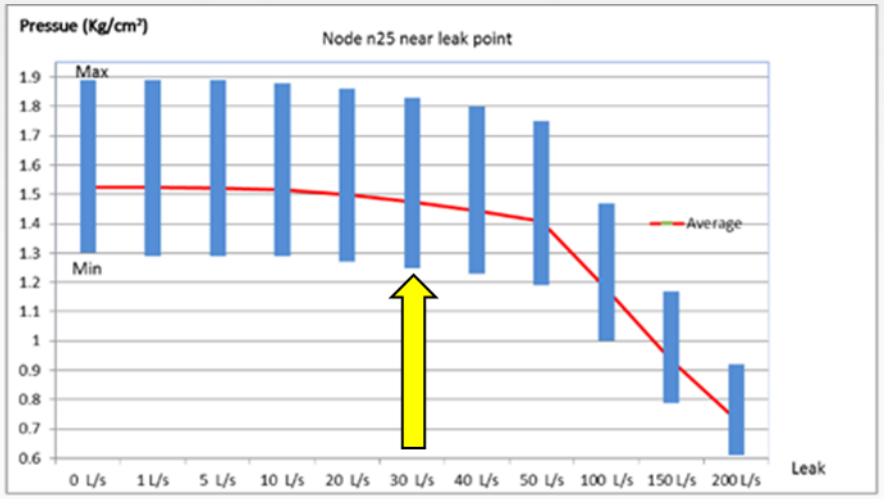
3.2 Model Development and Calibration



3.3 Factors Affecting Pressure Drops

1st Case: Pipe Diameter and Leak Quantity

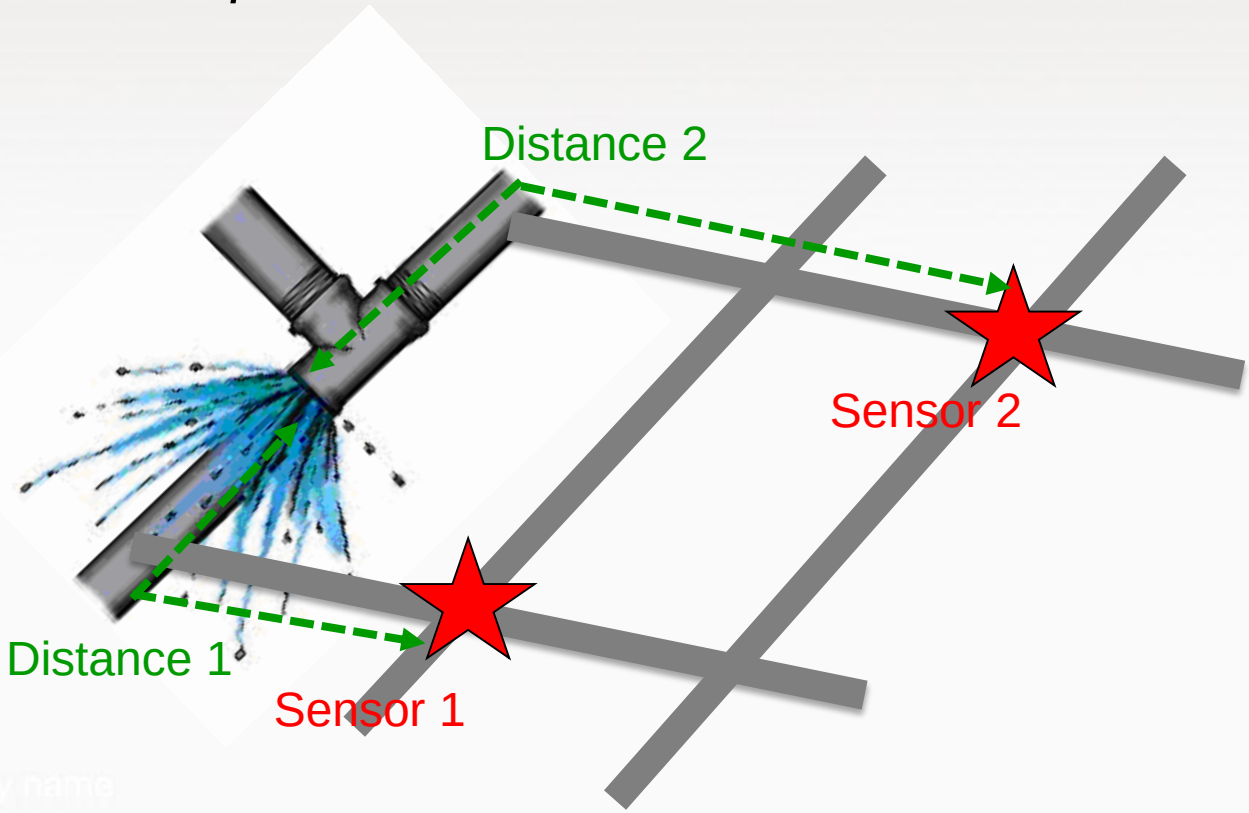




- The leak pipe diameter is 200mm at the far side of DMA inlet.
- The leak quantity is 0 to 200 L/s.
- The observable pressure drop was set not less than 0.05 kg/cm^2 for this study.

3.3 Factors Affecting Pressure Drops

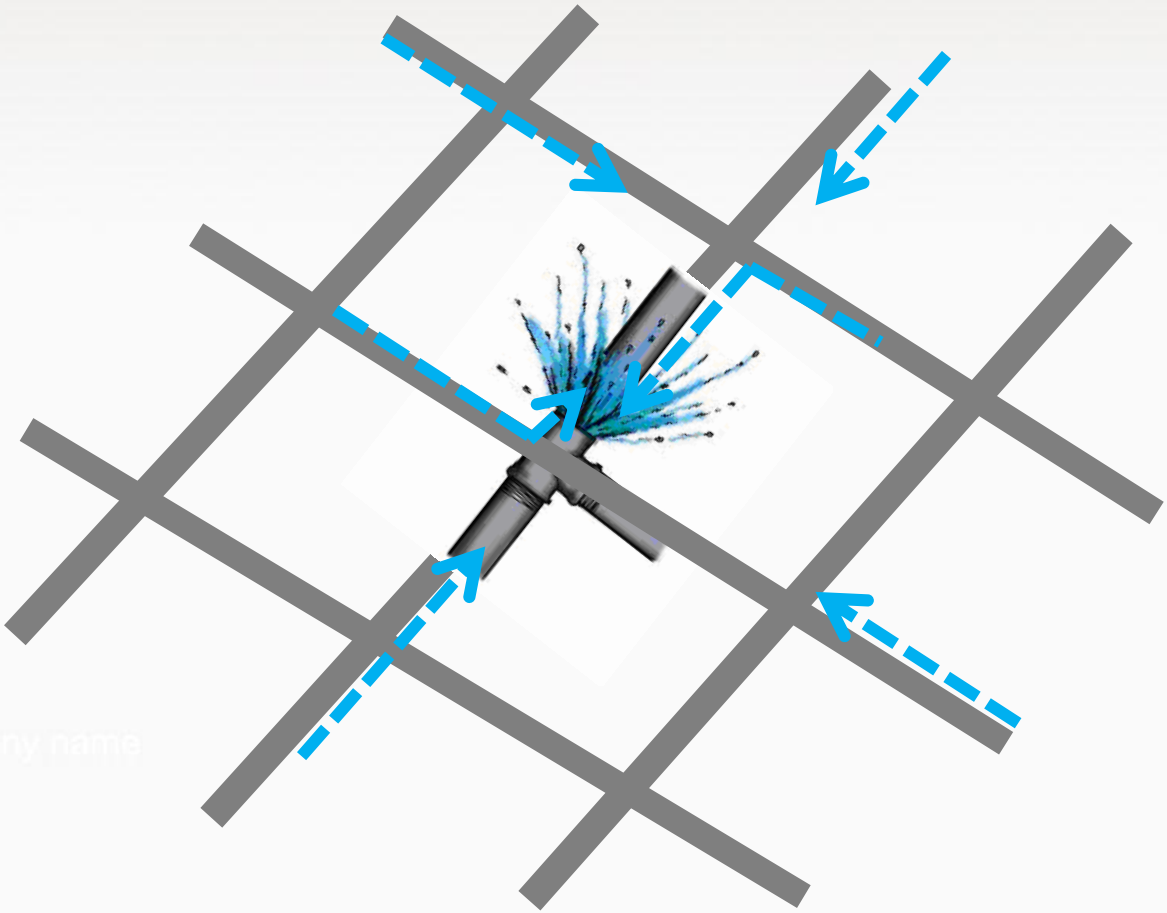
Result of 1st Case: The closer is the better.



∵ *Distance 1 < Distance 2*, ∴ *Sensor 1 is better than Sensor 2*

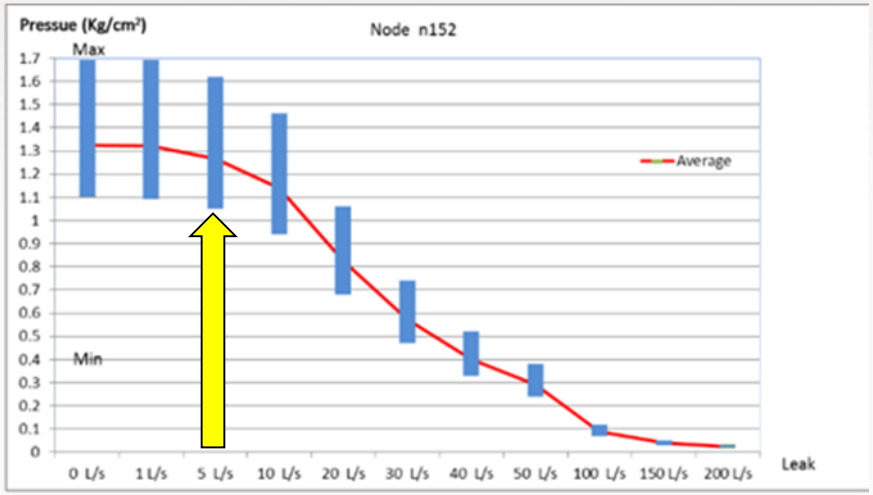
3.3 Factors Affecting Pressure Drops

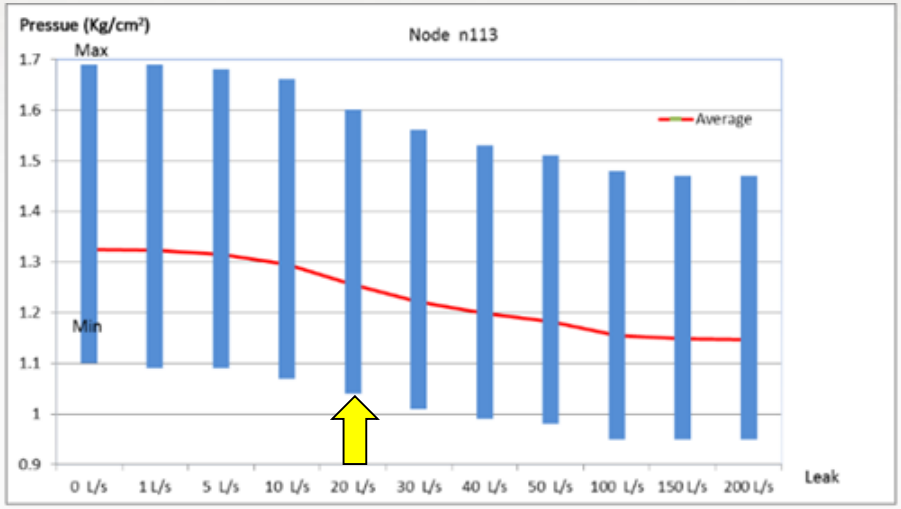
Result of 1st Case: A problem in a highly looped network.



3.3 Factors Affecting Pressure Drops

2nd Case: the Distance to Sensor and Dwelling Cluster (1/2)

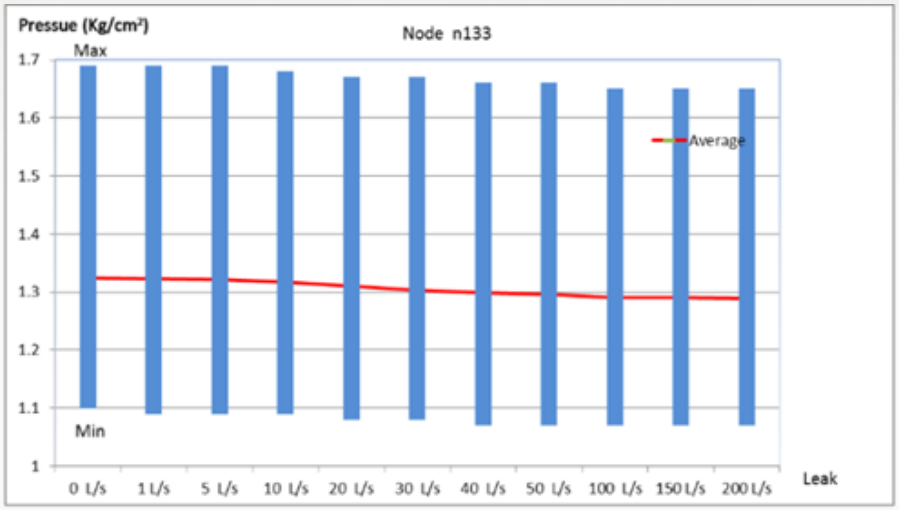


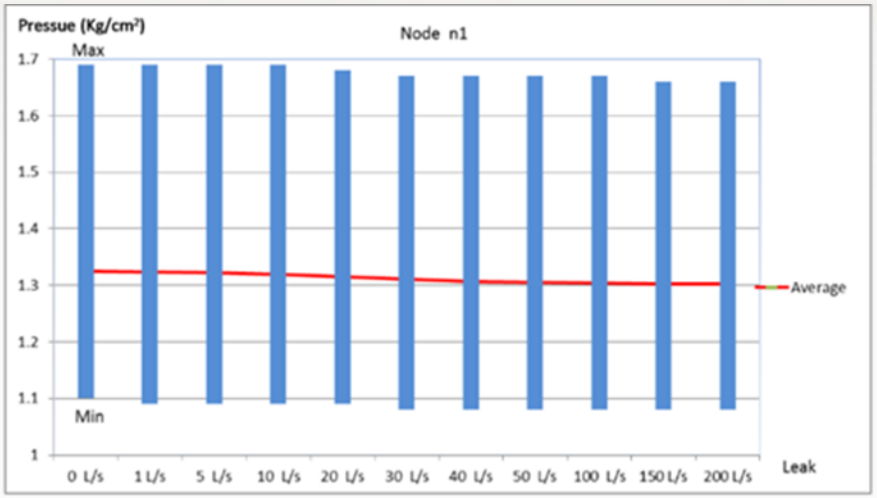


* The leak pipe diameter is 100mm at the near side of DMA.

3.3 Factors Affecting Pressure Drops

2nd Case: Distance to Sensor and Dwelling Cluster (2/2)

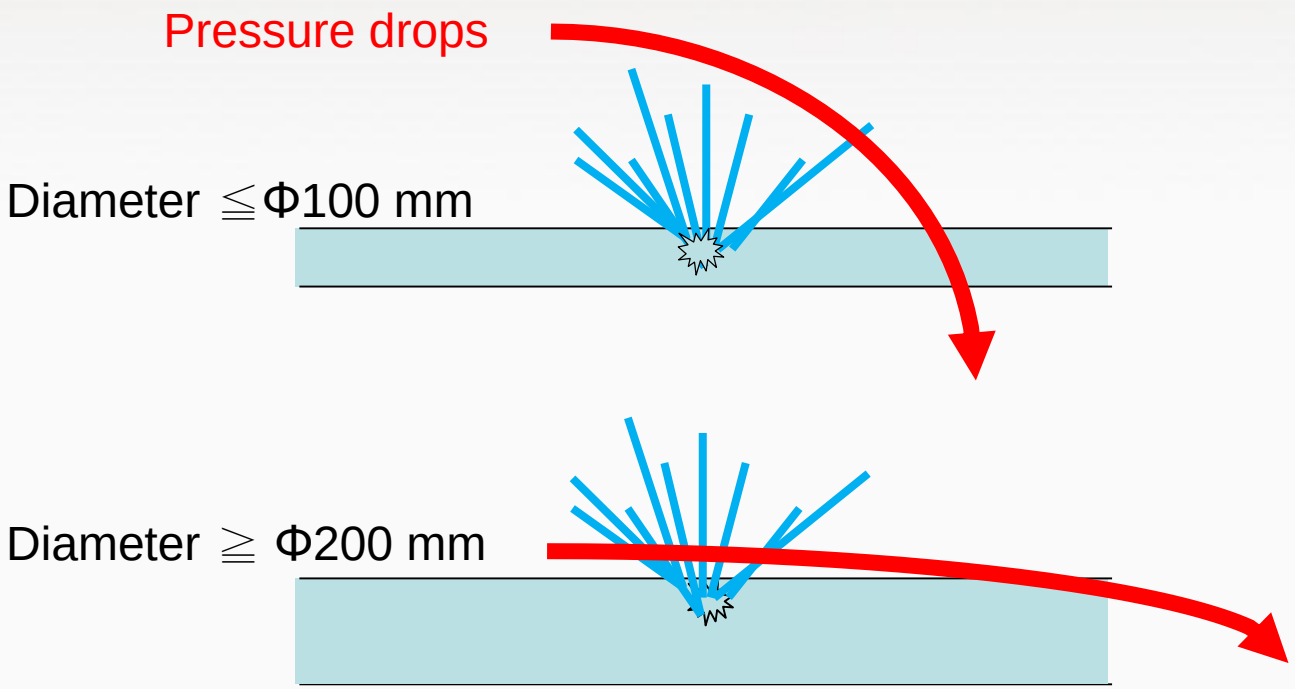




* The leak pipe diameter is 100mm.

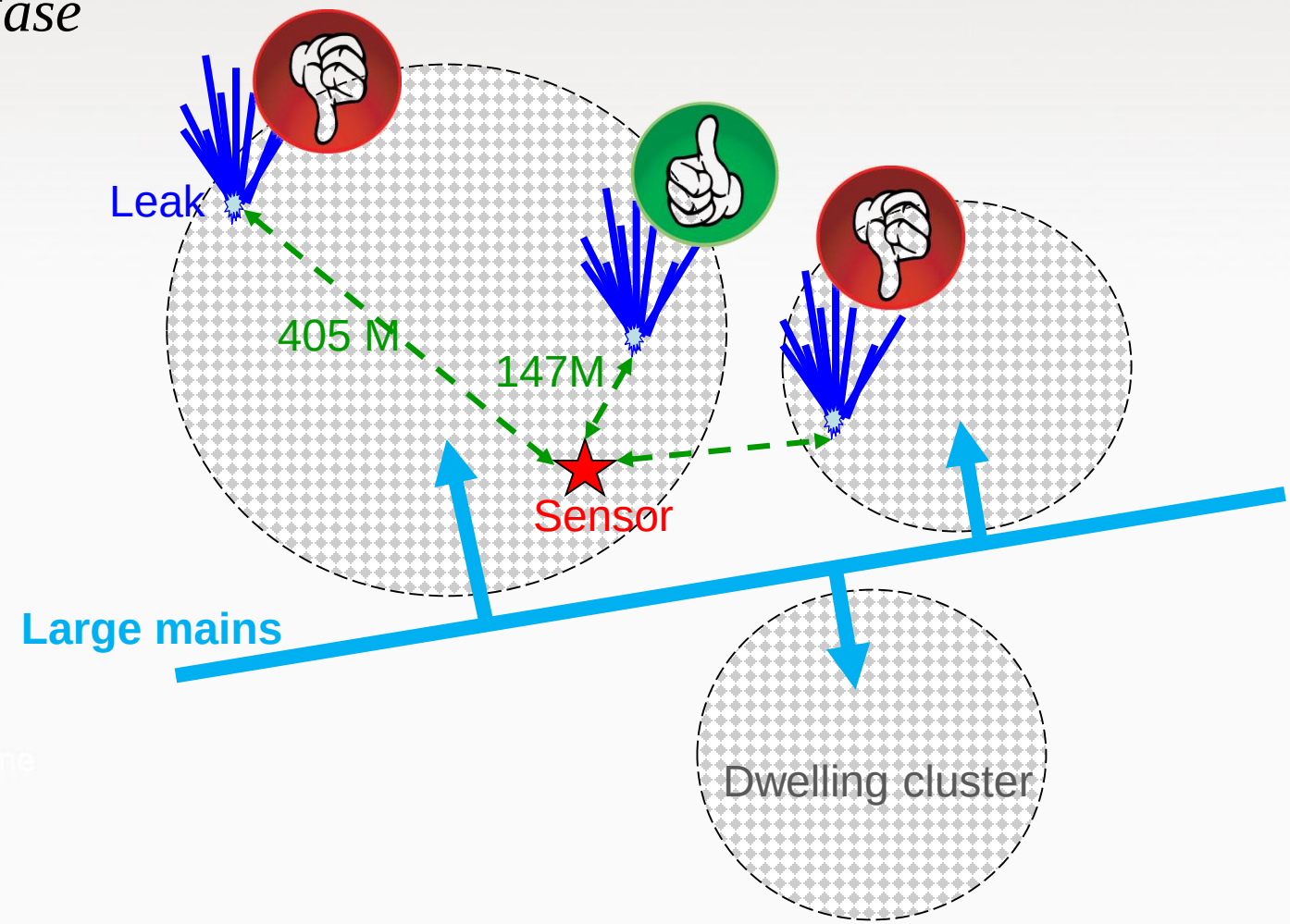
3.3 Factors Affecting Pressure Drops

Result of 2nd Case



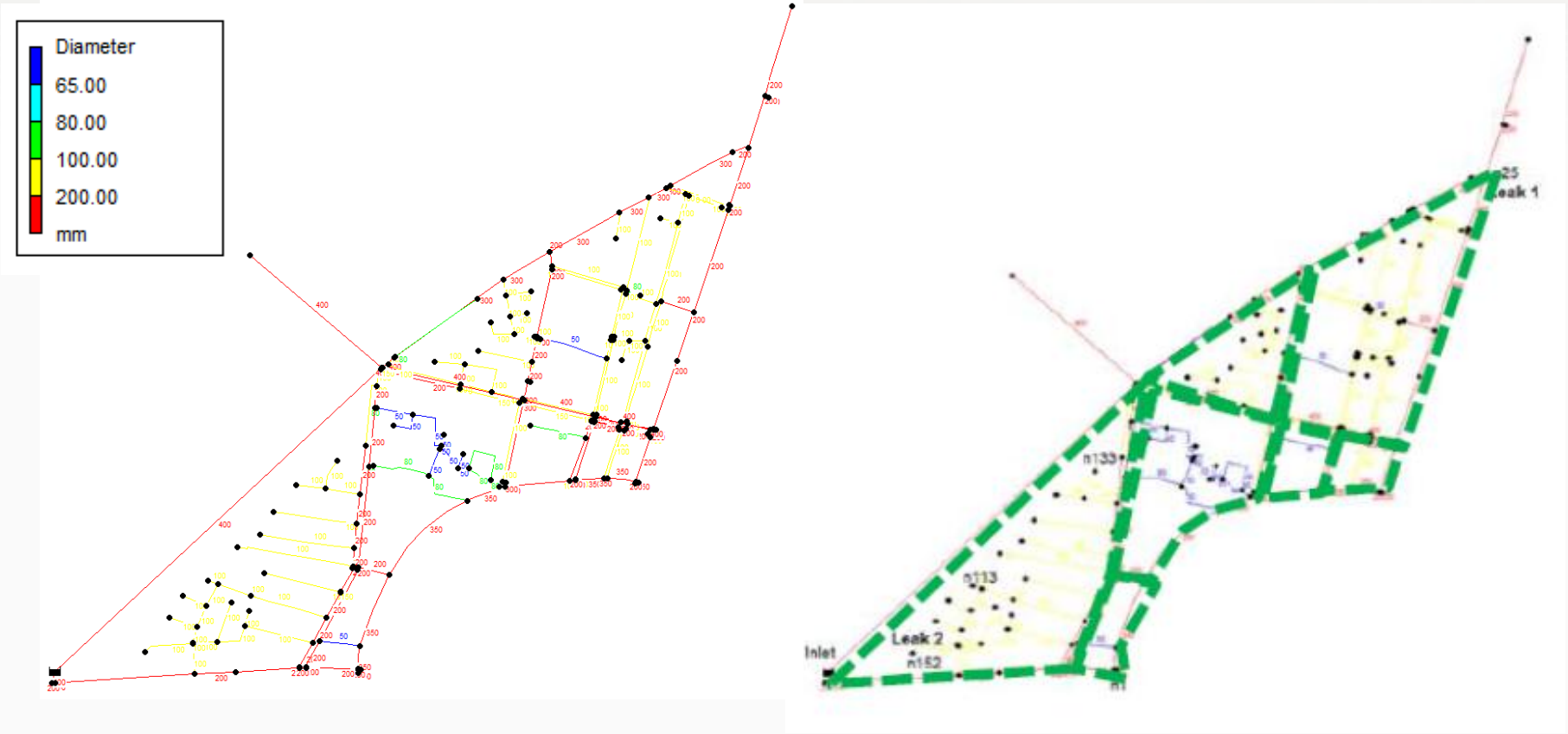
3.3 Factors Affecting Pressure Drops

Result of 2nd Case



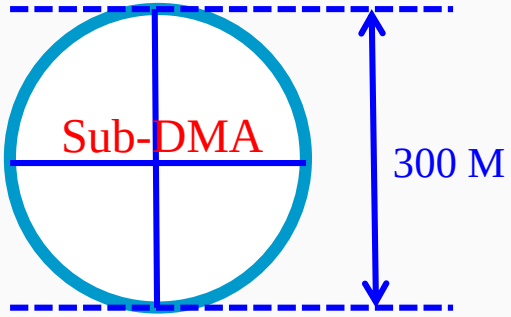
3.4 DMA Separation for Sensor Placement

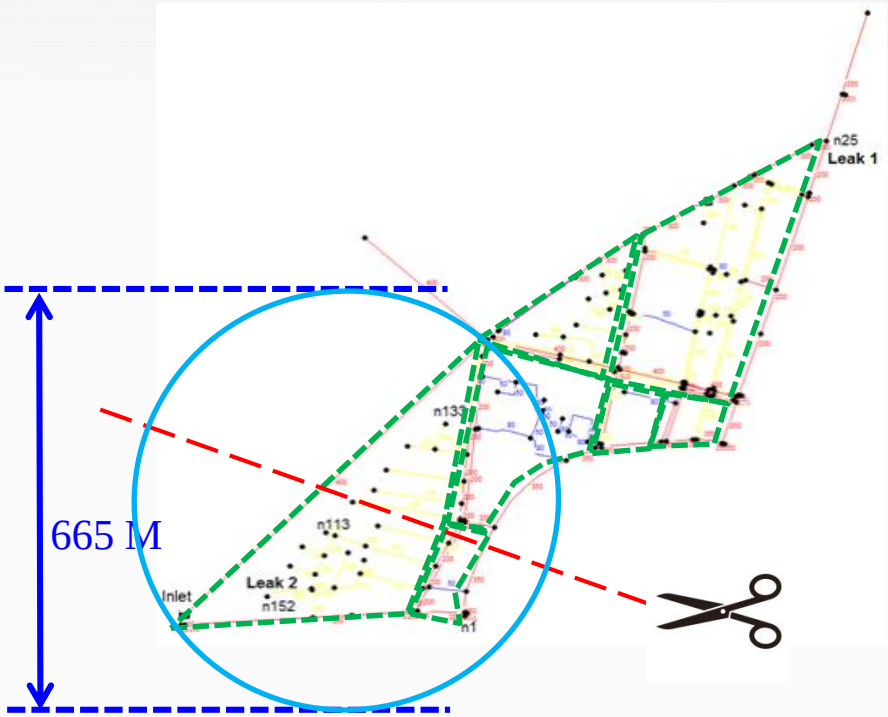
1. A sub-DMA use more than or equal to 200 mm pipe diameter as boundary.



3.4 DMA Separation for Sensor Placement

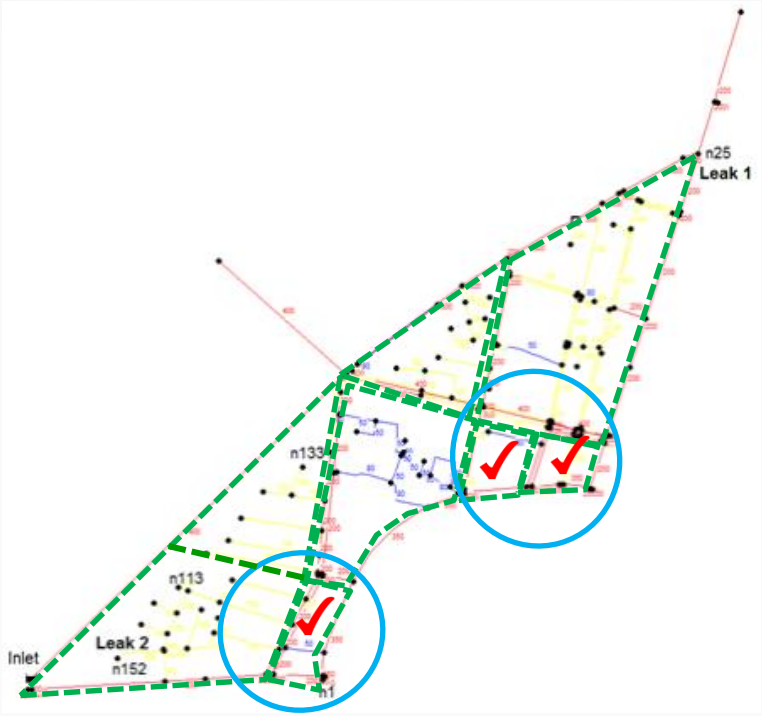
2. If the length or width of a sub-DMA is more than 300 meters , it requires dividing into two or more sub-DMAs .





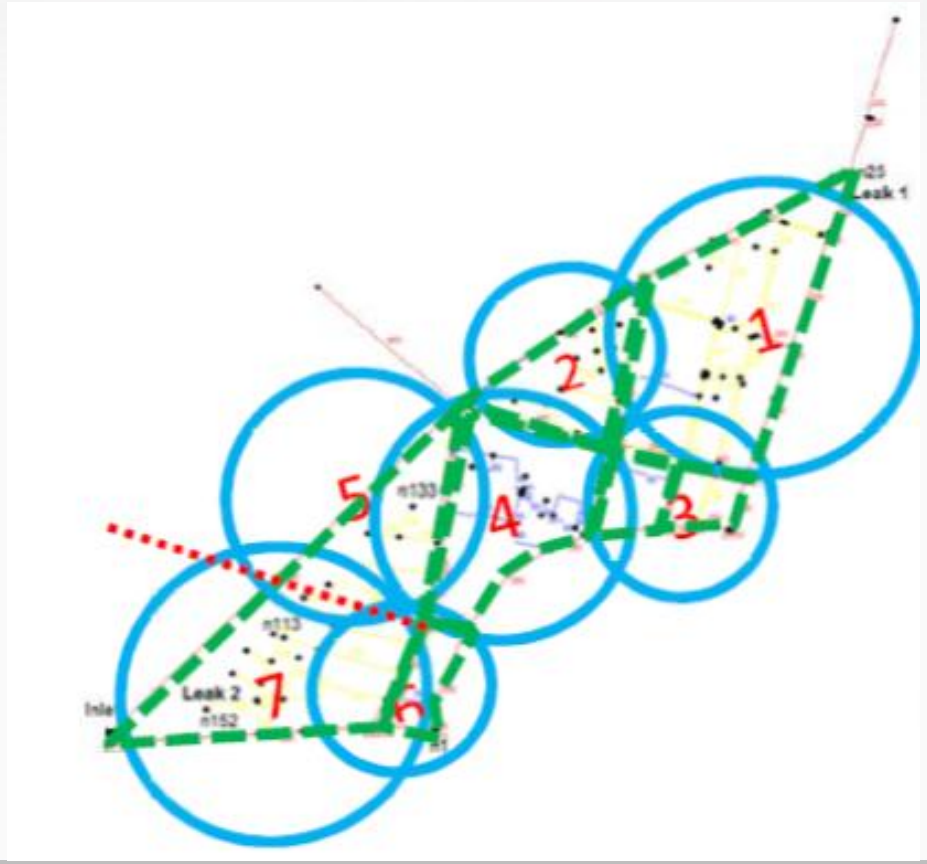
3.4 DMA Separation for Sensor Placement

3. If the result of above process forms some apparent quite little sub-DMA, they may merge into adjacent sub-DMA or become a single sub-DMA for each one.



3.4 DMA Separation for Sensor Placement

4. Each sub-DMA requires installing at least one sensor to detect pressure drops.

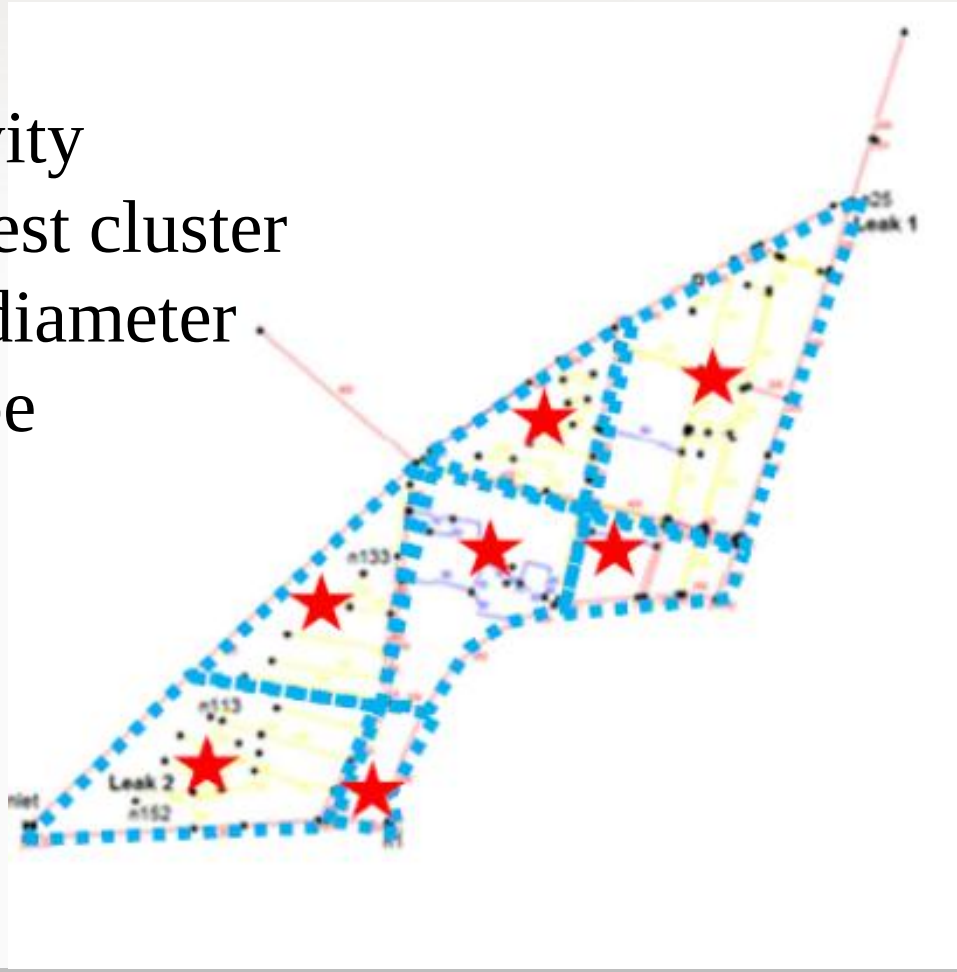


7 sub_DMA

At least 7 Sensors

3.4 DMA Separation for Sensor Placement

5. The location of a sensor in a sub-DMA is suggested at the following places:
   - the center of gravity
   - the center of largest cluster
   - the smaller pipe diameter
   - the end of the pipe



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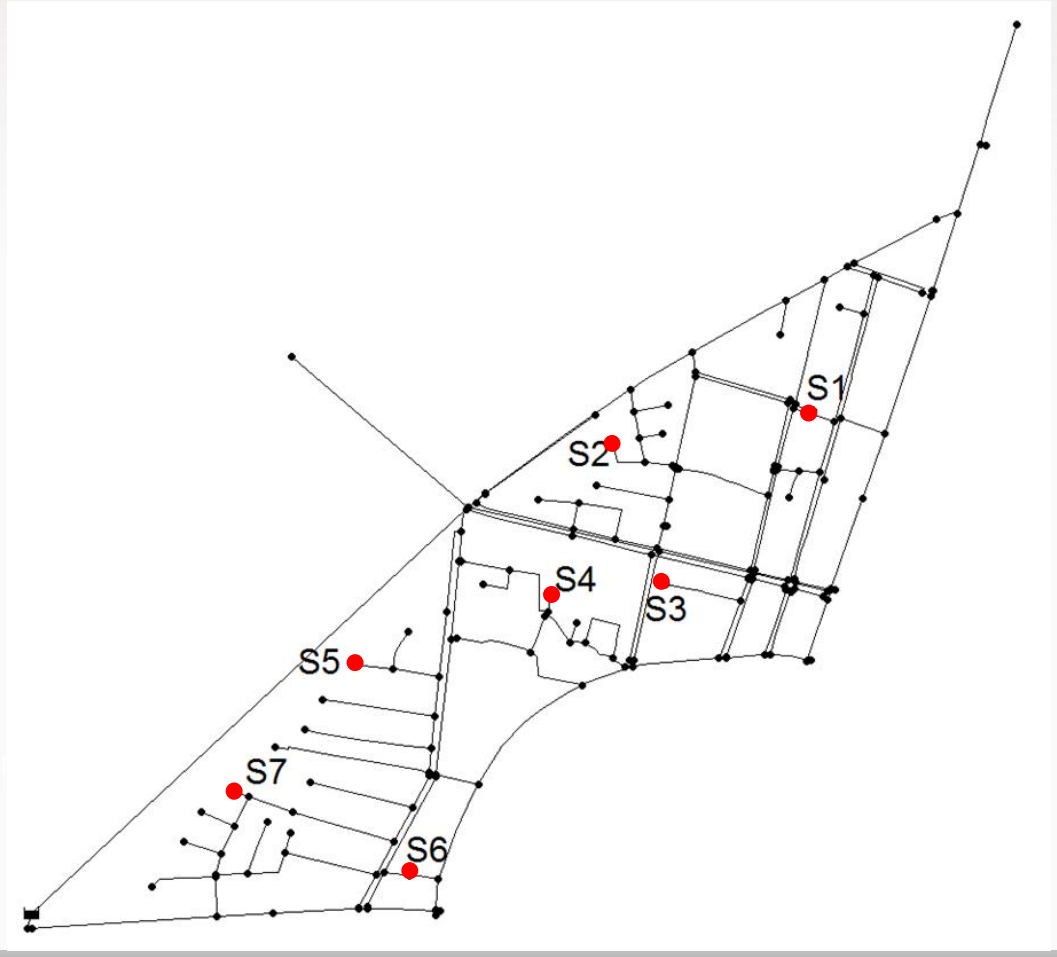
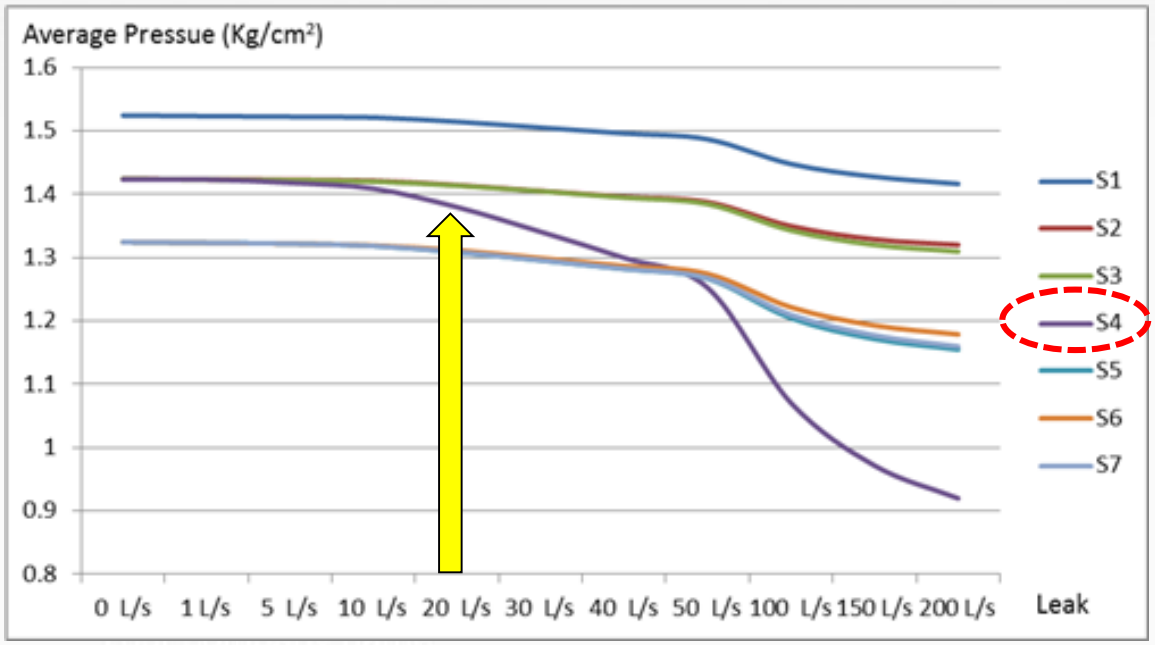
4. Application and Discussion

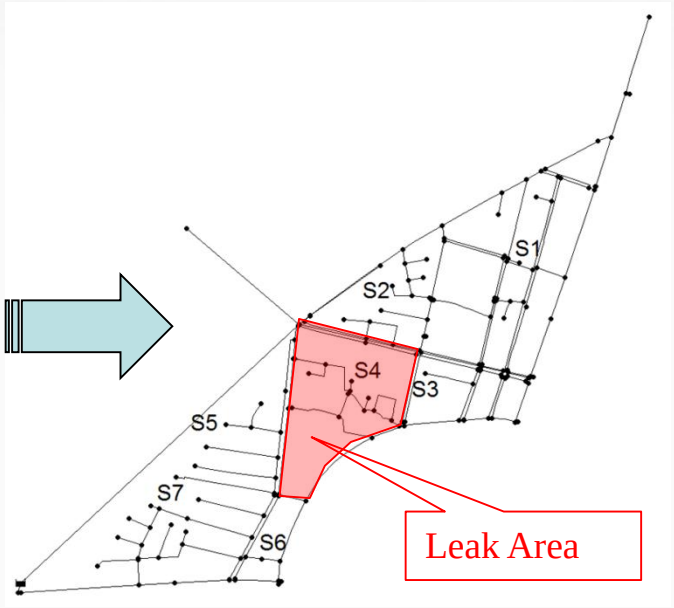
Application DMA with 7 sensors (S1~S7)



4. Application and Discussion

Application result





4. Application and Discussion

Discussion

1. Trade off between leak area and sensors
2. Factor of elevation and high demand variation
3. More cases for a robust outcome
4. Quantitative approach for the sensor location in a sub_DMA
5. Question of highly looped network

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5. Conclusion

- ✓ DMA segmentation methodology
- ✓ Min. $Q_{sensor} = Q_{DMA\ segmentation}$
- ✓ Sensor location :

$$\{dwelling\ distribution, pipe\ diameter\}$$

Thank you !

Any questions or comments?

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Jaoshyan Chen

Title: Beyond leakage management: How to decide where and how many detectors for leaks in DMA

Abstract : Drinking water leakage not only waste valuable water resource but also increase cost of utilities. Searching leak location in water distribution network is labor intensity work conventionally. Even with state-of-the-art technologies (such as leak noise correlation, noise loggers), it requires expensive equipment and professional staff. Although the establishment of district meter area (DMA) has assisted utilities decreasing the leak searching time and range, confirmation of leak location is still not a straightforward task.The use of data from supervisory control and data acquisition (SCADA) and water distribution network mathematical models can contribute to above scenario. According to the flow data comparing to the historical information in DMA, the leakage level could be defined. In order for the leaks to be located, the mathematical models require an approach capable of installing minimum amount of pressure sensors on best places and minimizing the discrepancy between measurements from sensor and estimations. The methodology presented in this paper aims to identify the

optimum places and numbers of pressure sensor to install in DMA in order to enhance the leak location efficiency. The mathematical model for leak detection was applied to practical DMA and the results obtained with the optimum installation and minimum amount of sensors are presented and discussed.

Profile: Jaoshyan Chen is a senior engineering at the Eighth Branch, Taiwan Water Corporation where he heads the Water Loss Management Center. The task which he has been challenged in the distribution system is water loss. He attempts to apply novel technologies in order to achieve a higher level of efficiency. He has been an integrated geographic information system (GIS) application with water distribution networks for more than 10 years. In addition to his current work, he previously served as water supply planning engineering. He is a member of Chinese Taiwan Water Works Association (CTWWA) and American Water Works Association (AWWA). He has an M.S. in civil engineering from National Taiwan University and a Ph.D. with a focus on transport simulation and data analysis from Southampton University, UK.

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