Repair or Replace Dilemma for Services and Mains

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The IWA Water Loss Task Force has been promoting the approach for leakage which combines four strategies to reduce leakage, namely, active leak detection, pressure management, speed and quality of repairs and targeted renewal of infrastructure. These have to be balanced to achieve the most cost effective leakage programme which reduces leakage to an economically and environmentally and socially acceptable level (Figure 1)

![Diagram showing the four strategies for leakage reduction](image)

Figure 1 Water Loss Control Strategies

A substantial amount of work has been carried out by the Water Loss Task Force to develop methodologies and case studies for active leakage control, pressure control and repair management. However, attention has only recently turned to the remaining method of controlling leakage – that of managing the infrastructure and in particular replacing the pipes at the end of their useful life.

The fact that this issue has only recently been considered is not surprising when considered alongside other leakage activities, where the cost of saving water through such activities as pressure reduction or active leakage control will be a fraction of the cost of saving water through mains renewal. However, mains do not last for ever and correctly identifying the investment needed and targeting the mains to be renewed can ensure that water undertakings get the maximum benefit for their investment. In addition, leakage activities can be incorporated into a comprehensive asset management plan for the distribution system.

Management of water distribution assets

A distribution system could be considered to consist of a large number of similar assets such as pipes, valves and other fittings with leakage detection and repair the reactive maintenance programme. However, a number of points need to be considered, so it may not be quite so simple.
First of all, what is the asset life? There are many factors which affect pipe failure including soil conditions, surface loading and weather. This is further complicated when one considers the question ‘what is the end of the asset life?’ A pipe may still continue to convey water even when it suffers from a large number of leaks or repeated bursts. Leaks are used here to indicate escapes of water which do not severely affect performance of the pipe, whilst a burst is used to indicate a failure which is so severe that the pipe cannot continue to convey water.

One approach might be to consider the cost of repairs over a period of time against the cost of replacement. However, what period of time should be chosen? Even where quite long periods have been chosen it can be difficult to justify the substantial costs of mains replacement on cost alone as a policy of reactive repair will continue to be more effective until very high mains leakage and burst rates are experienced. These rates may be substantially higher that those which are acceptable to customers or politicians.

An additional complication is the question of what costs should be included. In a number of countries there has been more focus recently on the so called ‘social’ or ‘indirect’ costs of repairs – such as the cost of traffic delays, additional pollution, degradation of the road surface etc. These may well be considerably higher than the direct costs as detailed in the UKWIR report ‘The Real Cost of Streetworks to the Utility Industry and Society’.

Without some sort of regular replacement programme it is possible that the situation experienced by some UK water companies could be repeated. In these companies the extensive network of ferrous mains laid in the nineteenth century has now deteriorated to such an extent that, even with an extensive leakage control programme, maintaining acceptable levels of leakage is extremely difficult. There is some evidence that ferrous mains have relatively low failure rates until a critical point when leakage and/or bursts start to increase at a rapid rate as shown in figure 2. In the later stages of the pipe’s life there may also be the problem that the pipe has deteriorated so far, typically by corrosion, that when a pipe suffers the disturbance required to repair the pipe – isolation, draining down and recharging, this in itself can initiate more leaks than previously existed.

Figure 2

![Failure profile of ductile mains](image)

The trick would appear to be to identify the critical point at which the failure rate is just starting to increase rapidly. However, this may not be so easy. Additional variables which are not continuous such weather and operational problems may make it difficult to identify the underlying rate of deterioration.

An alternative approach is to consider the whole pipe stock and maintain the current level of failure, or reduce it if this can be justified on a cost and/or social basis. Ideally the rate of capital investment should be such that the total cost of capital and operational expenditure are minimised. As capital investment rates (capex) fall operational expenditure (opex) rises. (Figure
3) Asset management information should allow an undertaking to identify the minimum whole life cost.

![Whole life cost](image)

**Figure 3**

However, to put together meaningful cost models there are a number of issues which need to be answered such as:

- What are natural rates of rise of leakage before and after services and mains renewal?
- What will future failure rates be with or without renewal?
- What are the comparative leakage performances of different pipe materials?
- Should service pipes be renewed at the same time as mains?

A specialist group within the water loss task force will look at some of these issues and try to give guidance on how to carry out cost benefit studies for services and mains renewal, including information on what leakage data should be collected for costing purposes, as well as guidance on materials selection and construction quality control to minimise future leakage.

**Starting from scratch**

Not all organisations have a robust asset information system. However, much of the information they will need can be collected and may already be available through, for instance, their leakage or repairs system.

Good records of the mains system in the ground is the first step. The availability of this information may be dependent on earlier operational policies. If there are gaps in the information it is essential to mobilise all employees and contractors working on the system to collect information at every opportunity. Other utilities may also be able to help. Whenever a water man is exposed there is an opportunity to check the material, age, soil surround and exact location. This will help improve the data base.

When repairs are made, it is important to collect as much information about the repair as possible. How the need for a repair was identified should be captured as this may indicate whether the leak developed rapidly or slowly over time. The time of identification may not be the exact time when the failure occurred, but when dealing with pipe lifetimes of decades the inaccuracies are generally not important. Information about the failure mode should also be collected and simple charts to explain what type of failure, e.g. ring fracture, failure of a ferrule etc. may help field staff. Pipe cut outs should be collected at every opportunity – when
connections are made as well as repairs. Soil samples collected at the same time can help provide information about factors affecting the pipe condition. Both pipe and soil sample collection can be encouraged by providing plastic bags with labels ready attached which just need details of the date and location of the work.

Where DMA’s have been established they can provide a useful unit for comparison. Repair levels, leakage levels, rate of rise and, if available on a DMA basis, costs per DMA can provide a simple basis for prioritisation of areas for renovation and replacement. Other factors such as water quality problems can also be taken in to account.

The Future

It is widely accepted that asset strategies which consider current and future asset performance under different investment regimes should be based on well thought out asset performance measurement. In addition the development of models which can identify current and future risks of failure based on past performance and other factors affecting asset performance where appropriate will ensure that water utilities can assess the consequences of any decisions not just in the short term but in years to come. In distribution, with the large number of similar assets, modelling current risk of failure and future performance is quite feasible. The larger the information base available the better and national failure data bases like the one established in the UK may well be worth initiating.

However, even where there is a well developed system for capturing data such as mains failure details and leakage levels, we still need to develop our understanding of which pipes will fail when. In the UK the concept of serviceability has been adopted which is the assets ability to carry out its function, which may not be directly related to the assets deterioration rate. Does this concept need to be considered more widely? Data collected through active leakage programmes can help inform understanding within companies and it is hoped that the Water Loss Task Force will be able to extend our knowledge still further.

Conclusions

Leakage management should not be seen as a separate activity but as part of an overall strategy to manage a water utility’s distribution system. If leakage data, including information about what pipes have failed when, is collected, this can help develop models to predict future failure rates and ensure that investment levels in mains renewal programmes are set at an appropriate level and that capital investment delivers the optimum benefit.

References

Burtwell, MH, Evans M, McMahon, W 2005 the Real Costs of Street Works to the Utility Industry and Society’ UKWIR Report ref No 05/WM/12/8