Pressure-Reduction Design in Severn Trent Water

by
Stephen Tooms and Richard Chalk

Severn Trent Water is a large water company, providing water and sewage services to a population of approximately eight million people in central England and Wales. The network is fairly mature, with a growth rate of approximately 1% per annum, and more than 98% of the population connected to the network. Over the last twenty years the company has invested heavily in pressure management and now has over 3000 pressure reducing valves in the network, through which over 40% of this population is served. The company has realised that there are opportunities for further pressure reduction within the network, which would deliver cost-effective savings. However identifying and prioritising those potential schemes on an individual case-by-case basis was seen as an expensive and staff-intensive process at a time when skilled staff are at a premium. Severn Trent Water worked with leakage and network-model specialists from Hyder Consulting, GL Industrial Solutions and Hydrosave to plan and investigate further pressure management by automating the selection of potential sites by batch-processing of network models.

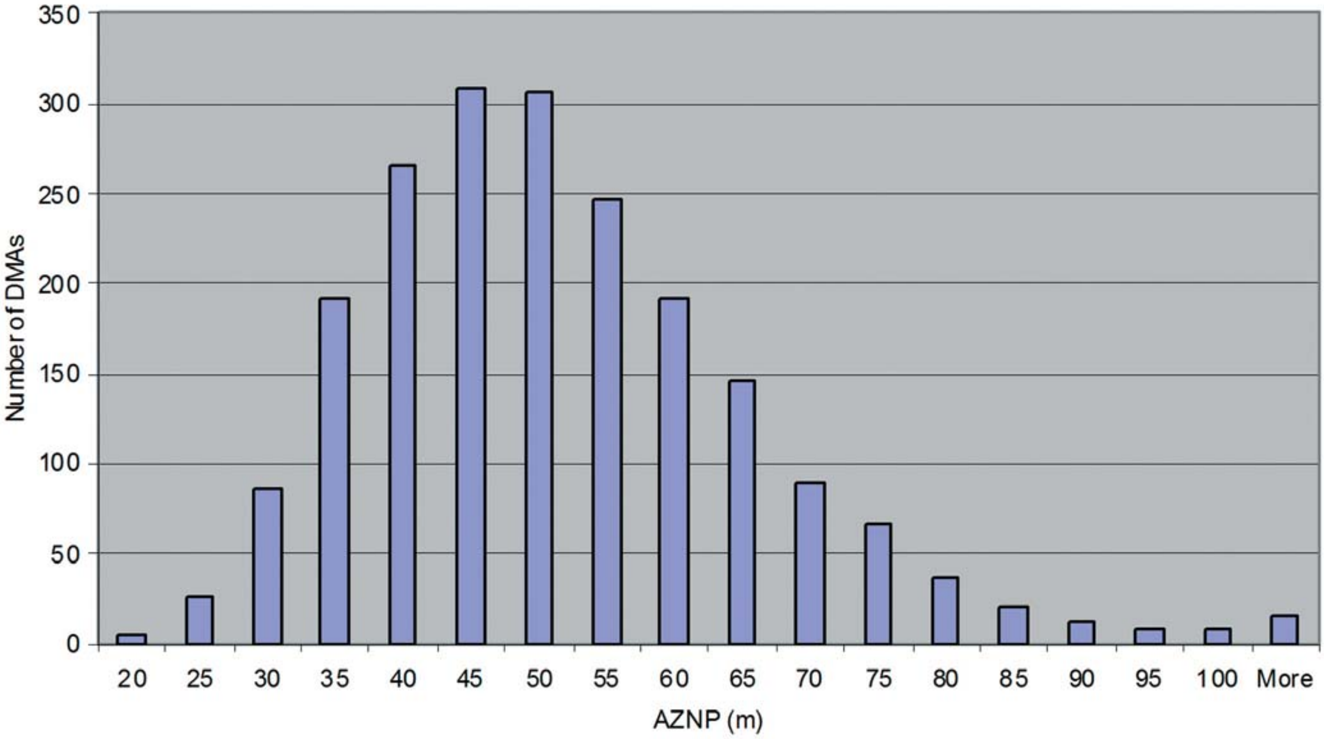

Figure 1: histogram of the distribution of average zone night pressures *Courtesy of Hyder Consulting*

Identifying the Potential

Severn Trent Water has hydraulic network models covering almost all of its supply network. These are kept in an online library which can be accessed throughout the company. These were initially used to assess the potential for pressure reduction at DMA level.

The range of pressures

The first part of the project was to assess the current range of pressures throughout the network. Average-day models in the Severn Trent Water model database were extracted. The models' 750,000 demand nodes were matched to the DMAs used for leakage control in a single process. Average pressures in each of the DMAs were also calculated.

The results (in Figure 1 above) showed that there is a large range of average pressures across the DMAs in the network.

According to this model analysis, more than 15% of DMAs (corresponding to 10% of properties) experienced average zone night pressures greater than 60 metres head.

DMA-level potential

The next stage in the project was to identify the potential for pressure management in more detail. The aim was to identify DMAs where minimum (critical point) pressures were high enough to enable sustainable pressure management without impacting on customer service. In each of the DMAs, the models were used again, in an automated process, to identify:

- the critical node (the node with the lowest pressure at some time during the day)
- the inlet to the DMA (where it is a single feed) and
- the average pressure in the DMA at each one hour time step.
- The modelled head loss across the DMA.

Actual night-flow losses were used to assess current leakage, and as a starting point for predicted leakage saving.

For each DMA where the minimum critical point pressure was greater than 25 metres, the critical point and average point pressures were recalculated to take into account the effect of a new PRV at the

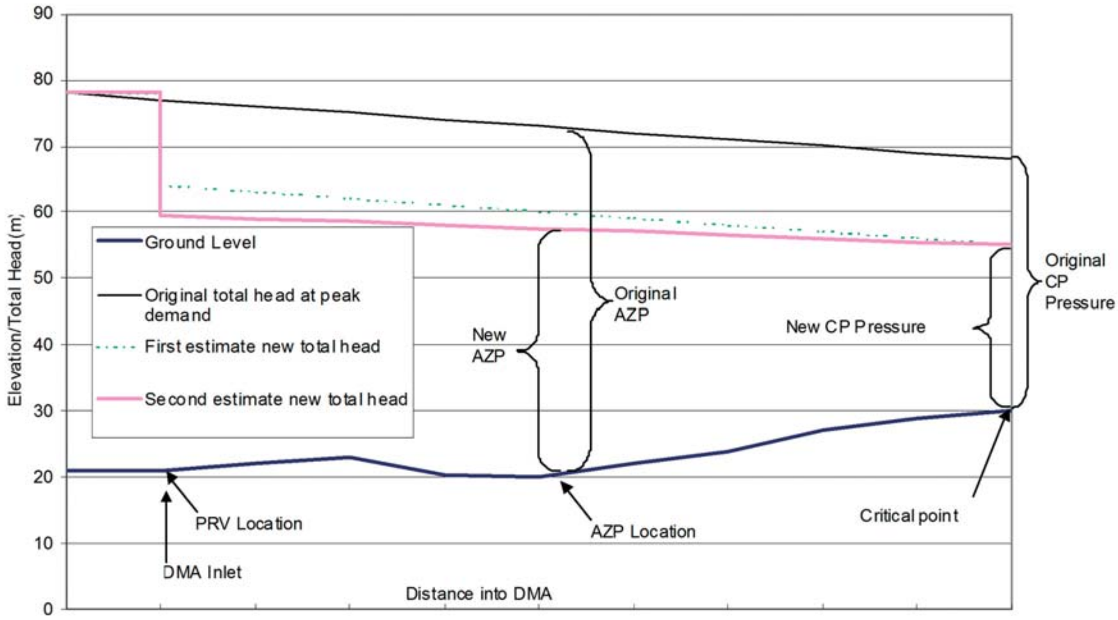

Figure 2: Assessment of the effects of pressure management *Courtesy of Hyder Consulting*

inlet. This recalculation included the head loss from the new PRV installation, the effect of alternative controllers and also the reduced head losses within the DMA resulting from reduced leakage. This is illustrated in Figure 2 above. In the figure, the second estimate of the total head takes into account the reduction in head loss caused by the reduction in demand. The new leakage (after pressure reduction) is related to the Average Zone Night Pressure (AZNP).

This process identified over 800 DMAs where further pressure management (at a whole-DMA level) was feasible according to the models.

Cost-benefit analysis

The next stage in the process was to carry out an overall cost-benefit analysis for pressure management. Again this was carried out as a batch process for all DMAs. Pressure management has a range of effects, which can include:

- Reductions in Leakage from existing leaks, which reduces water production and pumping costs
- Reductions in Natural Rate of Rise of leakage (NRR), which reduces the optimum detection costs and also potentially defers renewal
- Reduction in the rate of breakout of new leaks, which reduces repair costs and also reduces low-pressure, discolouration and no-water incidents and hence reduces customer-complaints

All three effects can produce considerable savings. The relationship between short-term leakage levels and pressure reduction is well-established. However although the effects on NRR and repair numbers have been shown to exist in a number of individual trials, it has proved difficult to make reliable predictions of the effects in individual areas.

In these circumstances it was decided that the cost benefit analysis should make a realistic assessment of leakage savings while taking a conservative view of the savings from reduction in NRR and reduction in repair numbers.

The overall estimate of net-present costs and savings is illustrated in Figure 3 below. The two lines show the estimated savings taking account of leakage savings only, and also taking account of the reduction in NRR and repair numbers.

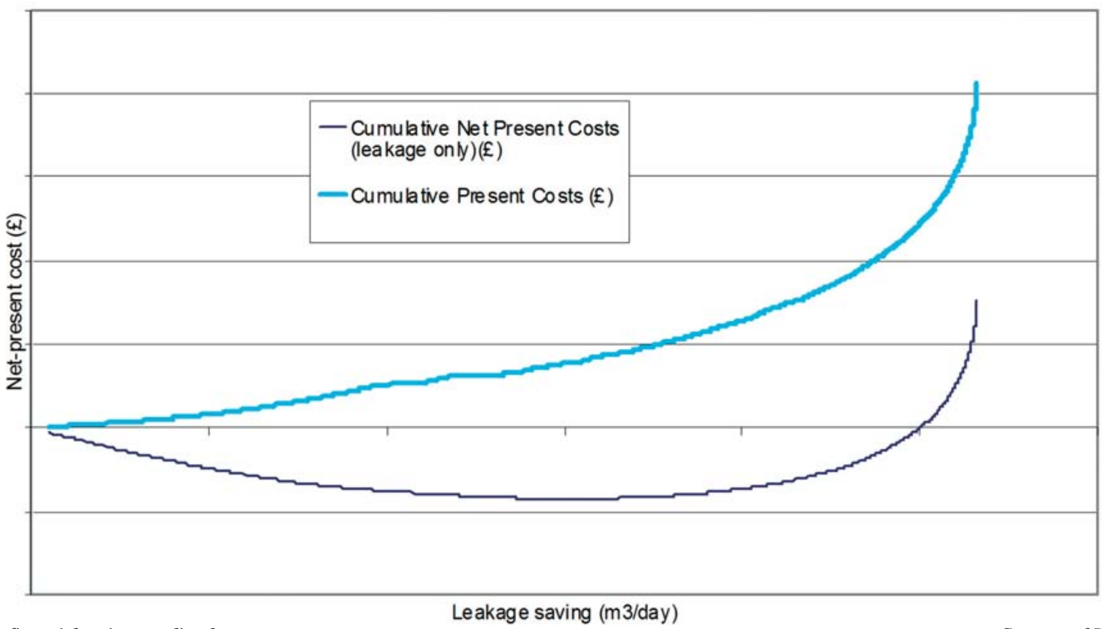

Figure 3: Net financial savings predicted *Courtesy of Hyder Consulting*

The results of this project, with some further analysis and the results of later trials, were used as an input to the 2009 Water Resource Management Plan (WRMP).

After the potential had been assessed, the next step was to look at the potential schemes in detail.

Design project

At the end of 2007 a programme of pressure monitoring was under way. This project installed over 4000 pressure monitors on telemetry throughout the network.

The design project followed the pressure monitoring project and used the data, as it became available, to confirm the schemes identified by the modelling approach and then carry out detailed designs.

This project covers two counties: one quarter of the network. The project is being carried out in eight stages:

1 Identification of potential schemes;
2 Selection of potential cost-effective schemes;
3 Outline design;
4 Investigation on site;
5 Detailed design;
6 Construction;
7 Commissioning
8 Post-commissioning appraisal

In the 619 DMAs in the study area, 460 potential schemes were identified in the first stage from relatively high critical point pressures. This included both DMA-level and new sub-DMA level schemes. From these, the zones with multiple feeds were rejected as, although they could be pressure-reduced, the costs were likely to be higher. Tall buildings and buildings higher than critical points were also considered. This was investigated by a combination of LiDAR data analysis (shown in Figure 4, where tall buildings are in darker colours) and use of aerial photography.

An initial cost-benefit analysis, similar to the company wide analysis described above, was carried out on these potential schemes. This identified 232 schemes that were cost-beneficial. Of these, 141 were selected by STW for further investigation.

At all of the 141 sites, the project team logged pressures at inlet, critical point and pseudo-average point. DMA flows were monitored. The results were used to re-assess whether the schemes were feasible. For sub-DMA schemes the boundary valves were closed temporarily during the pressure monitoring.

The results were used to re-assess the feasibility and cost-effectiveness of each scheme.

Next steps

The approved schemes will be constructed and commissioned. Over the following years the benefits, in terms of repair numbers, NRR, customer-complaints and ALC costs will be monitored to improve understanding of the effects of pressure reduction. At the same time further pressure reduction will be designed in the rest of the company.

Conclusions

This project is important in two ways:

- It identified further pressure reduction schemes in a region which had already been subjected to an intensive pressure management programme, indicating that further schemes can be available even in areas with established pressure management.
- The project illustrated how batch processing of network models can efficiently deliver the results of a complex analysis for practical implementation in even the largest water companies

Note: ***The Editor & Publishers thank Stephen Tooms, Senior Technical Consultant with Hyder Consulting and Richard Chalk, Leakage Strategy Manager Severn Trent Water for providing the above article.*** ■

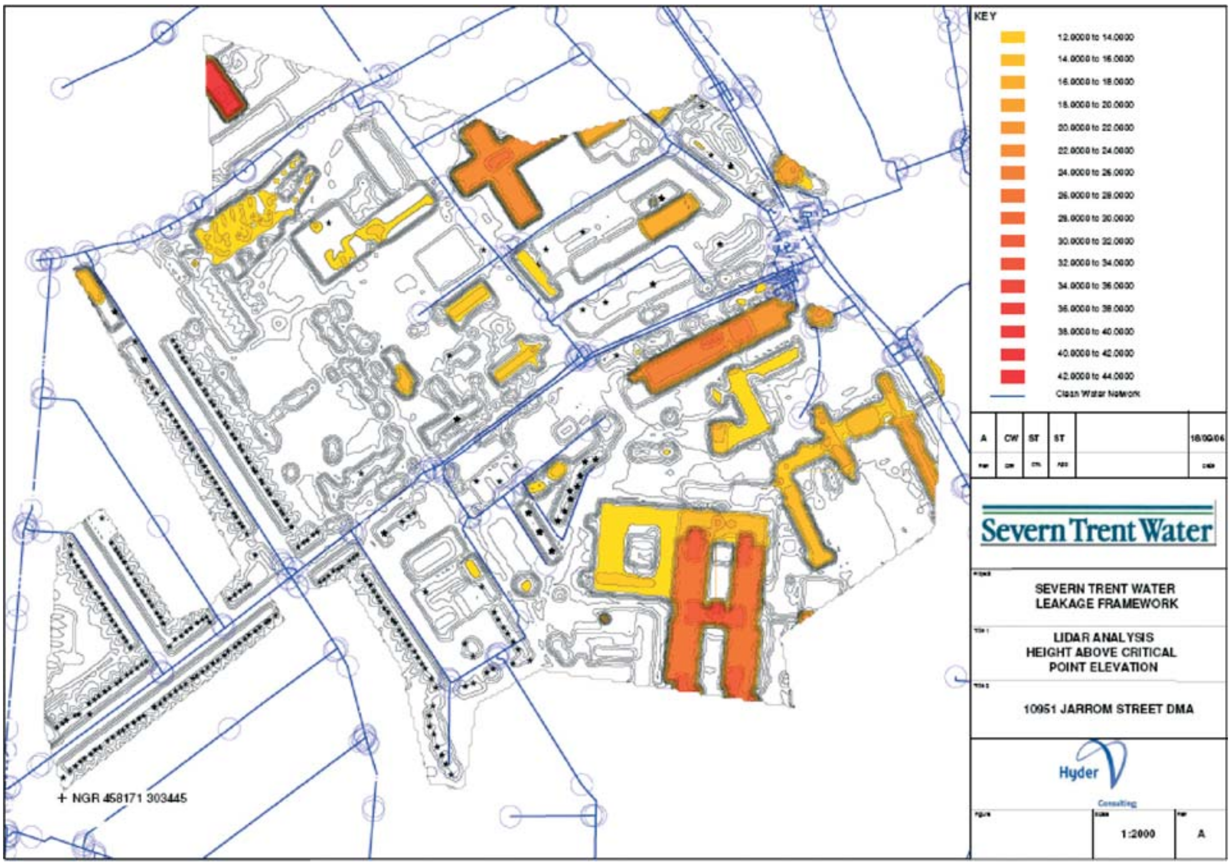

Figure 4: Property elevations above critical points from LiDAR data *Courtesy of Hyder Consulting*