An Economic Active Leakage Control Policy without a Performance Indicator is not a Myth

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Abstract

City of Calgary - Water Services instigated a leakage study of certain parts of the city to estimate the time period to compete a survey of Calgary. This paper explains the technique used and the findings from the study.

The paper shows that regardless of the level of water losses reported, it is still possible to perform Active Leakage Control (ALC) and develop new techniques to increase water loss savings.

Some of the findings from this study are as follows:

- There is a correlation between an acoustic numeric value recorded on the ground microphone and the size/type of water leak; the size and type of leak can be estimated by the analysis of data sets and from confirmed leaks. In assessing the impact of leaks on the infrastructure fitments, indications within the Calgary distribution system are that the numeric value of 45 (using the Gutermann Aqua Scope 3 - AS3) and above is the 'intervention' level for conducting additional investigation on metallic mains and surrounding infrastructure. It should be noted that whenever a survey such as this is to be considered an acoustic calibration exercise should be completed.
- The propagation of sound values (using the AS3) on the non-metallic material mains and infrastructure appear to much less to that of metallic, therefore without the addition of supplementary data sets taken from confirmed leak types on this material type the methodology established cannot be supported.
- This technique has proved successful and more investigation is required to obtain a generic footprint for non metallic pipe-work. This shows that some form of ALC can be performed with success from an unskilled operator with minimum training.

Introduction

Hydrosave was commissioned by City of Calgary - Water Services to assist with the development of a bespoke leakage detection methodology anticipated to complement the existing detection resources with the addition of a robust procedure, which if proven successful could be utilised by an unskilled operative in order to successfully identify potential areas of loss from the below ground infrastructure.

These potential 'areas of interest' (AOI) could then be recorded and passed to a skilled operator for further investigation and the confirmation of leak position carried out with the assistance of specialist acoustic equipment.

This paper presents the findings of the survey undertaken by Hydrosave in association with City of Calgary - Water Services during 1st – 5th May and 9th – 23rd June 2006.

The real losses currently being estimated from its below ground assets in Calgary are recorded as a percentage of volumetric input, this is currently estimated as being some 12 per cent of the total water into supply. No calculation of the ILI has been completed for the city as a whole but has been for smaller temporary DMA's, and these results are provided later in this paper.

Although 'percentage of volume input' is the method currently being used by City of Calgary - Water Services to measure the real losses, it is important to note that the authors do not support the use of the 'percentage of volume input' as the sole PI for real losses but rather as one of several PIs that should be used collectively

The City of Calgary - Water Services also does not agree with "percentage of water input" being the sole PI for water loss, and will be undergoing a full IWA water audit in late 2007 and 2008.

The following PIs are suggested as being more reliable PI:

- litres/service connection day or L/km/day (if service connections density is > 20);
- ILI

Survey Scope

The survey scope was to develop a robust methodology utilising an acoustic listening device based upon a leak noise value represented by a numeric reading and where possible obtain an acoustic "footprint" for the supply area. The equipment of choice chosen for this purpose was the Aqua Scope 3 AS3 manufactured and supplied by Gutermann Limited the reason being it displays a numerical reading for the acoustic noise heard. The data captured during the process was analysed to identify the correlation between the numeric value and material type and, where possible, substantiated with recorded values taken from known leak positions. Survey times were also monitored and measured so that an approximate estimate of manpower, projected timescales and geographical coverage could be ascertained.

The survey methodology itself and subsequent data collection and assessment were aligned with the International Water Association's (IWA) & American Water Works Association (AWWA) principles and practices

Survey Team

The project survey team consisted of personnel from both Hydrosave and City of Calgary - Water Services whose skills were complementary in the significant identification of the project outcomes.

Survey Areas

The water supply network coverage within the chosen areas for the development of the methodology is approximately 120 square kilometres. These areas are sub-divided into city districts that are represented by a variety of topographic and demographic property types. Each district incorporates about 30 square kilometres of water supply network and integrates a proportionate mix of both material and fitment types. The network is generally constructed on a generic grid-based design with a singular strategic supplying main. In some instances the areas are independently fitted with localised pressure management facilities.

Four districts in total were chosen which concentrated principally upon the residential areas:

- Lake View;
- Glenmore;
- Bowness;
- Spy Hill.

The real losses for these survey areas were unknown as flow monitoring by area is currently limited, however flow data was gathered 12 months prior to the survey.

Fitments, pipe-work and service valves within these areas are mostly accessible and in some instances situated within unmade access routes sited toward the rear of properties. Above ground fire hydrants are generally positioned within the carriageway and are clearly visible with servicing valves installed controlling the fire hydrants.

Analysing the DMAs

One of the main goals of establishing a DMA is to answer these two important and prime questions of water management, "Where is the water coming from?" and "Where is it going to?" Once the DMA is isolated and the flow meter(s) installed, the 1st question can be answered. The 2nd is answered by monitoring the incoming flow and calculating the losses.

Snapshot ILI & basic cost analysis in Bowness

With the zone closed in the following was losses was recorded

UARL = 12m^3/hour

CARL =50m^3/hour

If all leaks are located then 38m^3/hour can be saved equating to an annual loss of 332.8 ML with a dollar value of $29,880 (based on $90/ML). Based on this information, a leakage survey should be cost effective however other factors also have to be considered.

CARL/UARL = ILI

50/12 = 4.1

Bowness ILI = 4.1

Snapshot ILI & basic cost analysis in Lakeview

With the zone closed in the following was losses was recorded

UARL = 1.5m^3/hour

CARL = 10m^3/hour

If all leaks are located then 8.5m^3/hour can be saved equating to an annual loss of 74.5 ML with a dollar value of $6,700 (based on $90/ML). Based on this information, a leakage survey would not be cost effective however other factors also have to be.

CARL/UARL = ILI

10/1.5 = 6.3

Lakeview ILI = 6.6

This area was considered to small for the ILI calculation to be valid.

Based on this information it may not be worth while at this time to perform a leak survey of the area. The average cost for a repair is $8,000. If it was a single leak, it would pay for itself in a little over a year, however if the losses are coming from multiple small leaks, the cost may be prohibitive. This area has higher real losses than desired for such a small area, but the cost for multiple repairs may not be economically justified.

Equipment

The acoustic equipment utilised during the survey (Gutermann AS3) was selected by City of Calgary - Water Services and the methodology was to be developed using this brand of equipment.

Methodology - General Principle

The primary survey methodology was to incorporate the sounding of all available fitments. A secondary survey option was also identified which concentrated on the use of fire hydrants and fire hydrant controlling valves only.

Each survey option was completed under comparable circumstances by a two-man team comprising a team leader and an assistant with the data collection process defined by the following categories:

- Asset type;
- Asset number;
- Numeric reading;
- Material type;
- Geographical reference.

The primary survey option was completed by the sounding of every available fitment with the AS3. In some instances access to below ground servicing valves was partially obstructed and could only be made by the breaking and removal of the compacted debris around the proximity of the valve chamber and cover.

The secondary survey option was to concentrate on the sounding of the fire hydrant and fire hydrant controlling valve in order to determine if a correlation between the two methods could be obtained and if the survey option was successful in identifying high volume losses.

In both instances the survey equipment was configured with filters off, a volume setting of 75% of the total and held directly to the fitment surface for a minimum period of at least 20 seconds. No headphones were used and numerical values taken only, this was so no sound interpretation was taken into account from an experienced leakage engineer.

The numerical representation of generated system noise was captured from the digital indicator on the AS3 and duly recorded. In all instances the lowest numerical reading captured by the equipment was used.

Numerical Clustering

On the completion of each sub-division, the representative numerical data captured for each fitment surveyed would be overlaid onto a network schematic plan detailing asset position, size, type and distinct reference code. From this process a numerical footprint of the sub-division was obtained and an associated assessment completed. This highlighted any obvious numerical values in close proximity of the defined “intervention denominator” associated around a singular geographical point.

Prior to any further analysis, each high reading point was evaluated against an asset location. This was done as the asset may be in the location of a known noise, for example a pressure reducing valve or main incoming supply valve.

Each AOI would initially involve the re-capture of the numerical value recorded on the fitment at least 2 hours later or the following day at a different time within the day in case the value was that of domestic draw-off. Should the numerical values be comparable with those initially captured then a more robust leak location process should be instigated with the utilisation of standard leak noise correlation processes and above ground acoustic listening techniques.

The AOI’s may only then be removed from the schedule by the confirmation of leak position or quantification of the numerical value as legitimate consumption.

The overall numerical value data range captured throughout the project is presented at table 1

Table 1: All Fitments Survey Results

Primary survey – All fittings sounded	
Total numerical range	Material type
25 - 43	PVC
26 - 70	Cast Iron
27 - 60	Ductile Iron

Intervention Denominators

The numeric data captured was generally found to be proportional across all material and fitting types particularly where no leaks were present. In places where several leaks were located, a significant increase in the numerical value was recorded. This increase in the numerical value can not indicate the size of the leak recorded for a known type of pipe material without further assessment of data captured from known losses.

In an attempt to validate the numeric values captured and establish a leak noise threshold by material type, a simulation of a known loss was replicated from the operation of a fire hydrant and the impact of the surrounding numeric values recorded on all valve types situated in close proximity.

Firstly a simulation of a known loss was replicated from the operation of a fire hydrant and the measurement of the subsequent impact of this upon surrounding numeric values recorded on all available valve types situated within a close proximity, the results of which are presented within table 2.

Table 2: Numerical values obtained during test

Asset Type	Material Type	Distance From Source (m)	Numeric Value (1)	Numeric Value (2)	Numeric Value (3)
Sluice Valve	Cast Iron	57	34	35	39
Sluice Valve	Cast Iron	57	31	37	39
Sluice Valve	Cast Iron	51	31	37	49
Fire Hydrant	Cast Iron	0	42	78	82
Sluice Valve	Cast Iron	38	31	39	61
Sluice Valve	Cast Iron	43	35	38	69
Sluice Valve	PVC	43	36	32	38

(1) Reading captured prior to test

(2) Reading captured during test at 0.2 litres per second

(3) Reading captured during test at 1.0 litres per second

From the above it was found that the amount of induced losses had little impact on the numeric values recorded on fitments directly situated on the non metallic pipe. Only those fitments situated on the metallic pipe recorded any “uplift” in numeric activity which was found to be both distance and flow proportionate.

Below are numeric values recorded during this exercise and any singular point identified by a numeric clustering greater than 40 (after calibration of the acoustic noise propagation in this area) was initially highlighted as an AOI and duly scheduled for further investigation, the outcome of which has been summarised below in table 3

Table 3: Area of interest summary

Area Reference	Numerical Profile Range	Investigative Outcome
Bowness	40 - 59	PRV location no leaks found
Bowness	37 - 57	Incoming supply no leaks found
Bowness	46 - 60	Burst service pipe at ferrule connection
Glenmore	56 & 69 & 70	3no leaking service valves found

Completion of the investigative outcomes identified a number of leaks, the predominant being from a numeric clustering of between 46-60 and over a 200m distance. These leaks arose from a combined failure of a copper service pipe and associated ferrule connection situated at a cast iron main. Following excavation and visual confirmation prior to repair, the loss was estimated at some 3 litres per second.

The remaining leaks identified were found to be general losses from service valves, predominantly from around the operating gland or the general corrosion to the body and bolt sets. These leaks shown readings of 56-70 when the ASA3 was placed on the fittings but there was little or no transmittal of these leaks noise the surrounding fitments.

Unfortunately the impact on the numeric values obtained from the confirmed leak position did not incorporate a proportional or representative amount of plastic pipe material within the immediate peripheral vicinity. Therefore additional information should be obtained before a definite conclusion can be drawn.

In considering the relationship between numerical value and material type it is suggested that the following intervention denominators at table 4 be considered.

Table 4: Numerical intervention denominators

Pipe Material	Numeric Intervention Denominator Value
PVC	40
Cast Iron	45
Ductile Iron	45

Survey Cycle

The survey cycle was completed in accordance with the two methodologies outlined in the section above. As previously mentioned, the survey areas comprised a variety of topographical, social and economic property types thus allowing a realistic productivity ratio to be ascertained. From the data obtained it can be reasonably concluded that: -

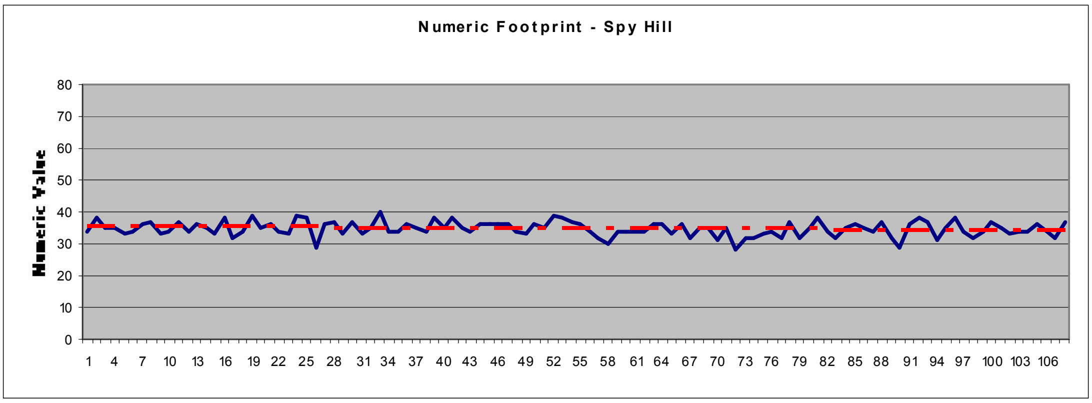
- In carrying out an all fitment survey, an average timescale between fitments of 5.51 minutes can be expected;
- In carrying out a fire hydrant & controlling valve survey only an average timescale between fitments of 5.0 minutes can be expected.
- Average daily distance listening on all fittings was 5.8km/ day
- Average daily distance listening on fire hydrants only was 14.2km/day
- It must be noted that coverage of mains length listening on fire hydrants only was 230% greater than doing that of all fittings.

(Timescales may vary dependent upon local climatic conditions)

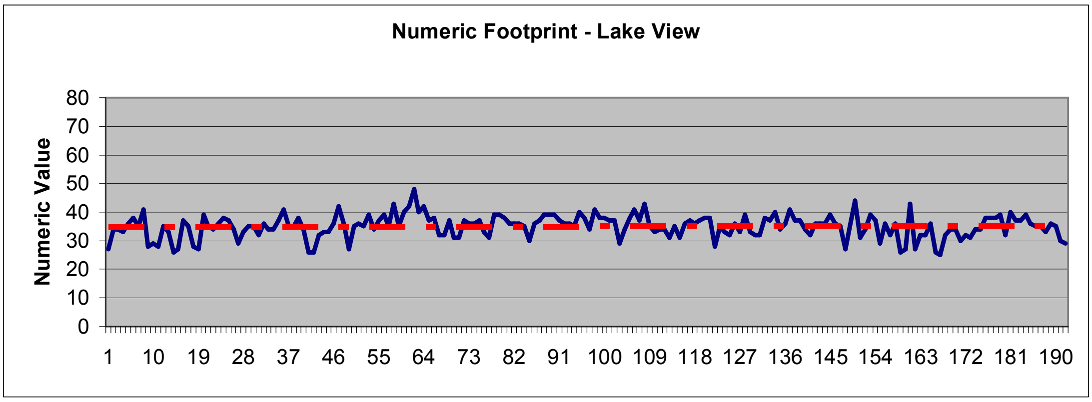
Numeric Footprints

In analysing the numeric data sets recorded during the survey it is possible to build a graphical representation of each district meter area. Each representation may then be considered as a numeric footprint of the water supply characteristics and utilised as a reference point when carrying out any future survey, especially if any significant time period has elapsed.

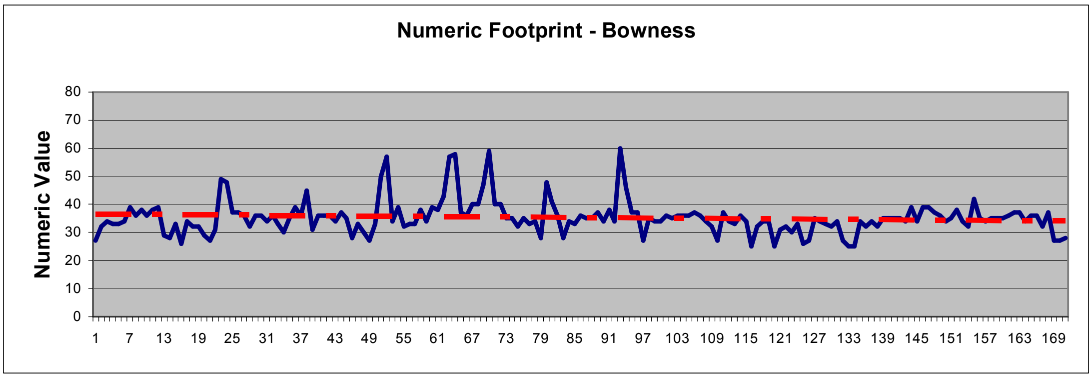
Graph 1: Numeric footprint – Spy Hill



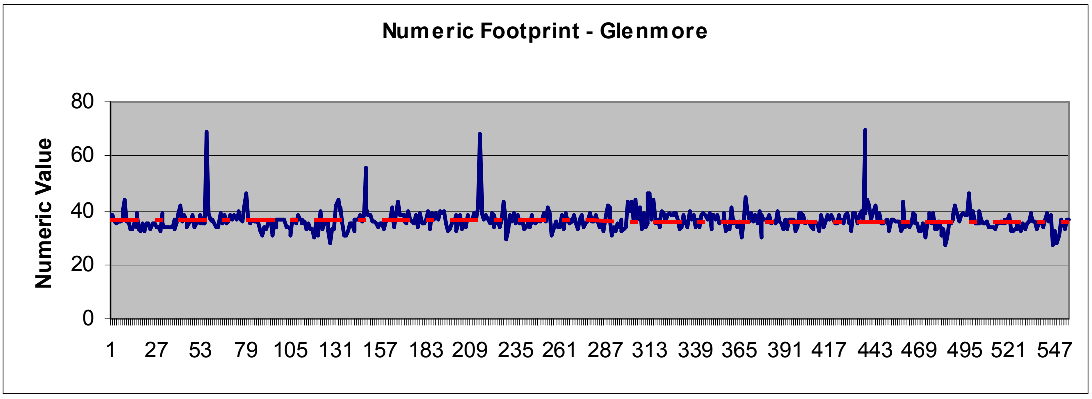
Graph 2: Numeric footprint – Lake View



Graph 3: Numeric footprint – Bowness

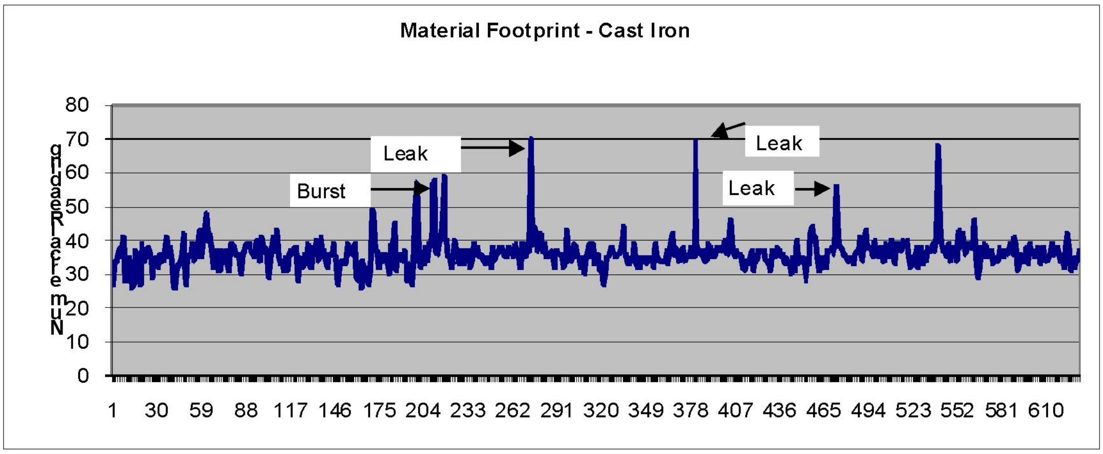


Graph 4: Numeric footprint – Glenmore

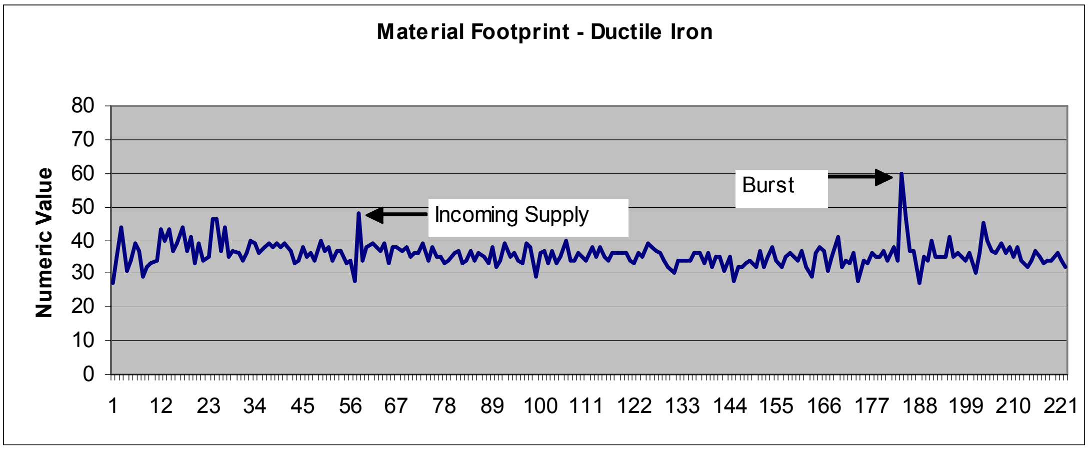


On the whole it was found that the footprint for most supply mains situated within the survey areas and constructed of a metallic composite such as Cast or Ductile Iron recorded a comparable numeric value. This was the case for both normal operating circumstances and where a leak noise was generated. However the footprint obtained for non-metallic composites such as PVC was recorded at a consistently lower numeric value; this can be anticipated due to the inherent low dispersal of sound through non-metallic composites.

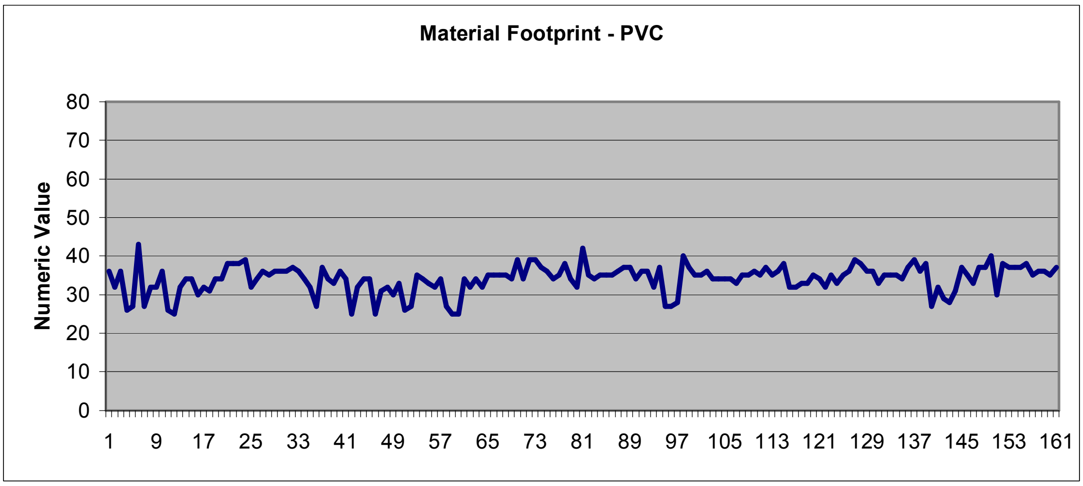
Graph 5: Numeric footprint – Cast Iron



Graph 6: Numeric footprint – Ductile Iron



Graph 7: Numeric footprint – Non Metallic



Conclusions

From the data sets obtained from completing the survey, the following conclusions have been made:

- There is a correlation between a numeric value, size of water leak and the pressure within the area.
- A calibration exercise should be carried out in each area to establish the acoustic noise transmittal properties and the intervention number.
- The propagation of sound values (using the AS3) on the non-metallic material mains and infrastructure appear to be much less to that of metallic mains. Therefore without the addition of supplementary data sets taken from confirmed leak types on this material type, the methodology established cannot be substantially supported.
- Although the secondary survey option may be useful in identifying a catastrophic failure within a survey cycle, the primary survey option to incorporate all fitments is suggested as perhaps a more robust method for inclusion into a routine pro-active control plan.
- Above ground fire hydrants were found to be generally susceptible to additional ambient and surrounding noise levels.
- Variation in local climatic conditions could in some instances impact on the numeric recordings obtained. In the case of high background noise, a numeric reading offset should be applied to compensate for the "uplift" in ambient conditions around the equipment.
- Fire hydrants, where water is replaced by air, gave a lower numeric value as the noise transfer was reliant totally on the wall material of the main. It is therefore considered that noise transferral is greatly enhanced when a main is pressurised with water and that sounding should only be carried out on fittings that are connected to a pressurised main.
- When carrying out an all fitments survey option, an average timescale between fitments of 5.51 minutes per fitting for each two-man team may be anticipated under average conditions.
- Average daily distance listening on all fittings was 5.8km/day
- Average daily distance listening on fire hydrants only was 14.2km/day
- This technique has proved successful and more investigation is required to obtain a generic footprint for non metallic pipe-work. This shows that some form of ALC can be performed with success from an unskilled operator with minimum training

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