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Application of neural networks to manage leakage in water distribution networks

D. Rogers (1), M. Gastaldi (2), A. Figliolini (3)

(1) Managing Director, DEWI S.r.l., Perugia, Italy email: dewiltd@tin.it

(2) Professor, University, L'Aquila, Italy email: gastaldi@ing.univaq.it

(3) Managing Director, INGEA S.r.l., Avezzano, Italy email: a.figliolini@ingeasrl.com

The social and environmental impact of a high leakage level in a world facing acute water shortages is very apparent. But almost as important for the operators and customers alike is the economic consequence of pumping and treating water which is then lost even before it arrives at the customer connection.

It doesn't always follow though that it is always economically viable to achieve and maintain a very low leakage level in every network. In extreme cases, where there is a plentiful supply of pure water supplied by gravity, it might be more economical to leave a leak, than to intervene. Conversely, when water is scarce and expensive to produce, it could be beneficial to locate and eliminate even the tiniest drop of leaking water.

International experience has clearly shown that the most effective way to reduce and maintain a low leakage level in a water network is to divide it into permanent sectors called DMAs. Ideally they are supplied by a single pipe on which is installed a flow meter. In this way, by analysing the minimum night flow, it is possible to not only quantify with accuracy the leakage level, but immediately identify the presence of new leaks.

Application of this methodology in many parts of the word has yielded significant reductions in the leakage level. What has been less impressive is the long-term management of these systems, which has often resulted in the leakage level returning to its original level. There are many reasons for this, not least the lack of priority given to monitoring the system when it doesn't cause any operational problems.

The solution is an automatic decisional support system which will allow the optimum leakage level to be maintained irrespective of the individual characteristic of the network. This paper outlines an innovative system which has been developed with the collaboration of the University of L'Aquila in Italy.

The key aspects of the system are as follows:

- automatic quantification of the leakage level by subtracting the estimated night use from the daily night flow transmitted by the data logger;
- estimation of the cost of intervention;
- quantification of the total value of the water to be recovered;
- cost / benefit analysis.

Of particular note is the following:

- estimation of the night consumption based on typical demand profiles derived from the monitoring of well over 1000 customers;
- application of a cost / recovery curve derived from a large number of leakage control projects;
- typical return frequency profile based on the evaluation of the performance of DMA's in many parts of the world and in many different types of networks.

Although such a system represents a major advance on manual control and decisional system, it still contains the same fundamental flaw of other DSS systems, namely that it bases it's decision on typical or statistical values or trends which are unlikely ever to be appropriate to individual DMAs. The DSS presented in this paper is different in that it also incorporates a neural network which continuously tracks and compares the reality with the prediction. The learning capability of this type of algorithm is ideal for this application in that it allows the system to modify the initial prediction based on the reality, thus enabling it to simulate more realistically the network that it monitors. So, although the initial decision will always be based on the statistical analysis, once the system becomes operational and acquires live data, it will very quickly adapt and improve its prediction based on local conditions.

By combining the latest optimising techniques with a solid practical bases, the DDS presented in this paper enables the goal of managing leakage economically to be achieved.