Portsmouth Water

Final Report

Sustainable Economic Level of Leakage (SELL) Assessment

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24/11/17	2.2	Update for Consistent Leakage

Executive Summary

Scope

This is a report of the assessment of the Sustainable Economic Level of Leakage (SELL) of Portsmouth Water for the Water Resource Management Plan. The outputs of this project are:

- A baseline leakage level that minimises costs (including external costs). This includes transition costs from the current leakage level. This is termed the Short-Run SELL.
- A cost vs. leakage reduction relationship, which could be used as part of the input to the water resource management plan.

Conclusions

All conclusions have been drawn using the new "consistent" leakage reporting method (Consistency of Reporting Performance Measures: Reporting Guidance – Leakage, Report Ref. No. 17/RG/04/5, UKWIR 2017).

The central estimate of the SELL without introduction of DMAs is **34.2 Ml/d**. The possible range of this value is 32.0 to 39.9 Ml/d. The main contributor to the uncertainty is the range of possible marginal costs.

It appears that a 4.7 Ml/d reduction in the SELL could be achieved through the introduction of DMAs to part of the network and that this could be achieved economically if water provided by this could be sold to Southern Water. The capital cost of achieving this saving is estimated at **£1.4million**. There would also be an increase in operating cost for flushing, but no change in operating cost for ALC. The programme would be carried out over several years. The SELL after the introduction of these DMAs would lie at **29.5 Ml/d**, in the range 27.6 to 33.7 Ml/d.

Further reductions could be achieved by extension of DMAs to more areas, more expenditure on active leakage control and surveys to find supply pipe leaks. A further saving of 8 Ml/d appears to be achievable at a capital cost of **£8.6 million** and an increased annual expenditure by **£377,000/year**. This would bring the leakage level down to approximately **21.5 Ml/d**. There is a great deal of uncertainty in the costs involved.

Further savings beyond this point are only likely to be achievable at significant cost and may include leakage reduction by targeted network renewal. Estimates of the costs and effects of this are included here based on the recent WRc report.

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1 Operational and regulatory background

This assessment of SELL is an update of the SELL assessment made for WRMP14. There have been a number of improvements in leakage measurement and the understanding of costs since then. The remaining options for pressure management have been examined in detail by Portsmouth Water and the practicable options have been implemented. More work has also been carried out on the costs and effects of the subdivision of SMAs into smaller DMAs. There are now more realistic possibilities of more extensive transfer of water between Portsmouth Water and its neighbours, particularly Southern Water.

Portsmouth Water has continued to use its established methodology for assessing leakage, while also working on an improved methodology that meets current best practice. This improved methodology has now been adapted to meet the requirements of the leakage consistency project (Consistency of Reporting Performance Measures: Reporting Guidance – Leakage, Report Ref. No. 17/RG/04/5, UKWIR 2017) and it is planned to be used from 2020 onwards. Shadow reporting of leakage using the consistent methodology and comparison to the reporting using the established methodology shows that the current (2016-17) difference between the established method and the "consistent" leakage level is 5.14 Ml/d. All conclusions and calculated results shown in this report have been drawn as if using the new "consistent" leakage reporting method. The same results, using the established methodology, would have been 5.14 Ml/d lower.

Although the consistent methodology has been finalised, the remaining unquantified parameters to be used in the new methodology will continue to vary for some time: particularly, in PW, non-household night use and plumbing losses. This will lead to changes in reported leakage and hence changes in SELL.

1.1 Scope

This project delivers:

- A baseline leakage level that minimises costs (including external costs). This includes transition costs from the current leakage level.
- A cost vs. leakage reduction relationship, which can be used as part of the input to the water resource management plan.

Activities considered included:

- Changing Active Leakage Control (detection and repair of hidden leaks) (ALC). This could include changed detection technology, improvements in management systems, intensive investigations of individual SMAs with high leakage, changes in the number of detection staff.
- Changing pressures by the use of control valves or pumps. This can include pump control, changed PRV control, new PRVs and zone reconfiguration.

However, the scope for this has been almost exhausted in the last five years, with remaining options being small, expensive, or both.

- Customer Supply Pipe leakage reduction activities.
- The introduction of more DMAs, subdividing the existing SMAs in to smaller areas that will enable improvements in the efficiency of leak detection.
- Targeted renewal of the distribution network.

External costs of leakage and leakage management have been assessed following the recommendations in the EA/Ofwat/Defra Review of SELL (Tripartite Group (Ofwat/EA/Defra), 2012).

2 Methodology

Overall the methodology was developed to meet the requirements set out in the main guidance and best practice documents. The key documents are:

Document	Summary of relevant content for SELL
Economics of Balancing Supply and Demand, EA, 2003.	Sets out how options for maintaining the supply-demand balance (including leakage reduction options) should be appraised.
Water Resource Planning Guideline, EA, 2016.	Describes the water resource planning requirements and sets out how leakage options should be assessed and reported for the water resource plan.
Review of SELL, EA/Ofwat/Defra, 2012.	Makes a number of pragmatic recommendations for how SELL should be assessed.
Best Practice Derivation of Leakage Cost Curves, UKWIR, 2011.	Provides guidance on the assessment of leakage cost curves, but concentrating on active leakage control. It also describes an alternative method, which is a development of a Method B approach.
Managing Leakage 2011- Report 3: Setting Economic Leakage targets, UKWIR, 2011.	Sets out principles of SELL.
Tripartite study: Best Practice Principles for Economic Level of Leakage Calculation, EA/Ofwat/Defra, 2002.	Now mostly superseded. This report provides guidance on principles of SELL, including the idea of Method A and Method B approaches.
Best Practice Guidance on the Inclusion of Externalities in the ELL Calculation, Ofwat, 2007.	Covers the calculation of externalities. Partially superseded by the Review of SELL (2012).
Leakage Reporting Consistency Guideline v2,Water UK, April 2017	Describes a consistent leakage reporting methodology for use from 2020, with proposed shadow reporting up until then.
Consistency of reporting performance measures: Reporting guidance – leakage, 17RG045,UKWIR, July 2017	Describes a consistent leakage reporting methodology for use from 2020, with proposed shadow reporting up until then.

Table 1: List of guidance documents

In summary the approach used here is to assess the key parameters (current leakage level, policy-minimum leakage, NRR) and produce a simple model of Active Leakage Control that produces the current leakage level for the current level of ALC activity. The costs and effects of increases in pressure management and of increases in main and service renewal are also assessed. The external costs of leakage, ALC (including further DMAs), pressure management and renewal are also assessed. The costs of different levels of the three activities (and their interaction) are assessed to identify a leakage level that minimises total costs. This is identified as the Short-Run SELL (i.e. the leakage level that would be optimum if no supply-demand issues or willingness to pay were to be included). The uncertainty in the Short-Run SELL was also assessed.

The cost of changing leakage level by each of the three methods is also assessed, to produce a projected leakage reduction vs. cost relationship.

2.1 Defining Methodology, Data Requirements and Level of Geographic Detail

One of the first decisions was to decide which analysis method to use, and therefore what level of zone hierarchy to use. The options for methodology included the “Method A” or “Method B” approaches (Tripartite Group (Ofwat/EA/Defra), 2002). A development of the “Method B” approach had also been developed and reported (UKWIR, 2011). Any method B approach requires a fairly detailed level of data on detection and repair activities: data that Portsmouth Water did not have available at the time of the project commencement. It is also a time consuming and detailed analysis. It was felt that the time and resources available could be better spent in deriving a pragmatic analysis, as recommended in the Review of SELL (Tripartite Group (Ofwat/EA/Defra), 2012). The Method B approach also relies on statistical analysis at DMA level. Portsmouth Water uses SMAs: larger zones which would provide less data and hence would be less likely to produce a successful result. Another consideration is that the Method B approaches only consider ALC. Pressure management and renewal would have to be assessed in a separate analysis. It was decided that a Method A approach would be more suitable in this case.

The Method A approach can use data obtained for larger zones and the results can be applied to these larger zones. Using a component model it would be feasible to incorporate pressure management and renewal into the same analysis. The approach is well established and was felt to be more appropriate to the Portsmouth Water situation. It would also allow more time to make pragmatic assessments.

Portsmouth Water’s distribution network is divided into 88 metered SMAs: averaging 3300 properties, but with up to 12099 properties. Some of these areas are permanently subdivided into (a total of 25) DMAs, while others can be temporarily sub-divided as necessary. There are also some unmetered (or Not On District (NOD)) SMAs. Every SMA is within a Reservoir Zone (RZ). RZs are fed directly from service reservoirs. The output from the reservoirs constitutes the distribution input. The choice of zone for the analysis was restricted to either the whole company or Reservoir Zones. Recent leakage levels had not been recorded at RZ level, but could be identified at SMA level and for the whole company. It was decided to do most of the analysis at Company Level. However, the costs and benefits of some savings could be assessed at RZ level. The table below summarises the data available at each level of zone hierarchy.

Zone level	Number of.	Long term leakage or night flow records available?	Asset data (properties, mains length)	Other leakage data available (HDF, pressures, detection, repairs)
Company	1	Y	Y	Y
Reservoir Zone	17	N	Y	Y
Metered SMA	88	Y	Y	Y
Unmetered SMA	13	N	Y	N

Table 2: Data availability by zone type

3 Assessing the Key Parameters

The data collected has been used to assess the key parameters that are required. These are:

- Policy-minimum leakage level
- Cost of water
- Proactive and total NRR
- Detection and Repair costs

The derivation of each of these is described below.

3.1 Assess the Policy-Minimum Leakage Level.

There are a number of terms for the lowest leakage level that has been, can be or theoretically could be obtained. The ones currently in use are: policy-minimum (PMLL), minimum achieved leakage (MAL), Minimum achievable leakage (MAbL) and background leakage. The term Base Leakage has also been used in the past. These terms are explained in the Glossary. The activities and costs of moving the policy-minimum towards the minimum achievable leakage level are discussed and estimated in Section 5.

The policy-minimum leakage level consists of two main components:

- The lowest leakage level that can be achieved by the current ALC policy
- The leakage from both detected and reported bursts that cannot be affected by the intensity of ALC: this is the time between knowing the location of the leak and its repair (the repair time).

Generally the first component is by far the largest.

3.1.1 Lowest Achieved Leakage Level

The lowest achieved leakage or policy-minimum level of leakage (PMLL) is used within many of the Sustainable Economic Level of Leakage models, and reflects the lowest level of leakage that can be achieved when using a particular policy. The PMLL reflects both the state of the network and the active leakage control policy being used by the company. The strict definition of the PMLL is the level of leakage that is achieved within an area (typically a DMA) following intensive active leakage control and repairs when there are no leaks running.

Although, at the DMA level, the PMLL will be achievable, for aggregated zones it will not be achievable as it will require all the DMAs within the area to be operating at the PMLL simultaneously. The PMLL for a resource zone is defined as the sum of the PMLL for the constituent SMAs and not the lowest level achieved within the resource zone.

Portsmouth Water use SMAs which are typically larger than the DMAs used by many companies; this will tend to result in a higher estimate of the PMLL.

A typical minimum night flow (also known as nightline) is shown in Figures 1 for the 5-year period of data that was provided by the company. The purpose of the following calculation steps was to derive a sensible estimate of the policy-minimum nightline for each year that would match an expert's assessment of the nightline trend. As can be seen in figure 1 the main requirements would be to exclude the outliers of very low (or zero) nightline spikes.

The keys steps in the calculation for Portsmouth Water were:

1. Analysis was performed using the SMA nightline data: the adjustment for night use is applied at the aggregated reservoir zone level, as this is considered more robust.

2. Although ALC and repair data was examined to identify minima that coincided with repair activity, it was considered sufficiently robust to identify the minimum historic nightline for each year. Through a 12 month period it is unlikely that the minimum nightline will be identified in any period where there is a significant leak running; limiting the analysis to periods following active leakage control and repairs would result in a higher estimate of the PMLL.

3. The daily minimum is calculated as the 7-day 20%ile value of the minimum 15 minute value between 2am and 4am.

4. Validation is applied to the data to produce a PMLL that would be selected by an expert viewing the nightline trace. We used our experience from other companies to apply the following validation rules which exclude:

   - Minima which have a zero value within the 7-day period used for the 20%ile calculation, as this affects the 20ile calculation.

   - Minima where the minimum is not maintained for at least three days, to remove "spikes" in the nightline,

   - Minima which are below 15% of the average nightline for the year, to remove outliers.

5. The PMLL and annual average nightline was calculated for each SMA for 2012-13, 2013-14, 2014-15 and 2015-16, and then summed to give values for each reservoir zone.

6. The initial estimate of the PMLL for each reservoir zone is shown in Table 2.

The graphs below show night flow data over four years for four example SMAs, showing how the annual policy-minimum values (blue dotted line) are derived from the night flows in each SMA excluding periods of zero data and periods of high night flow.

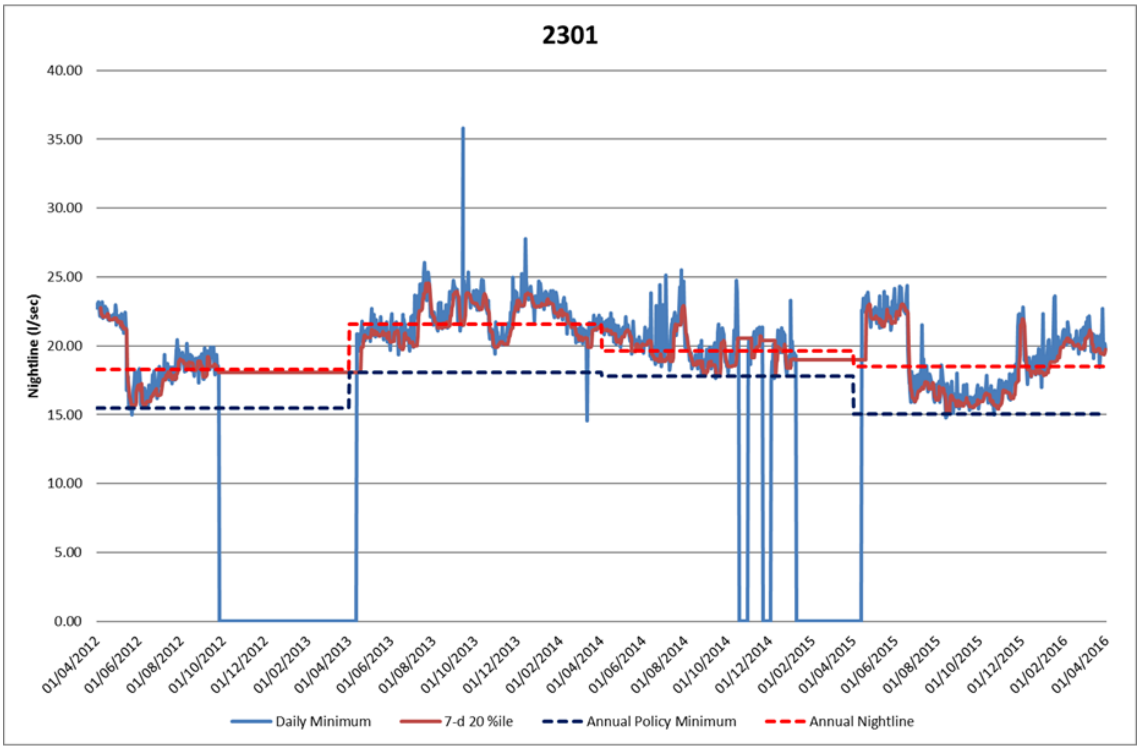

Figure 1: policy-minimum derivation for SMA 2301

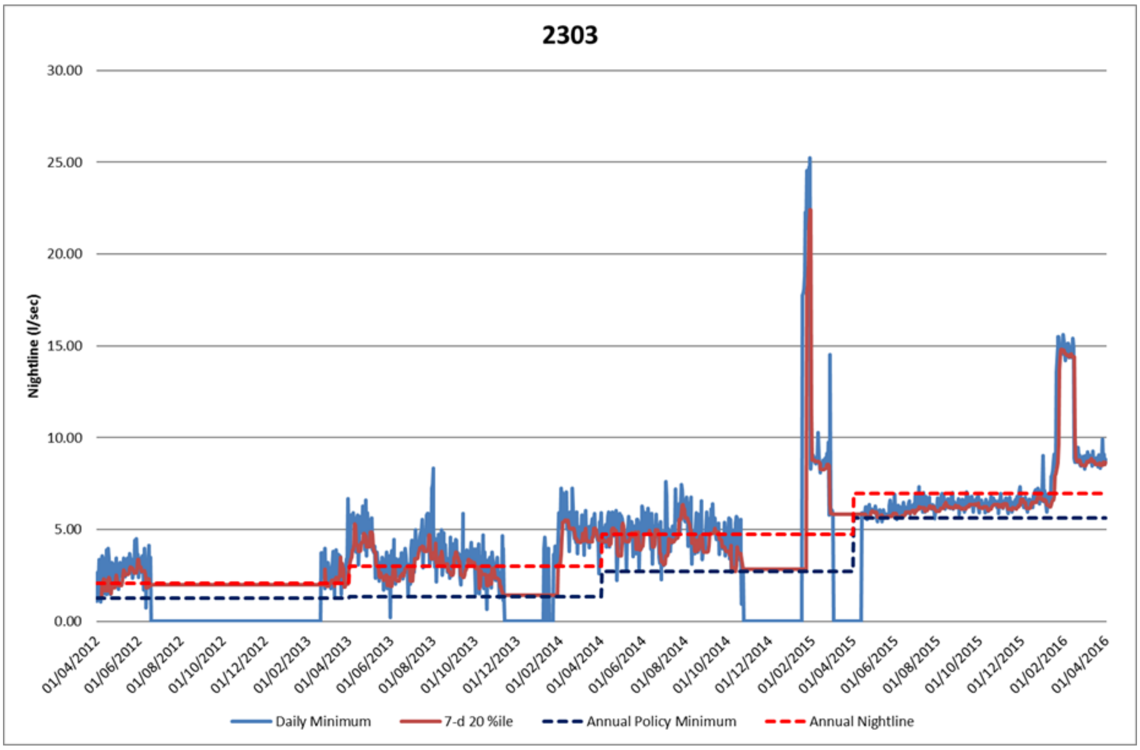

Figure 2: policy-minimum derivation for SMA 2303

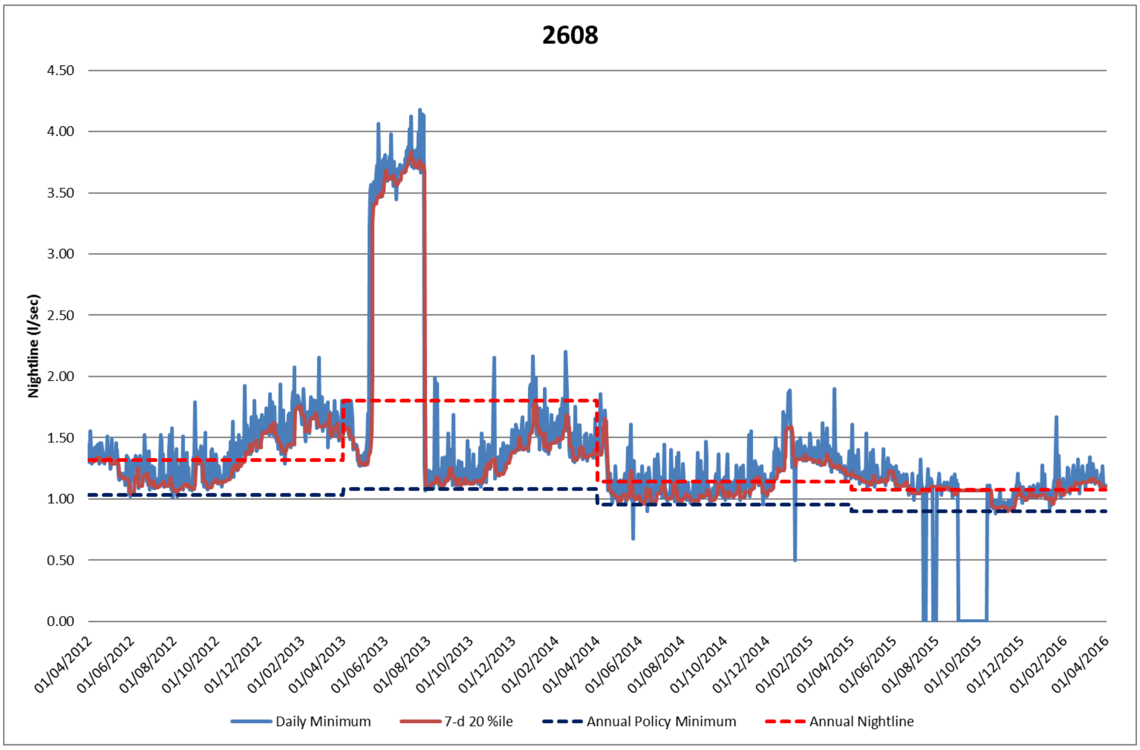

Figure 3: policy-minimum derivation for SMA 2608

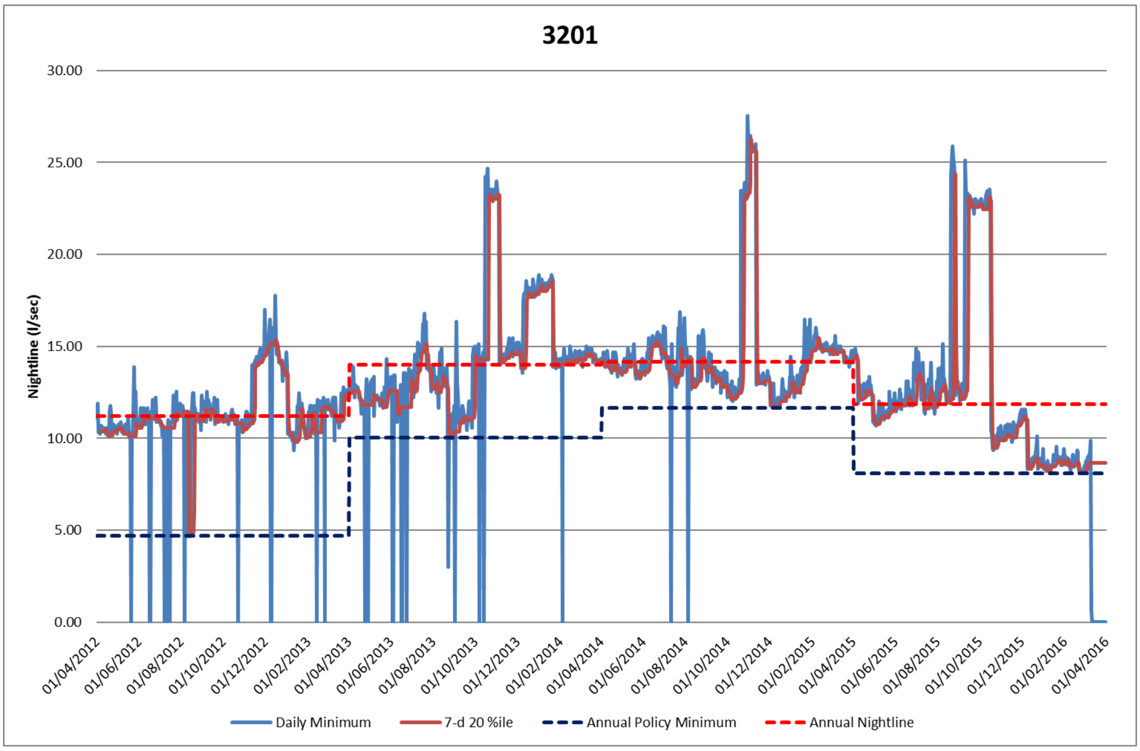

Figure 4: policy-minimum derivation for SMA 3201

Additional nightline traces are shown in Figures 2 to 4, which demonstrate the validation rules being applied within the calculation to exclude short-term spikes of low values or periods of missing data. These show examples of where the minima are the result of repairs (i.e. the minimum follows a sharp decrease in the nightline) and where the nightline is relatively stable throughout the year and the calculation correctly derives the minimum value.

Table 3 presents the results of the initial analysis compared to the same analysis of data up to 2011/12.

Reservoir Zone	Policy Minimum (Ml/d)		Nightline (Ml/d)		Comment
	2011-12	2015-16	2011-12	2015-16	
STREET END	0.0	0.0	0.0	0.0	No data
SHEDFIELD	0.8	0.8	1.4	1.1	
HOADS HILL	4.8	5.8	8.5	9.1	
FIR DOWN	0.4	0.4	0.5	0.5	
WEST MEON	0.0	0.1	0.1	0.1	
NELSON	2.6	2.5	4.0	9.5	
FORT SOUTHWICK	0.0	0.0	0.0	0.0	No data
GEORGE	1.9	2.1	3.1	3.1	
CLANFIELD	1.2	0.6	1.4	0.9	
LOVEDEAN	0.0	0.0	0.0	0.0	No data
CATHERINGTON	1.2	0.9	1.4	1.3	
RACTON	2.7	2.7	3.9	3.9	
APPLEDOWN	0.0	0.1	0.0	0.3	(was no data)
HIGHDOWN	0.0	0.0	0.0	0.0	No data
CANADA	0.0	0.0	0.0	0.0	No data
LAVANT	4.7	6.5	8.8	8.2	
LITTLEHEATH	7.7	6.6	10.4	8.9	
FARLINGTON	19.2	14.1	24.0	20.8	
WHITEWAYS LODGE	0.2	0.2	0.3	0.2	
COMPANY	**47.4**	**43.4**	**67.7**	**68.0**	

Table 3: Initial assessment of SMA-level policy minimum night flow and the SMA-level night flow that most closely mirrors the night flow used to assess annual leakage. Both have been summarised to RZ level.

Overall, the difference between annual average night flow and policy-minimum night flow at SMA level corresponds to a difference in leakage level of over 24 Ml/d for those providing data: the difference is even larger when pro-rata'd for SMAs not providing data. When one considers that the 2015/16 total leakage was 28.06 Ml/d, subtracting 24 Ml/d leaves 4 Ml/d. This corresponds to approximately 0.5 l/property/hour: much lower than other assessments of policy minimum and much lower than the UARL assessments used internationally. It also implies that the policy-minimum leakage level is less than zero in several SMAs. This difference between average and minimum is also 4 Ml/d greater than reported for the WRMP14 result. There are several possible explanations, but the most likely one is that the differences between average and lowest night flow are mainly due to differences in night use, rather than differences in leakage.

In 2014 we made an adjustment for the differences in night use by assuming that during the policy-minimum night flow period the larger night users (with night use greater than 8 l/hr) are not using water, we obtain a smaller difference in night flow losses, corresponding to a difference of between 4 and 8 Ml/d (depending on the assumptions used). This appeared to be more realistic, and was also more consistent with the relatively low detected NRR.

For this analysis we also looked at the distribution of policy minimum values between individual SMAs in an effort to identify SMAs that could be contributing to such a low policy-minimum value. The graph below shows the difference between the median of four years of average annual night flows and median policy minimum night flow values for the four years from 2012-13 to 2015-16.

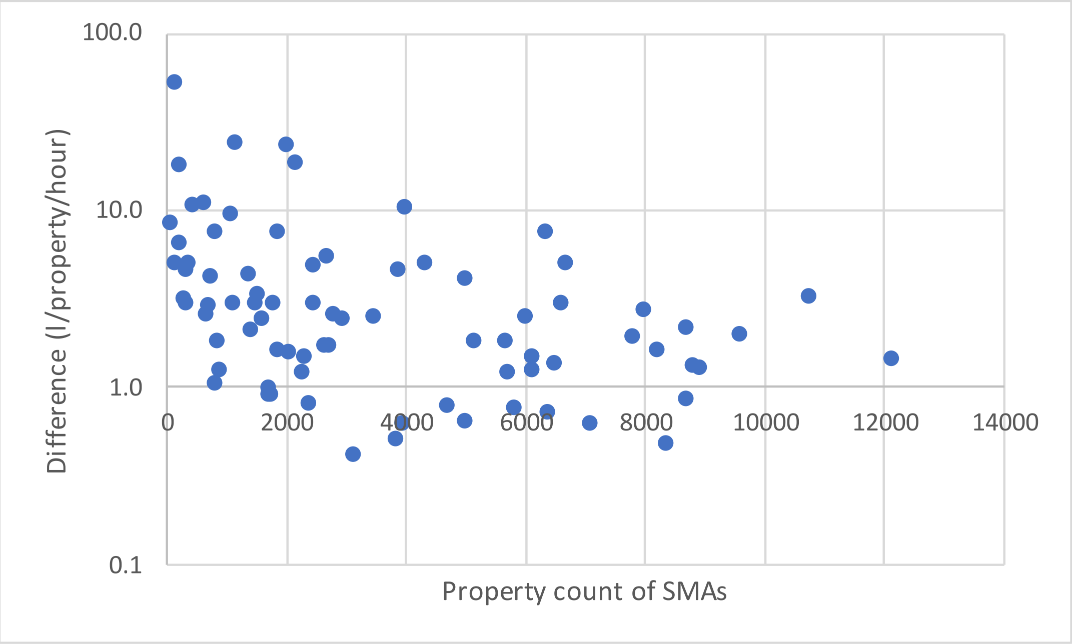

Figure 5: Difference between median annual average night flows over four years and the assessed policy minimum over the same period for individual SMAs.

This graph shows that while there is a spread of values, the median difference is around 1 to 3 litres/property/hour. The histogram below of the same data shows the same point.

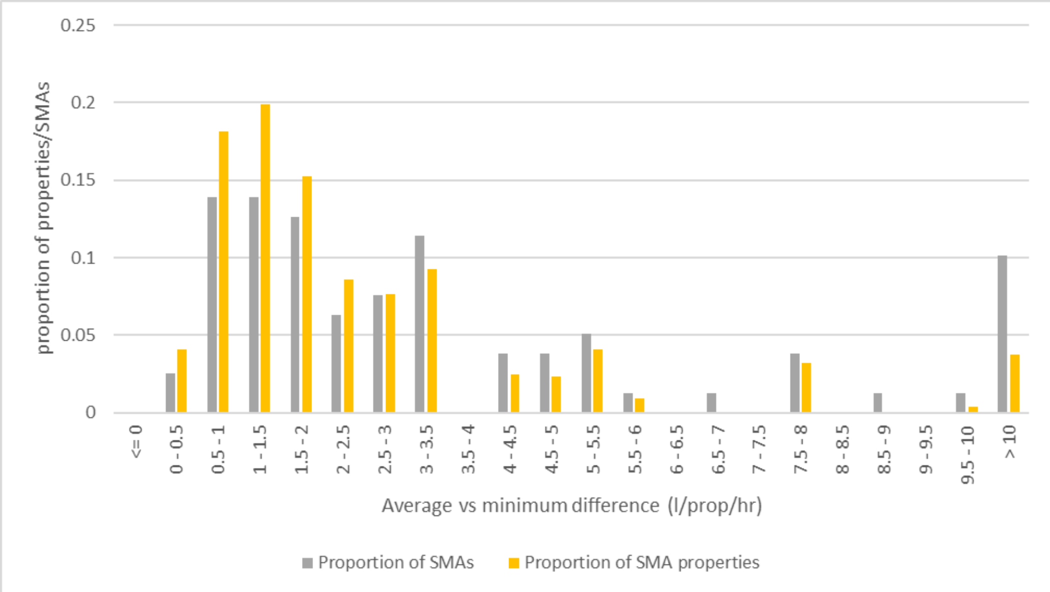

Figure 6: Histogram of difference at SMA level between median average night flow over four years and median policy-minimum night flow over the same period

This indicates that the difference (excluding very high outliers) between the average night flow and the policy-minimum night flow should be around 2 l/prop/hr, or approximately 12.6 Ml/d. The median value, including outliers, is 2.5 l/prop/hr, or 18 Ml/d. Using the 2015/16 leakage level (adjusted by 5.1 Ml/d to be consistent with the "consistent" leakage reporting) this indicates that this component of the policy-minimum leakage is between (33.2-12.6=)20.6 Ml/d and (33.2-18=)15.2 Ml/d. However, using the average (adjusted for consistency) leakage value over the four year period of 34.7 Ml/d indicates that policy minimum is in the range (34.7-12.6=)22.1 to (34.7-18=)16.7 Ml/d

3.1.2 Repair Time

Over the last four years data on repairs has been much more reliable than previously. However there has not been a significant change in the run time of leaks, which have remained around 14 days. Therefore, the policy-minimum component due to repair time probably remains around 1.0 Ml/d.

3.1.3 Overall Policy-Minimum

The uncertainty in policy-minimum is very large, partly due to the significant uncertainty in the actual night use during the policy-minimum. However it appears that the total policy-minimum leakage is in the range 17.7 to 22.5 Ml/d. We have used a value of 20.1 Ml/d in the analysis: the mid point of the range. This corresponds to 2.5 litres per property per hour in the "consistent" methodology. In the established methodology this would be 1.9 litres per property per hour: a low figure when compared to that used historically and in other companies.

3.2 The Cost of Water

The term "marginal cost of water" is used within many of the Sustainable Economic Level of Leakage models. However it really reflects the marginal benefit of a reduction in leakage. The calculation reflects the benefits seen in each zone when leakage is reduced and should comprise the following components:

- Volume-dependent cost savings at source works seen by the company; typically power, chemicals and other volume-related costs such as maintenance of activated carbon filters.
- Changes in the cost of pumping within the network (primarily power costs)
- Carbon cost saving, typically driven by the electricity saving due to less pumping in the network and at sources.
- Capital deferral seen by the company if supply-demand investment is required within the planning horizon. This component is excluded if the company undertakes a least cost planning exercise to avoid double counting the benefit of deferral, or if there is no projected capital requirement to maintain the supply-demand balance (as in this case).
- Environmental benefit of reduced abstraction,

The proportions of average water costs for Portsmouth Water as a whole are summarised in the table below:

Type	Proportion of water cost
Power at sources	73%
Chemicals at sources	11%
Activated carbon and "other" at sources	7%
Pumping within the network (boosters)	6%
Carbon costs	2%

Table 4: The breakdown of average water cost between types of expenditure

Portsmouth Water maintains a listing of the operating costs of the various sources and which sources could be used to supply each Reservoir Zone. The listing was used to estimate the cost of the most expensive source for each zone, as the initial assumption for the SELL is that the most expensive source in each zone will be the one that is reduced following any reduction in leakage. The marginal cost of water for each reservoir zone is shown in Table 5 below.

Reservoir Zone	Average cost (source cost only) (p/m^3)	Most expensive source (source cost only)(p/m^3)
STREET END	3.85	3.85
SHEDFIELD	3.85	3.85
HOADS HILL	4.64	9.68
FIR DOWN	2.58	2.58
WEST MEON	8.95	24.03
NELSON	6.45	6.45
FORT SOUTHWICK	22.75	22.75
GEORGE	8.29	9.60
CLANFIELD	10.18	10.18
CATHERINGTON	5.94	10.18
RACTON	4.12	4.12
APPLEDOWN	1.55	1.55
HIGHDOWN	5.37	5.37
CANADA	-	-
LAVANT	5.32	7.63
LITTLEHEATH	3.63	7.63
FARLINGTON	2.72	3.55
WHITEWAYS	7.26	7.26
Volume-weighted Average	**4.44**	**6.29**

Table 5: Marginal costs of water for Reservoir Zones

The marginal cost of water for the company is **6.29** p/m^3 if the most expensive available source was used, as shown in Table 5. Including weighted average booster costs and carbon cost brings this up to **7.25** p/m^3.

A review of the marginal cost of water in September 2017 indicated that:

- The marginal cost of water production in Itchen WTWs is actually lower than previously considered and may be 4.30 p/m^3, vs the 5.18 p/m^3 calculated from the 2015/16 data. To this should be added booster costs and carbon, bringing the marginal cost up to 5.26 p/m^3. This source would provide the majority of any additional water that would be provided to Southern Water. However this had negligible effect on the weighted average highest cost marginal cost.

- The marginal value of the sale of water to Southern Water (15p/m^3) was likely to be a significant cost driver. Reductions in leakage would allow water to be sold to Southern Water without affecting the long term supply-demand risk for Portsmouth Water's customers. There is some uncertainty about how frequently Southern Water will require the transfer and hence what proportion of the leakage saving would really be provided to Southern Water on average.

So the options for considering the financial marginal cost of water include:

- The marginal cost of water production (including carbon and boosting within the network), using the weighted average of the most expensive sources in each reservoir zone. This would provide a marginal cost of 7.25 p/m^3.

- The marginal value of the sale of water to Southern Water at 15p/m3, on the basis that additional water made available by leakage reduction would not affect water production, but just allow that water to be transferred to Southern Water

- A point between 7.25 p/m^3 and 15 p/m^3, reflecting the fact that at some points only the savings from reduced production are available, whereas at others the additional water made available can be sold to Southern Water without increasing the supply risk to Portsmouth Water customers. This range reflects the as yet unknown variability in supply to Southern Water.

It was decided that the range 7.25 to 15 p/m^3 should be used, with a central value between these two: 11.125 p/m^3. This does not include the environmental benefits of reduced abstraction, which are quantified in 4.1.1 below.

3.3 The Detected and Total Natural Rate of Rise (NRR) of Leakage.

The repair data for the last nine years was used to assess the average number of each type of repair. This included both proactive (detected) and reactive (reported) repairs. The summary data is shown in Table 6 below.

Year ending	Repair or replace asset type				
	Main	S/V or mains fitting	Ferrule	Service	Stop Cock
05/04/2004	105	24	14	284	446
05/04/2005	378	74	51	983	2147
05/04/2006	348	75	71	1082	2178
05/04/2007	272	95	62	942	1783
05/04/2008	324	73	64	672	1724
05/04/2009	373	106	67	613	1719
05/04/2010	303	88	75	498	1667
05/04/2011	260	73	100	402	1517
05/04/2012	264	63	63	413	1466
05/04/2013	293	28	21	198	242
05/04/2014	192	218	5	786	1149
05/04/2015	282	171	20	956	935
05/04/2016	228	131	22	588	781

Table 6: Repair data from 2003/04 to 2015/16

There are some definite trends in the data. Over the 13 years the pressure management of the company has changed and this is likely to have influenced the numbers of repairs. The trends in repair numbers are indicated in the graph below using the average of all the data as the baseline.

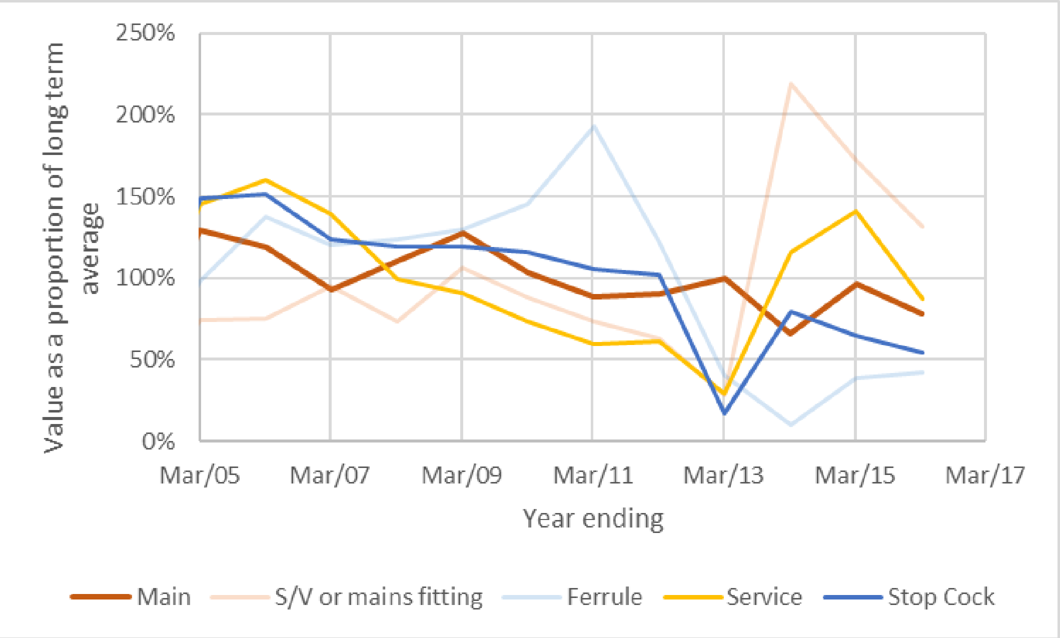

Figure 7: Change in repair numbers as a proportion of long term average.

The numbers of ferrule and mains fittings repairs are small, so trends in these are unimportant. However service, main and stop cock repairs have reduced since 2005. The main influence on this is likely to be pressure management. There was a significant increase in service repairs in 2013/14. This is almost certainly due to a change in source for the data: using customer-reporting records rather than direct repair data. Stopcock repair data was incomplete for 2012/13, which explains the apparent dip at that point. Mains repairs have continued their downward trend.

We assessed the number of detected and reported repairs by reference to the detection records. The proportion of detected mains bursts and services is shown in the table below.

Year	Main	S/V or mains fitting	Ferrule	Service (inc customer side)	Stop Cock
13/14	50%	42%	60%	49%	26%
14/15	38%	45%	65%	57%	36%
15/16	26%	48%	91%	53%	36%
Average	37%	44%	77%	53%	32%

Table 7: Proportion of repairs detected

The proportion of detected mains repairs (37%) appears to have increased markedly since WRMP14, when only 22.3 % of mains repairs were identified as detected. The proportions of service repairs detected, at 53% is also markedly higher (cf 42% at WRMP14). However the trend in repair numbers generally is down over the long term and this means that the rate of recurrence of detected leakage (or Natural Rate of Rise) is reasonably stable.

These proportions detected are high compared to typical other companies, though probably not an outlier. The high proportion detected may be due to one or more of several factors including the relatively low average pressures reducing the probability of leaks coming to the surface, local geology or an efficient leakage monitoring system that identifies leaks before they are reported.

To assess the detected NRR (NRRd) we need an estimate of the flow rate of individual leaks. The 1994 Managing Leakage reports (WSA & WCA Engineering and Operations Committee, 1994) set out some estimates for flow rates of individual leaks. However the Managing Leakage 2011 reports (UKWIR, 2011) point out that these flow rates are much higher than those now typically found. Therefore we have estimated the flow rates, ensuring they are significantly lower than the Managing Leakage 1994 flow rates.

It is worth noting that with the "Method A" approach, the aim, in developing the ALC cost curve, is to obtain the current steady state leakage level at the steady state level of expenditure. The NRR only influences the transition costs between leakage levels and this is not the main contributor to the shape of the total cost curve. Therefore the estimation of NRR used here should not produce significant uncertainties in the outcome. However the NRR and the difference between the policy-minimum and the current leakage levels should be reasonably consistent with each other: the ratio of detected NRR to the difference between average and policy-minimum leakage would be expected to be between 1 and 4 (corresponding to a theoretical intervention frequency of between 6 months and two years). The estimated leak flow rates are set out in Table 8 below.

	Mains repairs	Mains fittings	Service leaks
Flow rates (m3/hr)			
Reported	3000	180	300
Detected	1500	90	150

Table 8: Estimated leak flow rates

The estimated detected NRR is set out in Table 9 below.

	Mains	Mains Fittings	Services (inc private side and ferrules, excluding StopCocks
Detected repairs per year (average of three years	87.3	77.0	424.7
Detected leak flow rate(l/hr)	1500	90	150
Total annual flow rate (l/hr)	131000	6930	63700
Detected NRR (Ml/d/yr)	3.2	0.2	1.5

Table 9: NRR estimates from repair numbers

The estimated NRR is 4.9 Ml/d per year. The difference between the policy minimum and the average leakage is estimated at 17 Ml/d. So these two values are more or less consistent although it may indicate that the policy-minimum vs average leakage gap estimate is too large.

The NRR reported in Table 9 above only takes account of repair numbers and uses the company property-weighted HDF of 24.3.

We have not attempted to asses the detected NRR using the gradient method (UKWIR, 2005). Instead we have assessed the numbers of detected leaks and estimated the flow rate of the leaks. This gives a reasonable estimate of the NRR.

3.4 Detection, Repair and Monitoring costs

The summary company level costs for the five years to 2011/12 and the budget for 2016/17 are shown in the table below

Actual costs	2007/08	2008/09	2009/10	2010/11	2011/12	2016/17
Location Costs	£127,343	£209,553	£155,874	£194,092	£177,628	£263,398
Repair Costs	£1,095,668	£1,284,707	£921,124	£1,280,403	£1,259,533	£1,590,221
Monitoring Costs	£132,761	£148,879	£112,492	£153,986	£159,864	£237,056
TOTAL COST	**£1,355,772**	**£1,643,139**	**£1,189,490**	**£1,628,481**	**£1,597,025**	£2,090,675

Table 10: Leakage related costs for six years

These costs are set out in the table below corrected to 2016/17 prices using RPI.

At 2016/17 prices	2007/08	2008/09	2009/10	2010/11	2011/12	2016/17
Location Costs	£160,969	£266,250	£189,278	£224,063	£198,720	£263,397
Repair Costs	£1,384,985	£1,632,300	£1,118,527	£1,478,120	£1,409,095	£1,590,221
Monitoring Costs	£167,817	£189,160	£136,600	£177,764	£178,846	£237,056
TOTAL COST	£1,713,772	£2,087,711	£1,444,407	£1,879,949	£1,786,663	£2,090,675

Table 11: Leakage related costs in 2016/17 prices

This table shows that current budget costs are actually reasonably consistent with expenditure in the period up to WRMP14 when inflation is taken into account although monitoring costs have increased slightly.

We should view the monitoring and location costs as variable. However repair costs, in the long term, will not vary as significantly with changes in leakage level by ALC. Repair costs tend to peak during changes in detection activity and then fall back to, typically, a higher level than before as smaller leaks are found by the more intensive detection. The effect of the peak in repairs should certainly be included. The second effect is not so clear cut. It is quite possible that the larger number of smaller leaks is driven by the way detection staff are motivated and measured and that different management approaches could reduce this effect. Therefore we will not take account of this effect here.

TMC

4 Calculating the Short-Run SELL

4.1 ALC Cost Curves

We have used the "Method A" (Tripartite Group (Ofwat/EA/Defra), 2002) approach to derive ALC cost curves with a hyperbolic relationship between leakage and detection cost.

At whole company level the steady state ALC cost curve would be as shown in Figure 8 below.

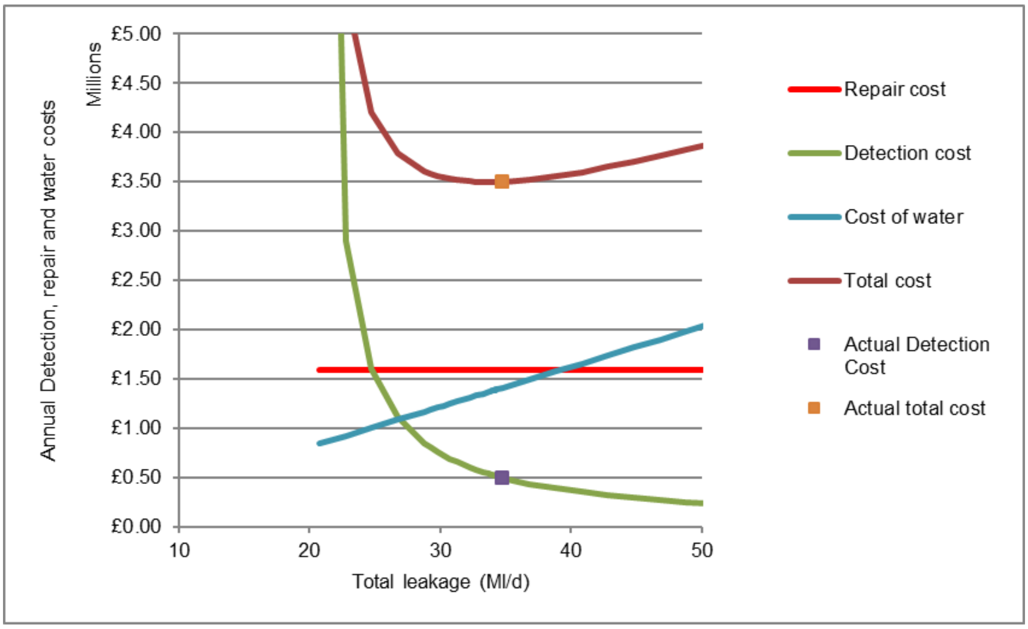

Figure 8: Steady state ALC cost curves for the whole company: internal costs only.

Note that Figure 8 uses the assumption that repair costs are independent of leakage level. In reality at lower levels of leakage the repair cost is likely to be higher, so the minimum point on the curve would be at a higher leakage level than shown here and this is covered below. Also note that this cost curve is based on 29.6 Ml/d average leakage, rather than the 28.06 Ml/d from 2015/16, which was a particularly benign year.

4.1.1 Including External Costs

Following the approach set out in the Review of SELL (Tripartite Group (Ofwat/EA/Defra), 2012), (Ofwat, 2007), the external costs of leakage management are £148.34 per repair. This cost increases the cost of repairs. However it will not move the minimum cost point in the cost curve, because transition costs are not yet being considered. The effect of changing numbers of repairs (and hence repair costs) during transitions to different leakage levels is examined in Section 4.1.2 below.

The external value of water should include environmental value of leaving water in the environment. However, Portsmouth Water is in the unusual position that water that is not abstracted from its main source returns to Portsmouth Harbour. The beneficial effects of freshwater in the harbour have been discussed elsewhere. The net impact (reported by Portsmouth Water for PR09) is that as long as the water entering the harbour exceeds a certain flow rate there is not additional benefit from additional flow and therefore the marginal environmental cost of water from this source is zero.

In these circumstances we took an alternative approach in PR14. We worked with Portsmouth Water to identify the sources with least environmental impact of abstraction and used this to assess how the abstraction would be adjusted to minimise environmental impact. We then assessed the marginal cost of water that would arise from this approach. The net effect was to increase the marginal cost of water to 9.06p/m^3. This compares to the 6.29p/m^3 of financial marginal cost of production discussed in Section 3.2 above: an increase of 2.77 p/m^3.

Another alternative approach considered was to use the Environment Agency abstraction licence fee of 2.83 p/m^3 as a marginal cost (even though it is not a true marginal cost, because it does not vary with actual abstraction).

Together these two different approaches give a very similar addition to the marginal cost of water of approximately 2.8 p/m^3. This is the value used to reflect the value of reduced abstraction. Adding 2.8 to the existing marginal cost of 11.1 p/m^3 this makes the central estimate of the marginal cost of water, including the environmental benefits of reduced abstraction, 13.9 p/m^3.

The graph below shows the effects of including the environmental benefits of reduced abstraction and the increased cost of repairs due to traffic disruption costs. Note that although the external cost of repairs is increased, the leakage level of the minimum in the total cost curve is only affected by the marginal cost of water change, not the external cost of repairs.

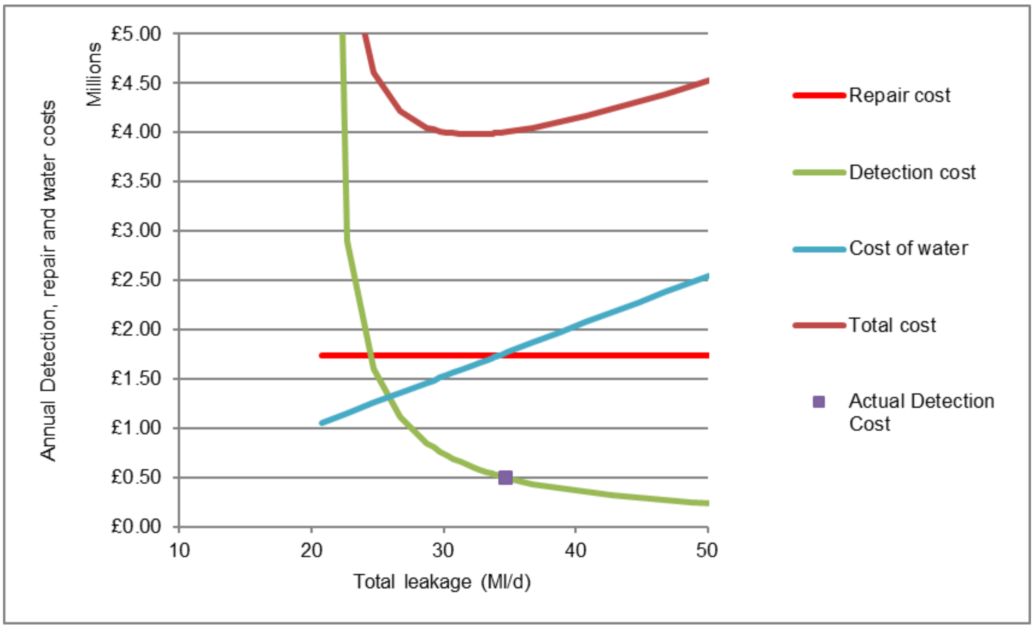

Figure 9: Steady state ALC costs as a function of total leakage, including external cost of repairs and increased marginal cost of water

4.1.2 Including transition costs

If we include transition costs in the effect of ALC, then the total cost of repairs will increase. For each 1 Ml/d of leakage reduction, additional repairs are required. Assuming the same size of leaks as used in the NRR estimation we can assess the numbers of leaks required and assess the cost of these extra leaks (including the external cost of repairs). This extra cost can be annuitized. The effect of this can be seen in the graph below, where the repair cost increases as leakage is reduced, leading to an increase in the leakage level at minimum total cost.

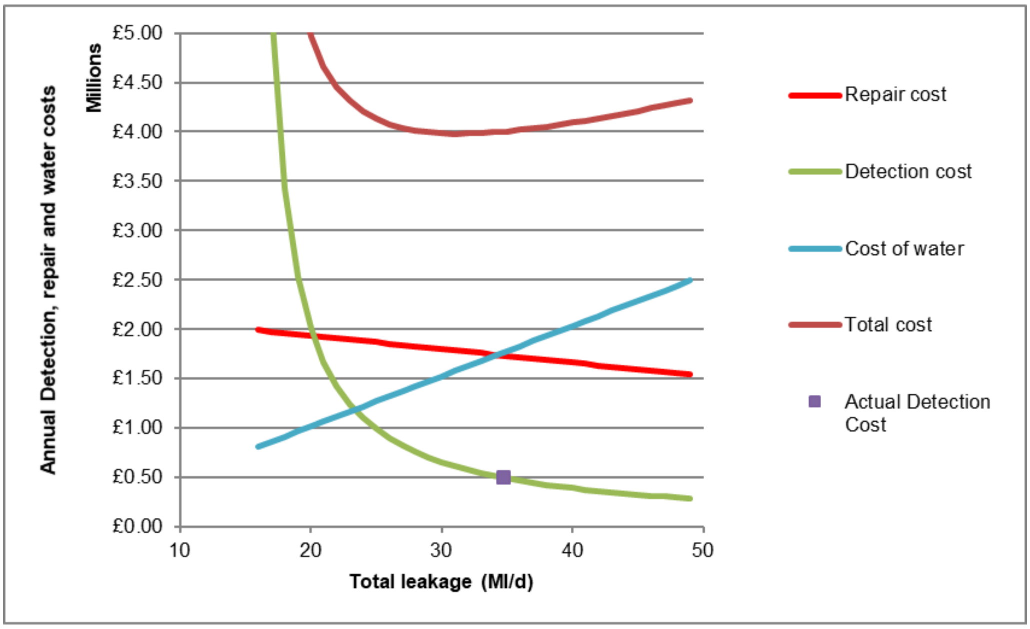

Figure 10: Cost curves for ALC including transition costs.

The point where total costs are minimised is 29.1 Ml/d. However the cost curve is reasonably flat and if we set a range of possible values based on a total cost being within 5% of the minimum value we obtain a range between 23 Ml/d and 39 Ml/d. It may be better to set a range based on a sensitivity analysis. This is set out in the following section.

4.1.3 Sensitivity of ALC cost curves to NRR and policy-minimum and marginal cost of water

The shape of the total cost curve is affected by the values of detected NRR (NRRd) and policy-minimum. However there is a limit to how much NRRd and policy-minimum can vary independently. The graph below indicates the range in the total cost curve for the likely range of policy-minimum and detected-NRR values.

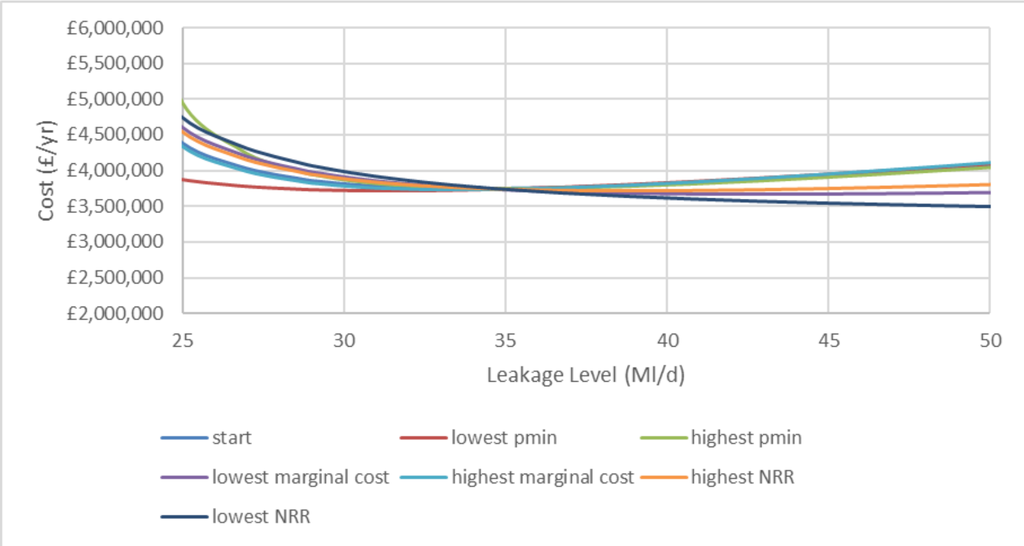

Figure 11: Cost vs. leakage for ALC including external and transition costs for a range of NRRd, marginal cost of water and policy-minimum values

The leakage level for the minimum values in these cost curves are shown in the table below.

	Parameter change	leakage at minimum cost (Ml/d)
Starting value	none	34.2
lowest pmin	From policy min 20.1 to 15.1 Ml/d	31.2
highest pmin	From policy min 20.1 to 22.0 Ml/d	34.8
lowest marginal cost	From 13.9 p/m3 to 75.7 p/m3	42.9
highest marginal cost	From 13.9 p/m3 to 17.8 p/m3	32.1
highest NRR	Twice the default value of 4.9 Ml/d/yr	38.8
lowest NRR	Half the default value of 4.9 Ml/d/yr	33.2

Table 12: impact of uncertainties in input parameters on the short run (ALC driven) SELL

This improved approach indicates that the short run SELL is between 31 Ml/d and 43 Ml/d and that the most important uncertainty is the marginal cost of water.

If these three main contributions to the uncertainty are treated as independent errors, then by RMS addition of errors, the range of the SELL is between 32.0 Ml/d and 39.9 Ml/d.

4.1.4 Uncertainties due to Modelling Assumptions

The UKWIR report on leakage costs curves (UKWIR, 2011) identified the hyperbolic curve as probably more reliable than a logarithmic curve approach. The shape of both can be related to a physical explanation of the leak detection process. An alternative cost curve for ALC was developed for the UKWIR long term leakage project (UKWIR, 2011). We could use these alternative curves to derive a range of outputs to examine the impact of alternative modelling approaches and hence the uncertainty due to the modelling assumptions. The equations for the logarithmic cost curve are set out in Appendix C of the 2002 Tripartite Best Practice Report (Tripartite Group (Ofwat/EA/Defra), 2002). There are two fitting parameters for this curve: we have set the "n" parameter at the value set out in the Tripartite report and varied the "A" parameter to obtain the current leakage level at the current cost. Using one of the curves in Figure 11, the equivalent curve using the logarithmic approach is shown in **Error! Reference source not found.** below.

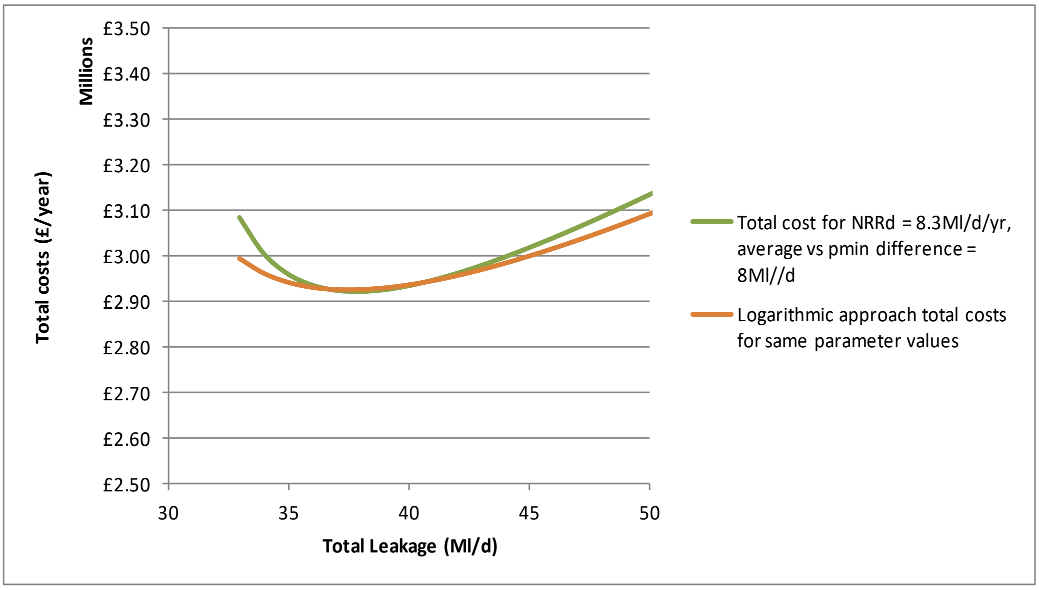

Figure 12 Comparison of hyperbolic and logarithmic cost curves

The logarithmic cost curve is flatter with, in this case, a very similar minimum point. This indicates that the uncertainty due to differences in modelling method is not likely to be significant.

4.1.5 Conclusions for ALC

Overall, the results of the modelling indicate that the Short-Run SELL, taking only ALC into account, is in the range 32.0 to 39.9 Ml/d with a central estimate of 34.2 Ml/d.

This range could be tightened significantly by reducing the range of possible marginal costs of water.

4.2 Pressure Management in the Short-Run SELL

At WRMP14 there had been a dramatic reduction in the hour day factor due to a change in the operation of the PRVs feeding Portsmouth and Gosport. It is not expected that there will be any further significant changes in the hour day factor.

In the summer of 2013, following the production of the draft WRMP, Portsmouth Water employed Hydroco to review models of the PW network and identify potential pressure management schemes. The results of this are set out in three pressure management study reports for Racton, Littleheath and Lavant. A further study was carried out by Tooms Moore Consulting to look for other potential schemes. As a result of these projects several options were identified and investigated and the feasible ones were installed and commissioned.

The whole of the PWC area, with the exception of a few villages, operates at reasonably low pressures. The further opportunities for pressure management are very limited and it is very unlikely that any of the remaining pressure management options would have negative average incremental costs.

4.3 Efficiency Improvements in the Short-Run SELL

The projected Short-Run SELL (assuming no efficiency improvements) is likely to increase over the WRMP's 25 year forecast period due to expansion of the network. At the same time the efficiency of leakage management is likely to improve. We propose that we should assume that small ongoing efficiency improvements keep pace with the expansion of the network, so that the Short-Run SELL remains stable over the period. However we have also examined the potential of more DMAs as a way to improve efficiency and this is covered in the section below.

4.4 Subdivision of the network into DMAs in the short-run SELL

The Portsmouth water network is divided into SMAs, Strategic Meter Areas. The average size of these is 3500 properties, but some are much larger: the largest is Stubbington, with 12099 properties. One opportunity for reducing leakage is to subdivide the network into much smaller DMA (District Meter Areas, or Distribution Monitoring Areas), so that the search area for each leak that occurs becomes much smaller. In total 288 potential DMAs have been identified and costed by PWC, including the metering of some areas that are not currently within SMAs.

4.4.1 Initial analysis – now superseded

This section summarises a review of the cost effectiveness of DMAs to determine if they provide a economic solution to reduce leakage. The analysis has assumed the expenditure on active leakage control (ALC) will remain unchanged, but an estimate of the leakage saving at this level of ALC made.

The SMA nightlines were used to estimate the average nightline and policy minimum nightline within each SMA. A factor was applied to the nightlines to ensure they were consistent with the company reported leakage of 33.2 Ml/d (in the "consistent" method: 28.1 Ml/d in established method).

Introduction of DMAs was assumed to result in a reduction in policy minimum (by 20%) and in reducible leakage (by 50%) if ALC expenditure was maintained at the current levels. These estimates are consistent with a typical reduction in leak run times, and with estimates made by the Company. This was compared to an alternative approach: in theory the cost of detection is approximately proportional to the search area for any given leak. By assessing the reduction in search area required for each SMA for an individual leak and how that extra efficiency would be used to find more leaks a very similar reduction in reducible leakage was estimated, validating the 50% assumption.

The Company provided the cost per SMA of converting to DMAs – the total cost of the 101 SMAs included with the sample analysed in detail was £4.14M.

SMAs were ranked based on the capital cost per Ml/d of leakage reduction, and then grouped into 11 tranches. This analysis indicated that 4.45 Ml/d of leakage savings (tranche 0-4) have a benefit cost ratio greater than one, with a total capital cost of £571k. This analysis has now been superseded by improved data.

4.4.2 DMA analysis from September 2017 with improved cost data

Following on from this work more data was provided on the costs of installing 139 DMAs. These covered 61 SMAs and excluded some already complete DMAs and some small whole SMAs that effectively already formed DMAs. It included construction of DMAs in currently unmonitored parts of the network.

The DMAs were assigned to SMAs and divided into tranches and the costs and savings estimated using the same assumptions as before. The DMAs were grouped into schemes that covered whole existing SMAs. To take account of the fact that some SMAs had previously been un-monitored as SMAs, because they were fed directly from the reservoirs, the initial leakage savings from these were assumed to be twice the average per property saving for the others. This is based on experience in other companies where newly monitored areas tend to have some long standing leaks.

The graph below shows the projected leakage savings vs the average incremental cost of installing DMAs (including capital cost, maintenance but not leakage savings).

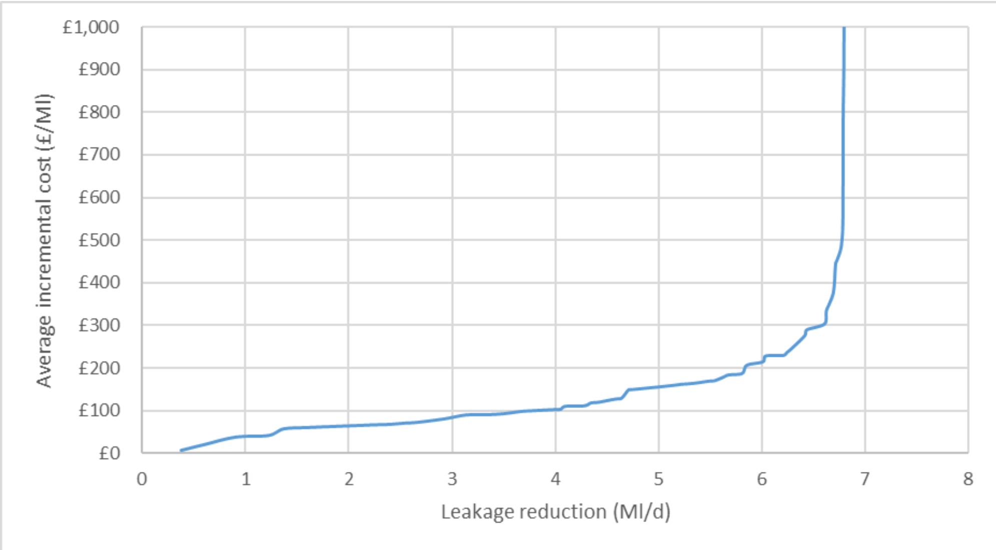

Figure 13: AIC vs leakage reduction for DMA installation.

Reading off the marginal cost of water against the left hand axis in the graph shows that for a marginal cost of £139/Ml (13.9p/m^3) the saving that could be made at zero net present cost is 4.7 Ml/d.

These savings are divided into 11 tranches. The table below indicates the expenditure that would be required for each tranche of work.

tranche	Capital cost	Investigation cost	Maintenance cost per year	present cost of capital, investigation and maintenance (£)	Leakage saving (Ml/d)	Value of water saved at central marginal cost (£/yr)	Present value of savings (£)	Benefit/cost ratio	Net present cost at central marginal cost (£)	Average incremental cost exc water (£/Ml)
0	£26,636	£6,000	£539	£40,291	0.597	£30,346	£431,292	10.70	-£391,001	13.01
1	£96,010	£12,000	£1,680	£131,889	0.620	£31,534	£448,179	3.40	-£316,290	40.98
2	£155,751	£21,000	£2,767	£216,078	0.672	£34,153	£485,401	2.25	-£269,322	61.99
3	£125,812	£18,000	£2,263	£175,980	0.497	£25,255	£358,937	2.04	-£182,956	68.27
4	£226,571	£30,000	£4,010	£313,570	0.746	£37,928	£539,045	1.72	-£225,476	81.00
5	£196,495	£30,000	£3,586	£277,465	0.565	£28,737	£408,424	1.47	-£130,959	94.60
6	£394,574	£60,000	£7,195	£556,830	0.941	£47,843	£679,966	1.22	-£123,135	114.03
7	£166,557	£27,000	£3,083	£237,367	0.298	£15,152	£215,344	0.91	£22,023	153.49
8	£440,890	£51,000	£7,604	£599,958	0.695	£35,348	£502,383	0.84	£97,575	166.30
9	£484,527	£66,000	£8,627	£673,132	0.609	£30,972	£440,187	0.65	£232,945	212.94
10	£742,757	£96,000	£13,084	£1,024,707	0.555	£28,238	£401,325	0.39	£623,381	355.55

Table 13: Estimated costs and savings from installation of DMA

4.4.3 Conclusion for new DMAs

This result for new DMAs indicates that 4.7 Mld of leakage could be saved by installation of tranches 0 to 6 of new DMAs at negative AISC for the marginal cost of water of 139 £/Ml (13.9 p/m^3). The one-off cost of this activity would be £1.4million. The error in the projected saving is estimated to be +- 1.5Ml/d.

4.5 Results and conclusions for short-run SELL

Including both optimising Active Leakage Control and creating new DMAs the projected SELL using the marginal cost of 139 £/Ml is estimated at 24.4 Ml/d. The range is estimated from RMS addition of errors as 22.5 to 28.6 Ml/d. The table below shows the variability of the SELL in response to the marginal cost

Marginal cost of water (£/Ml)	Short-run SELL: ALC only (Ml/d)	Short-run SELL: ALC and DMAs (Ml/d)
50	59.9	58.7
60	49.6	48
70	45.1	42.7
75.7	42.9	40.2
100	38.1	34.4
139	34.2	29.5
150	33.6	28.9
178	32.1	26.5
200	31.3	25.4

Table 14: The impact of changes in marginal cost of water on short run SELL

The same data is shown in the figure below.

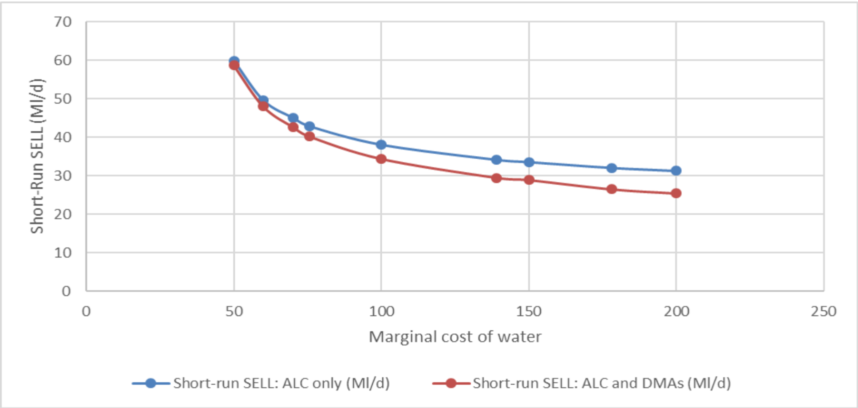

Figure 14: SELL as a function of marginal cost

This saving could not be achieved immediately but would require a programme over AMP7 to achieve the SELL.

5 Other options for further Leakage Reduction

5.1 Options for further ALC beyond the Short-Run SELL

5.1.1 More intensive leak detection

More intensive leak detection could provide further leakage reductions beyond the Short-Run SELL. Using the cost curves developed in Section 4.1, we estimate that the relationship between Average Incremental Social Cost (AISC) and the leakage level that can be achieved by ALC is as shown in the figure below.

The ability to make a reduction would be modified by the introduction of DMAs. So there is a significant risk of double counting of benefits. We have selected a low estimate of policy-minimum leakage, which is equivalent to a very low background leakage estimate and this makes it appear that significant savings are possible at relatively low cost. If the background leakage is actually higher then the cost of further reduction will also be much higher.

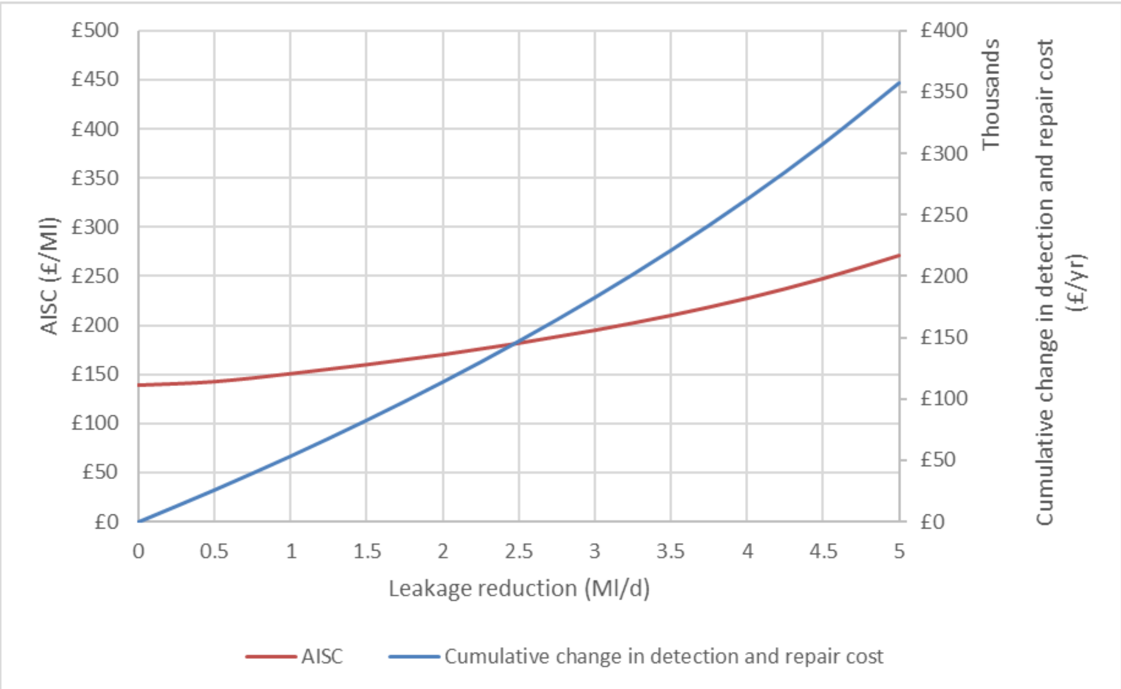

Figure 15: AISC of leakage reduction by more intensive ALC

5.1.2 Targeted reduction of leakage in SMAs with high policy-minimum leakage

In the WRMP14 SELL analysis we identified an option for targeted leakage reduction in high policy-minimum leakage SMAs. However we have also identified an option to introduce DMAs and use these to reduce leakage substantially. There is significant double-counting of benefits between these options, so we have not included the targeted reduction as a separate option.

5.2 Options for Further Pressure Management

The options for further pressure management at a DMA/SMA level are now very limited. Some limited pressure management has been identified as a possibility as part of the introduction of DMAs. Further reductions are possible at sub-DMA level and we have used the UKWIR long term leakage targets pressure vs expenditure relationship to estimate the cost of further pressure reduction.

The property-weighted AZP for Portsmouth Water is 32.73 metres head. Inserting this into the Long Term Leakage Goals pressure management cost curve (with modelled costs inflated by RPI from 2007-08 to 2016-17). The result is shown below.

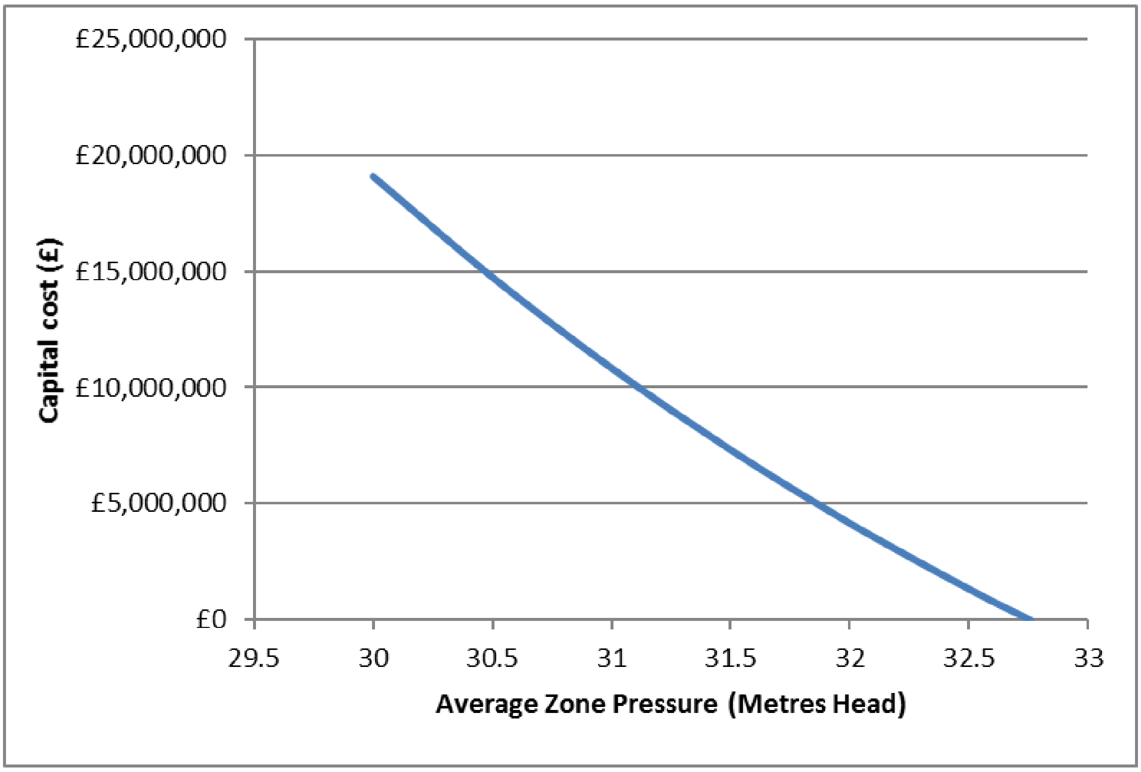

Figure 16: Estimate of the capital cost of reducing AZP, using the pressure vs. cost relationship from the UKWIR Long Term Leakage Goals project

Including assessments of changes in operating cost and assessing the effect of pressure management on leakage levels, the net present cost vs. leakage reduction, and AISC cost curves can be derived. These are shown in the graph below.

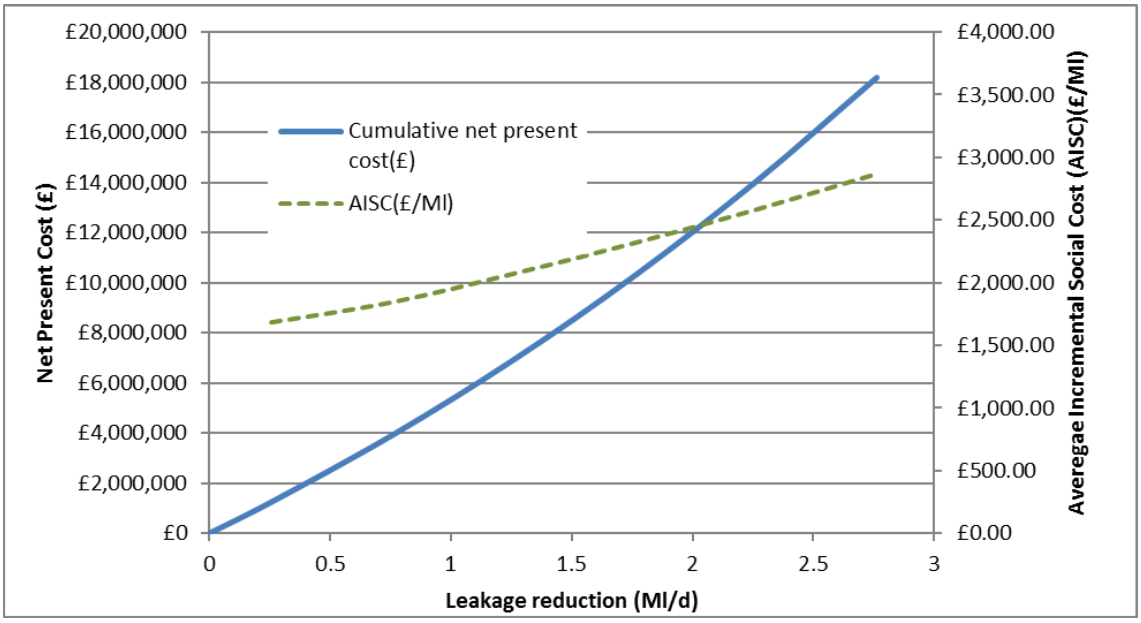

Figure 17: Cumulative net present cost and AISC estimates as a function of leakage reduction by pressure management using the UKWIR Long Term Leakage Goals pressure vs. cost relationship estimate.

The results appear to show that the AISC of leakage reduction by pressure management is in the range £1500 to £2600 per Ml. This result should not be viewed as a reason not to look for cost effective further pressure management. However it does indicate that the scope for cost effective further pressure management is limited.

5.3 Options for Infrastructure Renewal to Reduce Leakage

Infrastructure renewal for leakage reduction is closely bound up with the renewal programme. Work carried out for PR14 and reported as part of the SELL analysis in 2014, indicated that it may be possible to achieve small leakage reductions (of around 0.5 Ml/d) by renewal without increasing the total cost of renewal and that further leakage reductions of 0.5 or 2.5 Ml/d could be achieved by changed targeting of renewal combined with a greater length of renewal. Taking a simplistic view this data indicated that a further leakage reduction by additional renewal would cost of the order of £3million per Ml/d for the first 0.85 Ml/d, and £2.1million per Ml/d for the next 1.0 Ml/d and £1.6million for the next 1.0 Ml/d. This is equivalent to AISCs between £130/Ml and £330/Ml if it is assumed that savings last 50 years rather than the 10 or 15 years assumed for operational solutions such as ALC or pressure management.

For PR19 PWC commissioned a report from WRc on renewal options. In our opinion, the strategies should provide a useful input to the SELL/WRMP process, both to quantify the 'free' leakage benefit of a strategy targeted at bursts and alternative strategies targeted at leakage reduction. Although the report presents eight strategies (a "do nothing" plus seven alternatives) there are effectively four that we consider we could include:

2) Renew 110 km in AMP7 focussed on bursts, which is predicted to reduce leakage by 1.86 Ml/d by the end of AMP7

3) Renew 55.1 km in AMP7, which will maintain the burst rate, but also reduce leakage by 1.59 Ml/d by the end of AMP7

5) Renew 95.5 km in AMP7, which will maintain the burst rate, water quality and target PVC mains, and will also reduce leakage by 1.61 Ml/d by the end of AMP7

8) Renew 200.0 km in AMP7, which will maintain the burst rate but also reduce leakage by 5.00 Ml/d by the end of AMP7

The approach appears to be robust, particularly the impact on bursts: it makes use of a cohort based approach and the mains renewal groups used by Portsmouth Water. The impact on leakage is based on the UKWIR/CP135a equation, which was developed in 2007. This is a regression through data from mains renewal schemes which were mainly driven by water quality or bursts, and not leakage. We have experience of using this approach in the past, and although it has a number of shortcomings we think it is suitable for a high-level planning estimate. As it is based on schemes where a leakage reduction was not the primary driver it may under-estimate the benefit. However as estimates that result in an increase in leakage are excluded they will tend to over-estimate the benefit. At a high-level these impacts may largely cancel, but there is a significant risk that they will not. Our experience of other large scale renewal schemes indicates that much of the reported leakage saving is actually an increase in recorded consumption that gets recorded as a post-scheme leakage reduction in the water balance. While this may happen in Portsmouth Water there is a risk that it will not.

The four options could readily be reduced to two alternative options: a "free" reduction of 1.59 to 1.86 Mld that would be included in a baseline leakage projection or a 5.00 Ml/d reduction at a capital cost of between £30m and £50m. If reductions in bursts are not included (as the scheme sets out to maintain burst rates) this implies and AIC of between £740/Ml and £1290/Ml.

5.4 Options for Supply Pipe Leakage Reduction

The SELL review report (Tripartite Group (Ofwat/EA/Defra), 2012) recommended that Companies should consider developing separate SELL models for supply pipe leakage. The other leakage options already have an impact on supply pipe leakage. Additional leakage reduction options for supply pipes include:

1. Increasing the rate of take-up of metering, by voluntary or compulsory means. This could be combined with smart metering options.

2. Smart metering of existing externally metered properties to identify existing leaks on supply pipes and give immediate warning when new leaks occur.

3. Temporary monitoring of supply pipes to identify leaks.

4. Targeted replacement of supply pipes and categories of supply pipes with high failure rates.

5. Changes to supply pipe repair payment policies

Simple estimates for option 1 indicate that cost of the option (for all unmeasured households) is of the order of £60 million with a saving of 2.2 Ml/d (the number of unmeasured households multiplied by the difference between measured and unmeasured supply pipe leakage). This is equivalent to an AISC (Average Incremental Social Cost) of around £6000/Ml and a benefit/cost ratio of 0.01. This approach is very simplistic for an option that also influences customer consumption, but it does indicate that the option should not be included in the Short-Run SELL. Using smart metering as well might provide greater savings at an increased cost, with a similar order of AISC.

For option 2 (smart metering of existing externally metered households) the unit costs would be lower than for unmetered properties because the housing for the meter already exists. However the system set up costs for smart metering may be very high, especially in view of the relatively low meter penetration in the company. Savings in supply pipe leakage from smart metering are not simple to define, but assuming saving of 5 litres/day per supply pipe would give a saving of approximately 0.2 Ml/d at a capital cost of £2.4 million, equivalent to an AISC of £3150/Ml and a Benefit-Cost Ratio of 0.03. The business case for smart metering would be much more complex than simply leakage reduction, but it is clear that it can't be justified simply on leakage benefits in Portsmouth Water and should not be included in the Short-Run SELL.

Option 3: temporary supply pipe leakage monitoring, has developed since WRMP14. It is now possible to identify leaks on supply pipes even without a meter using the StopWatch system. This system has been used as a surrogate for other potential supply pipe survey options on the basis that the cost is known and it is currently one of very few providers in the market, so alternative costs are not available. The cost of a survey is around £25 per property. The evidence indicates that it will detect a leak on around 2% of properties and that the typical flow rates are 50 litres/hour, or 1200 litres/day. The repair cost of the 2% of properties with a leak is a small part of the total cost and is assumed here to have a cost of £300. If the recurrence rate of these leaks is low (they appear to be generally long lasting as leaks of this size have not historically been searched for) and a duration of ten years is assumed for the benefit, then the AISC of this survey is £450/Ml. Costs are likely to reduce to less than £150/Ml in the short term as the system becomes more efficient. For metered properties there was formerly a device (LeakFrog) that could be used to monitor continuous flows on meters. The AISC of this approach was lower, at £90/Ml, but the system is not longer available.

Option 4: targeted replacement of supply pipes, and option 5, changing repair payment policies, have not been considered here.

The supply pipe leakage reduction options considered did not find any options where the benefit-costs ratio was greater than 1, so none should be included in the Short-Run SELL. However it appears that option 3 could be considered if further leakage reduction was required.

5.5 Combining Further Leakage Reduction Options

The table below summarises the options for further leakage reduction beyond the Short-Run SELL:

Action	AISC range (£/Ml)	Potential leakage reduction on its own(Ml/d)	Notes	AISC range corrections (£/Ml)	Potential leakage reduction after double counting removed (Ml/d)
New DMAs	£13 to £356	4.7 Ml/d with AISC less than marginal cost of water, a further 2 Ml/d at higher AISC.	The 4.7 is already included in the SELL . Of the remaining 2.0, 0.4 is very high cost, leaving 1.6 Ml/d	£153 to £212	1.60 Ml/d
More intensive ALC	£0 to £150	5 Ml/d	Potential double counting of benefits with DMAs, pressure management and renewal. Uncertainty due to dependence on policy-minimum assumption. Factored down to account for double counting.	£237 to £431	3.15 Ml/d
Supply pipe leakage reduction by temporary monitoring	£343	7.2 Ml/d	Costs should reduce over the next few years but savings are uncertain. Factored down to account for double counting.	£772	3.20 Ml/d
Infrastructure renewal	£1290	5.0 Ml/d	Based on findings from WRc report (UC12759.02 Sept 2017). Potential double counting of benefits with other options. Factored down to account for double counting.	£2811	2.74 Ml/d
Further pressure management	£1500 to £2600	2.7 Ml/d	Uncertain costs and no specific sites. Potential double counting with all other options. Factored down to account for double counting	£2851	1.22 Ml/d

Table 15: Estimated leakage reduction impacts and costs, beyond the short term SELL

In combining these options, the main difficulty is in avoiding double counting of benefits. The simplest way to deal with this is to order the detailed options in order of AISC and then take account of benefits already obtained from the lower AISC options to recalculate the benefits of following options. Due to the benefits of introducing DMAs for the effectiveness of ALC, the additional DMAs have been included first (excluding the last tranche due to its high incremental cost) without changing detection expenditure (making a further saving of 1.6 Ml/d) followed by further ALC to achieve a total saving of 3.15 Ml/d, supply pipe survey, producing a further 3.2 Ml/d of saving, and then renewal and further pressure management and shortened repair times, giving a notional total saving of 11.9 Ml/d. The results of this process are set out in the graph below.

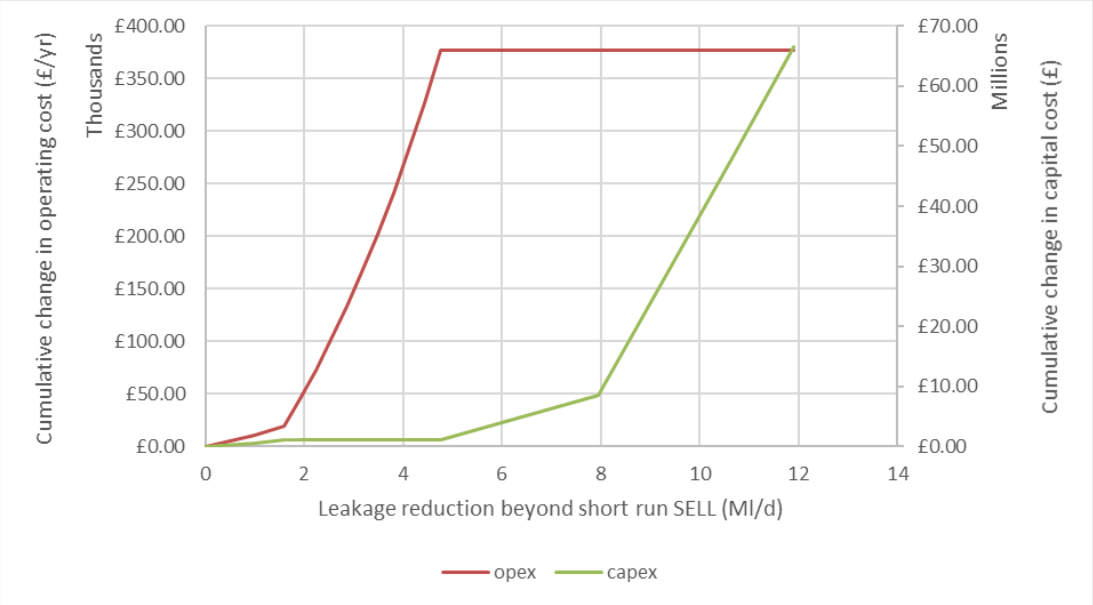

Figure 18: Capital and operating cost changes as a function of leakage reduction.

The Average Incremental Social Cost (AISC) of this is set out in the graph below

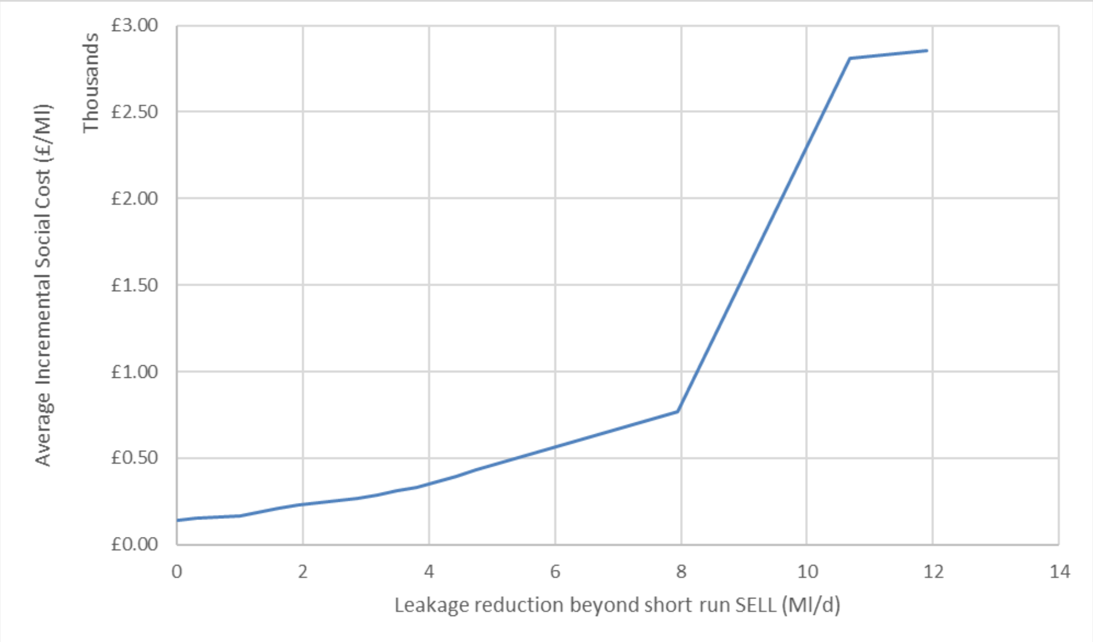

Figure 19: AISC of savings beyond SELL

It is clear from this graph that the AISC increases steadily through the reduction with a distinct jump in cost at the point where renewal is included at 8.0Ml/d reduction.

5.6 Conclusions for leakage reductions beyond SELL

It appears that a leakage reduction beyond SELL of a further 8 Ml/d could be achieved at a capital cost of £8.6million and an increase in operating cost of £377,000 per year. Further savings may be feasible, but costs increase beyond that point. This further reduction would lead to a total leakage of approximately 21.5 Ml/d under the "consistent" reporting methodology.