Winter 2020

National Water Resources Plan –
Draft Framework Plan
Technical Appendices

Appendix H
Sustainable Economic Level of Leakage Report

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Data Disclaimer:
This document uses best available data at time of writing. Some sources may have been updated in the interim period. As data relating to population forecasts and trends are based on information gathered before the Covid 19 Pandemic, monitoring and feedback will be used to capture any updates. The National Water Resources Plan will also align to relevant updates in the National Planning Framework.

1. Executive Summary

The Sustainable Economic Level of Leakage (SELL) is the optimum level of leakage, when balancing both the cost of leakage management and the cost of lost water. This incorporates internal costs, and externalities such as the cost of carbon. The SELL described in this report is referred to as the short run SELL and should be considered the optimum level of leakage for Irish Water, irrespective of supply-demand considerations.

This report has been prepared following a 2019 review and update of the Sustainable Economic Level of Leakage (SELL) for Irish Water, to provide current data for inclusion in the National Water Resources Plan (NWRP). The SELL was first estimated in 2015 for the Greater Dublin Area (GDA) by Atkins, and for Irish Water overall by Ryan Hanley in 2016. These estimates were carried out using the best available data at the time and applied two different methodologies. This report describes the sources of data used in the estimation of the SELL. The calculation itself is carried out using a model that collates the data inputs. This report describes the approach taken and assumes some prior knowledge and understanding of leakage economics and derivation of the SELL. This report is intended to provide technical detail in relation to the data and calculations and provide a summary of the outputs from the modelling. The SELL has been peer reviewed by Beal Consultants, to ensure the outputs presented are robust.

This update has been completed based on data that was available up to December 2019 and applies a single methodology that is in line with equivalent UK best practice where practicable. Whilst there remain a number of areas where data will improve significantly over the coming few years, this 2019 update has sought to make best use of the data improvements that have taken place over the last few years. This update has estimated the SELL for:

- The GDA
- Irish Water overall
- The remainder of Irish Water as the residual of the Irish Water operating area minus the GDA.

In estimating the short-run SELL there are a number of key data inputs:

- The estimation of **background leakage/policy minimum**. Ideally, a long time series of DMA leakage data would be used for this. The LMS (Leakage Management System) does not have a long time-series of data available yet but has been used to estimate background leakage through the application of the 25th percentile of the minimum achieved levels of leakage in DMAs. This approach makes best use of the available data and is designed to exclude DMAs that have not seen intense active leakage control over the last 12 months. This is the component that the SELL is most sensitive to and presents the greatest uncertainty in the calculation of SELL. Other estimates such as generic formulae for estimating background leakage are also considered in the SELL.
- The **marginal cost of water** is the cost of water saved if demand is reduced by 1 Ml/d. This has been based on 2016 analysis of the GDA treatment works, inflated to 2019 prices. The improved interconnectivity of the GDA has been used as the justification for taking the most expensive of the main works.
- **Analysis of steady state repair data** is used to determine how much effort is required to maintain leakage levels.
- **The variable cost element of active leakage control costs** is required and used in the SELL. This excludes activities such as DMA maintenance and is designed to represent purely the time spent working on the network to identify hidden leakage through active leakage control.
- **Externalities** (external costs), of which the most significant is related to the cost of carbon, based on forecasts of the shadow price of carbon.

In terms of methodology, the approach taken has compared the SELL using a generic cost curve with a company specific SELL model for Irish Water. The SELL has been assessed for the Greater Dublin Area (GDA) and for Irish Water overall. The non-GDA SELL has been taken as the residual between Irish Water and the GDA SELL.

The SELL has been split pro-rata across Water Resource Zones (WRZs) using property data. The short-run ELL for the GDA is 120 Ml/d, and the SELL for the GDA is 119 Ml/d. The short run SELL of 119 Ml/d is within a range of 113 Ml/d and 127 Ml/d, based on 1% of the total cost (ALC plus marginal cost of water). With further pressure management that is considered economic, **the short-run SELL for the GDA is 114 Ml/d.**

The short-run ELL for Irish Water (National) is 544 Ml/d, and the SELL is 539 Ml/d. The short-run SELL for Irish Water of 539 Ml/d is within a range of 509 Ml/d and 576 Ml/d, based on 1% of the total cost. With further economic pressure management **the short-run SELL for Irish Water (National) is 534 Ml/d**. The remainder of Irish Water has been taken as the difference, therefore **the non-GDA SELL is 420 Ml/d.**

The SELL of 119 Ml/d for the GDA is considered the best current estimate using available data from late 2019. However, there remains considerable data uncertainty at this time, particularly with respect to active leakage control efficiency and in relation to background leakage estimation. The estimate of background leakage will improve over time, as a longer time series of data builds up within the LMS. It is recommended that improved data and visibility of active leakage control performance and efficiency is something that is addressed in the near future, as this is a key area that requires more robust data and information.

The short run SELL is an input into the NWRP demand forecast, with long-run options being provided to further reduce leakage over time. The total cost curve is relatively flat, with a range of 14 Ml/d within 1% of the total cost for the GDA. Sensitivity analysis has shown that there are a number of inputs that can result in the SELL both increasing and reducing.

In light of the data uncertainties and to test the sensitivity of the estimates, we have also estimated SELL using UKWIR Managing Leakage 2011 estimates of distribution network background leakage, and a less optimistic view of active leakage efficiency. We have also explored the impact of additional economic pressure management in the GDA. This results in a **short-run SELL of 130 Ml/d** for the GDA and 534 Ml/d for Irish Water overall with a non GDA SELL of 404Ml/d.

It is recognised that the SELL is one of the key inputs when making strategic decisions in relation to long-term projects for the supply demand balance. In the interest of making "no regrets" investment decisions at this time, given the uncertainties in relation to input data associated with the SELL, taking a prudent view of SELL is advised. This will mitigate the risk associated with some of the key data uncertainties and give greater certainty for long-term planning.

Irish Water should seek to update the SELL in the mid-2020s, if not before, when data improvements have been completed.
The results from this update are presented in the table below. **Table 1.1 X X**

Line	Description	GDA	National	Remainder (non GDA)	Note
1	Short run ELL, steady state	120 Ml/d	544 Ml/d	424 Ml/d	Internal costs only
2	Short run SELL, steady state	119 Ml/d	539 Ml/d	420 Ml/d	Including externalities
3	Short run SELL with economic pressure	114 Ml/d	534 Ml/d	420 Ml/d	As line 2 minus 5 Ml/d of pressure management in

Line	Description	GDA	National	Remainder (non GDA)	Note
	management in GDA				GDA
4	Lower bound of short run SELL with a total cost within 1% of the minimum	113 Ml/d	509 Ml/d	396 Ml/d	Lower bound of line 2
5	Upper bound of short run SELL with a total cost within 1% of the minimum	127 Ml/d	576 Ml/d	449 Ml/d	Upper bound of line 2
6	Alternative short run SELL	135 Ml/d	539 Ml/d	404 Ml/d	Using Managing Leakage 2011 estimate for background leakage and a less optimistic view of ALC efficiency
7	Alternative Short run SELL plus economic pressure management in GDA	**130 Ml/d**	**534 Ml/d**	404 Ml/d	Using Managing Leakage 2011 estimate for background leakage and a less optimistic view of ALC efficiency and 5Ml/d of pressure management in GDA

2. Introduction and context

This report has been prepared following a 2019 review and update of the Sustainable Economic Level of Leakage (SELL) for Irish Water, to provide an update for the National Water Resources Plan (NWRP). The SELL was first estimated in 2015 for the Greater Dublin Area (GDA) by Atkins, and for Irish Water overall by Ryan Hanley in 2016. These estimates were carried out using the best available data at the time and applied different methodologies.

These estimates of SELL were used to set out a glide path to reduce leakage, however there have been some changes and improvements in data since 2015 and 2016, and this update collates these within a single methodology that is in line with equivalent UK best practice where practicable.

This update has estimated the SELL for:

- The GDA
- Irish Water overall
- The remainder of Irish Water as the residual of the Irish Water minus the GDA.

Managing leakage is important in the context of the NWRP as it can create greater headroom between demand and the amount of water available for use and is therefore an integral part of managing the supply demand balance. In addition to this macro-economic consideration, is the operating cost to Irish Water that incorporates not only the cost of managing leakage but the power, chemical and treatment costs associated with the treatment and distribution of water.

The approach taken has firstly assessed the short run economic level of leakage (SR-ELL)[1]. This report details the estimation of the SELL from the optimum level of leakage based on the marginal cost of water and the short run measures which can control leakage (i.e. active leakage control and some pressure management). Externalities such as social and environmental costs have been included in the estimation.

One of the outcomes of the review of the SELL in the UK for Defra, Ofwat and the Environment Agency in 20122 was that it is considered vital that least cost planning includes a range of leakage management options. This report covers a number of options to reduce leakage beyond the SR-SELL. These options are then available for selection and will enable Irish Water to determine its long run SELL and to integrate this more fully into the NWRP. This approach is considered to be best practice, as even without a supply demand deficit in the planning horizon, it fully assesses the longer-term costs and benefits of making further reductions in leakage.

[1] EU Reference document – Good Practices on Leakage Management – Main Report, January 2015
[2] Calculation of the sustainable economic level of leakage and its integration with water resource planning, SMC, 2012

3. Current Position

The current position in terms of leakage performance is shown in the table below, as provided by Irish Water. For the purposes of the SELL, the current position for 2019 will be taken as the lower of the: 2019 target or the reported 2018 position. For the GDA the current position will be 213.5 Ml/d, and nationally 756 Ml/d as both are lower than the reported 2018 position. The Q1 and Q2 positions for 2019 YTD suggest that even with a winter event in 2019, the targets would be likely to be achieved.

	2017	2018	2019 Q1 Actual	2019 YTD Average (Q1 & Q2)	Against Target Ml/d	%YTD	Comparison with Q1	2019 Target
National Supply (DI) Ml/d	1672	1700	1699.0	**1695.8**	3.74 Ml/d		3.24 Ml/d	**1699**
GDA Supply (DI) Ml/d	557	569	573.5	**572.81**	-1.3 Ml/d		0.69 Ml/d	**574**
National DI (Ml/d) Excluding GDA	1115	1131	1125.5	**1122.9**	5.1 Ml/d		2.6 Ml/d	**1125**
Leakage National	755 (45.2%)	781 (45.9%)	727.7 (42.8%)	**716.8 (42.3%)**	39.2 Ml/d	**42.3%**	(42.8%) 0.5%	**756**
Leakage GDA	224 (40.2%)	225 (39.5%)	212.7 (37.1%)	**210.8 (38.8%)**	2.7 Ml/d	**36.8%**	(37%) 0.2%	**213.5**
National Excluding GDA	531 (47.6%)	556 (49.2%)	515.0 (45.8%)	**506.0 (45.1%)**	36.5 Ml/d	**45.1%**	(45.8%) 0.6%	**542.5**

Nett Leakage Trend	2017	2018	2019 Q1	2019 Q2	2019 Q3	2019 Q4
	755	781	727	705.9	tbc	tbc
Gross Leakage Savings	28.59	78.81	28.5	27.4		

Figure 3.1 Current position

In terms of current DMAs, the LMS is being implemented with data improvements being made continuously. The average DMA size is considered in general to be reasonable with very few DMAs containing more than 2000 properties. There are a relatively small number of oversized DMAs, and these are discussed further as part of leakage options. It is noted that there appears to be a greater proportion of the oversized DMAs in the GDA, and this is perhaps an area for focus in the coming decade as leakage levels are reduced. This is demonstrated in Figures 3.2 and 3.3 below.

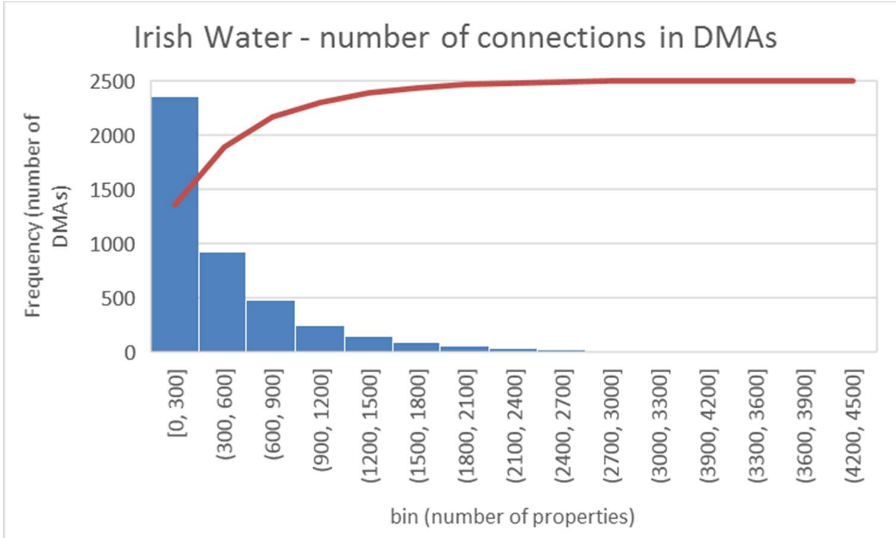

Figure 3.2 Frequency distribution – number of connections in DMAs nationally

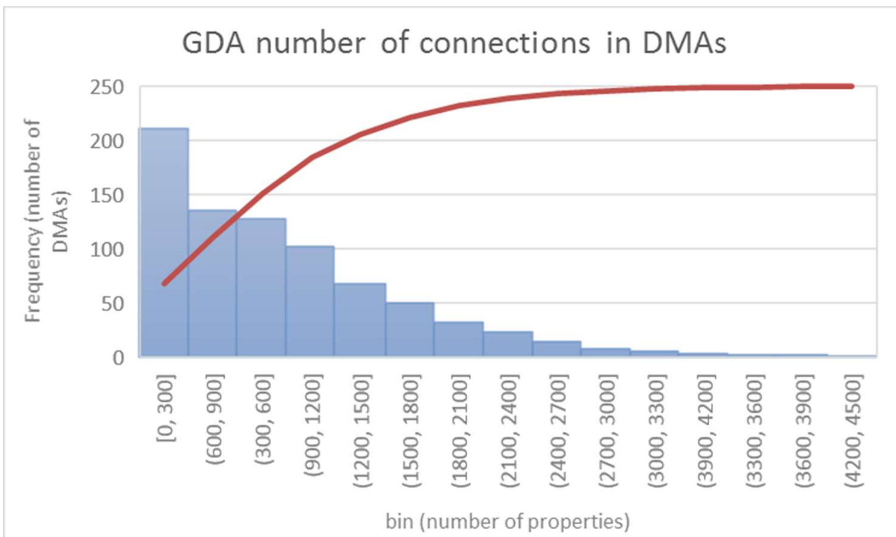

Figure 3.3 Frequency distribution – number of connections in GDA DMAs

4. Source Data

Table 4.1 Source data

Component of SELL	Data Source	Received/ Obtained	Comment
Current position in terms of leakage levels for GDA and nationally	Slides presented to CRU November 2019	From AR via email 19/11/19	Using Q1 and Q2 2019 position as current level of leakage
Marginal Cost of Water	Spreadsheet provided by Irish Water	From TC via email 10/12/19	2016 analysis
Repair data	Irish Water Sharepoint	Maximo repair data. Accessed 10/12/19	Raw data and summary of repair data and backlog
Repair data -run time and costs	Email from Paul Buchanan	From PB via email 19/12/19	Repair run time
General data	Netbase	Report from Netbase 10/12/19	Report CT-NB-01 DMA Characteristics report, data from Nov 2019
Pressure	Netbase	Report from Netbase 15/12/19	Report SD-NB-06 Pressure Optimisation Management Report
Inflation	Online	December 2019	https://statbank.cso.ie/px/pxeirestat/Statire/SelectVarVal/saveselections.asp Used to inflate MCW from 2016 to 2019
Shadow price of carbon	Online	December 2019	https://www.gov.ie/en/publication/public-spending-code/ Public Spending Code – for Shadow price of carbon
Leakage	Netbase	Report from Netbase 19/12/19	Report WB-NB-02 Global Leakage Jan 2019 to Dec 2019
Externalities	SMC 2012 report	Report	SMC 2012 review of the SELL for Ofwat, EA, Defra used for social cost impact of leakage management

5. Marginal Cost of Water

The marginal cost of water (MCW) is defined as the additional cost of providing an additional m^3 of water and includes private costs for the ELL (power, chemicals etc.) and externalities in the form of social and environmental costs for the SELL. For the purposes of this review in 2019, the MCW is based on the GDA and applied to both the GDA and non-GDA areas. Longer-term data improvements would allow regional or specific treatment works MCW to be calculated.

Different approaches can be taken to determine the marginal cost of water (MCW):

1. Calculating the additional/variable power and chemical cost for producing and distributing an additional m^3.
2. Taking an average of the production cost of the most expensive sources
3. Analysis of time series data to determine an empirical relationship between demand and cost, the gradient being the MCW.

For Irish Water we have used approach 2 to make the most appropriate use of data that was available.

5.1 Internal costs

Irish Water provided the following raw data for 2016 for the main treatment plants in the GDA from financial reporting systems:

Table 5.1 Internal WTP costs (2016)

WTP Name	24Hr. Design Capacity (m^3/day)	WTP_2016 Average Production m^3/day	Goods and Services	Chemicals	DBO Costs	Energy (2017)
Ballymore, Ballyboden, Leixlip combined	561,000	459,876				
Ballymore Eustace WTP (Liffey Waterworks)	312,000	282,246	€3,713,255	€902,556	€0	€354,172
Ballyboden Water Treatment Plant (Supplemented by BME WTP)	14,000	13,248	€4,604,243	€3,440,634	€0	€34,214
Vartry WTP (Supplemented by BME WTP)	75,000	64,680	€0	€0	€874,323	€24,054
Leixlip WTP	235,000	164,382	€2,726,218	€1,158,200	€0	€1,593,308

The total OPEX for each WTP divided by the volume produced does not derive a robust marginal cost of water, as the total costs includes both fixed and variable costs. The MCW is based on variable costs to represent the saving associated with a 1 Ml/d reduction in demand.

It is noted that the allocation and reporting of costs between the different water treatment plants (WTP) is not considered robust and this is an area for future improvement. Costs in Irish Water may be allocated against one treatment plant but utilised across other plants e.g. the financial expenditure doesn't necessarily fully align with the true running cost of the plant. For this reason, we proportionally allocated the total costs for Goods and Services, Chemicals and DBO costs between the treatment plants based on the average production volume for each plant. Energy costs were considered to be allocated reliably against the relevant treatment plants. Additional fixed costs in terms of staff costs were estimated based on the number of staff at WTPs using organisational charts provided by Irish Water for 2016. The breakdown of costs is shown in the Figure 5.1 below.

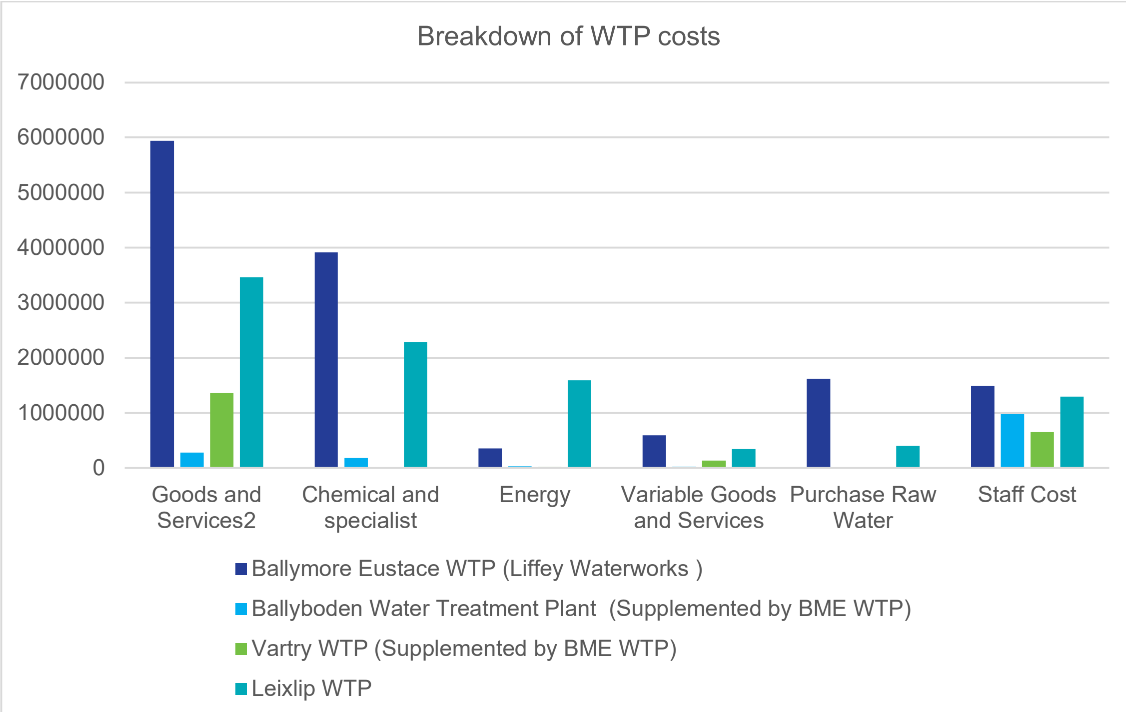

Figure 5.1 Breakdown of WTP costs

The calculation steps are as follows:

1. Goods and services summed to €11,043,717, pro rata between the four WTPs Ballymore Eustace, Ballyboden WTP, Vartry WTP and Leixlip WTP based on the average production volume per day (total 515 Ml/d for the major works).
2. Chemical and specialist/DBO costs are split pro rata between Ballymore Eustace, Ballyboden and Leixlip based on the proportion of the average production volume of each WTP associated with the total of these three plants (460 Ml/d). At 2016 Vartry WTP was largely based on sand filtration, however this has been upgraded and the costs will increase and are expected to now be in line with the other works. This update in cost was not available at the time of this update, however this is not considered material as the most expensive source in the GDA has been used to represent the MCW.
3. Energy costs were taken as provided for each WTP.
4. The purchase of raw water was included as a fixed cost for Ballymore Eustace, €1.62m for 2016.
5. Staff costs were based on staff numbers from organisational charts in 2016 and a rate of €65,000 per person. This is a fixed cost and does not affect the MCW.
6. The total cost was calculated as the sum of Goods and Services, chemical and specialist, Energy, Purchase of raw water and staff costs.
7. An assumption was made that 10% of goods and services would be allocated to variable costs. Whilst power and chemical costs make up the majority of the variable costs, it was considered feasible that other costs might potentially also increase with higher usage and output. Improvement in data over time will be necessary to validate this assumption but at this time it is considered to be appropriate as increasing the variable cost element slightly, would increase rather than decrease the MCW.

8. The fixed costs were calculated as 90% of the Goods and Services and the staff costs.
9. The variable cost was calculated as total cost minus fixed costs.
10. The total volume produced in Megalitres was calculated from the average production volume in m^3/d divided by 1000 and multiplied by 365 days.
11. The marginal cost for each site is the variable cost divided by the annual volume.
12. The weighted average of the WTP MCWs and the maximum MCW were then calculated.
13. The 2016 price was inflated to 2019 prices[3]. The rate of inflation for 2019 was not published at the time of this report, therefore an average from 2017 and 2018 was used to represent inflation for 2019.

The MCW for the GDA based on the most expensive source (Leixlip) is €77 per Ml. This WTP in 2016 produced 31% of the total demand of the four major works, and the GDA interconnectivity justifies using the most expensive source as the MCW in the SELL. The MCW for Ballymore Eustace is €63 per Ml and for Ballyboden is €51 per Ml. The weighted average for all major works is €60 per Ml.

The Vartry works has been upgraded since 2016 and is expected to be similar in terms of MCW to the other three major works now. These MCW costs are all in 2016 prices, when the rate of inflation was applied including taking the average rate of inflation from 2017 and 2018 to use for 2019, the MCW for use in the SELL is **€78 per Ml excluding externalities**. This is the MCW that is to be used for estimation of the ELL and based on Leixlip which in 2016 cost €77 per Ml, inflated to 2019 prices at €78 based on CPI.

5.2 External costs

The cost of carbon must be included in the MCW for use in the SELL. Table 7[4] of the Central Technical References and Economic Appraisal Parameters report provides a table for the shadow price of carbon for use in policy appraisal. The forecast is stable in the short term, but increases over time:

[3] https://statbank.cso.ie/px/pxeirestat/Statire/SelectVarVal/saveselections.asp
[4] https://www.gov.ie/en/publication/public-spending-code/
Public Spending Code - Central Technical References and Economic Appraisal Parameters July 2019, Department of Public Expenditure and Reform

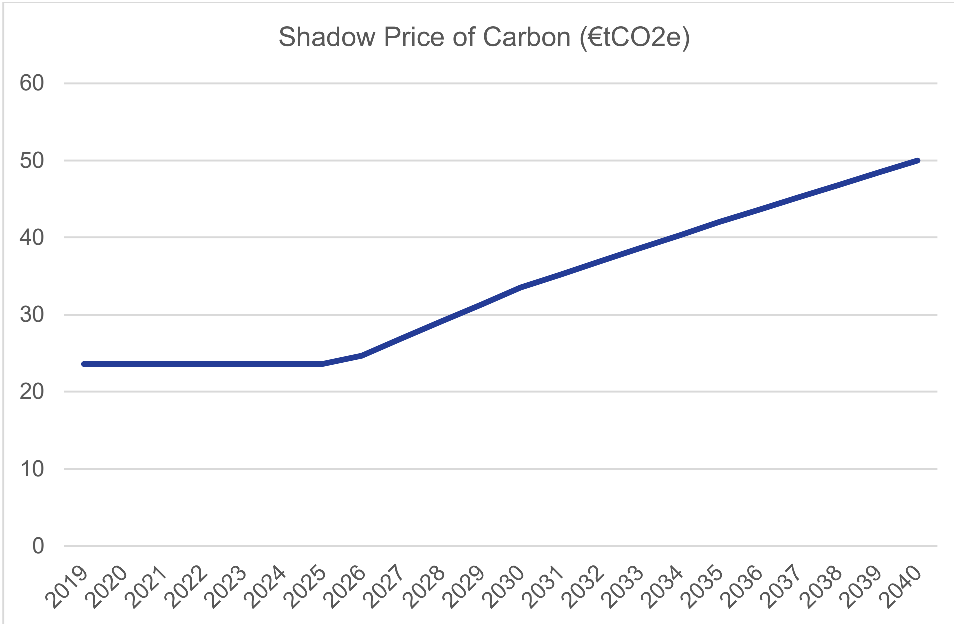

Figure 5.2 Shadow price of carbon

The carbon emissions per kWh has been based on 468gCO2/kWh[5] and the kWh per Ml is based on an average UK value of 0.56 kWh per m3[6]. The calculation in terms of cost of carbon is as per the following formula:

$$\left(\frac{(Demand\ m3/d\ \ x\ 365.25)\ \times 0.56\ \times 468}{1000000}\right) \times shadow\ price\ of\ carbon$$

Taking 2019 as a worked example,

(((1 Ml/d x 1000 x 365.25) x 0.56 x 468)/100,000) x 23.6 = €2259.1 (= 1 Ml/d)

2259.1/365.25 = **€6.18** per Ml based on 2019 prices.

As the cost of carbon increases over time, this results in the MCW increasing over time accordingly:

[5] SEAI - Energy Related Emissions in Ireland 2016 report
[6] Quantifying the energy and carbon effects of water – full technical report, Elemental Solutions, April 2009 (on behalf of Energy Saving Trust and the EA)

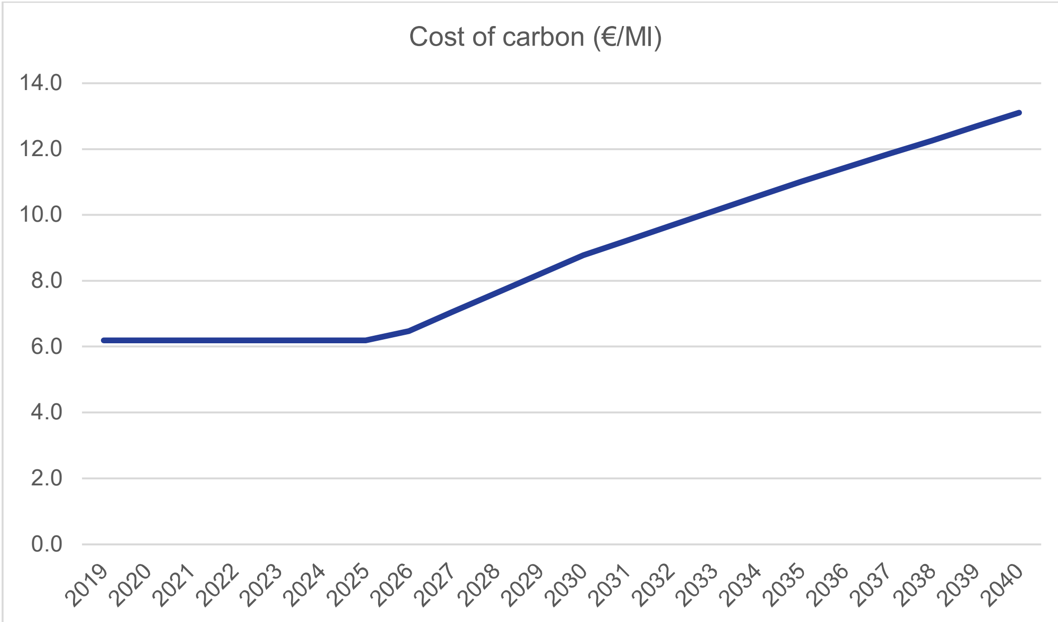

Figure 5.3 Carbon cost per Ml

For 2019, the MCW is €78 plus €6 giving an overall MCW including carbon of **€84 per Ml** for use in the SELL.

There are a number of recommendations to improve data over the next 5 years to improve future estimation of the SELL:

- Review the current financial reporting and data collected for treatment plants and ensure that site specific data is captured rather than allocation of costs being lumped against one plant but used across several sites.
- Ensure that fixed and variable costs can be separated out consistently.
- Carry out an analysis of costs across all treatment plants across Irish Water.
- Collate data for each treatment plant/site in terms of KWh per Ml and associated pumping data and link this to pump efficiency studies/data/investigations.

6. Steady State

The steady state repair rate is a key element of the estimate of the SELL and is the number of repairs that are required in a normal year to maintain leakage at a constant level. This provides a baseline against which alternative levels of leakage can be compared. This analysis would ideally use a robust time series dataset of DMA leakage data and repairs. The LMS (Leakage Management System) is being implemented however there is not a robust long-term dataset yet available, therefore this analysis has been based on the information that is currently available for 2019.

The LMS system will over time improve the understanding between leakage and night use, as night use monitors are being implemented in 2020. Longer term, this analysis will need to be revisited for future NWRPs when there is a longer time series of data.

For the 2019 update of the SELL, the repair data is compared with the minimum night flow and real losses to derive a view of steady state based on the current conditions.

The number of repairs nationally is relatively consistent throughout the year as shown in Figure 6.1 below.

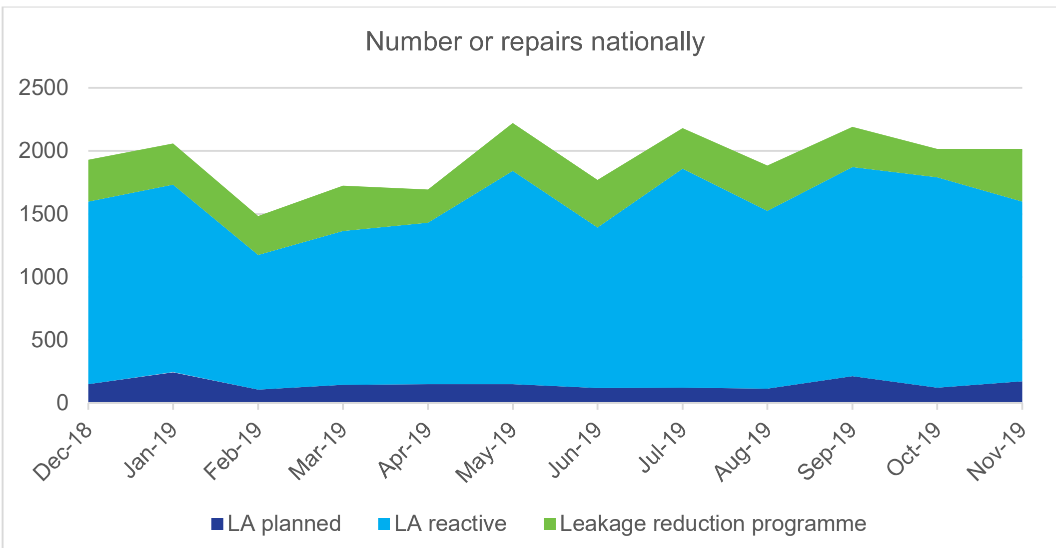

Figure 6.1 National repairs

There was a peak in GDA repairs in January 2019, driven by reactive repairs, although noting that this could have been related to backlog reduction. The repair performance is generally fairly constant as shown in Figure 6.2.

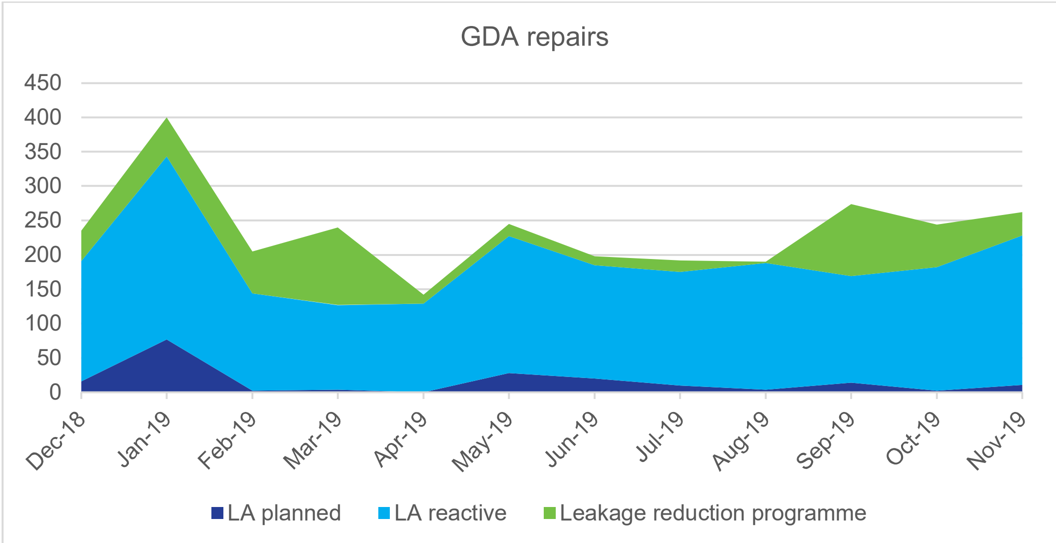

Figure 6.2 GDA repairs

The non GDA repairs are presented in Figure 6.3 below.

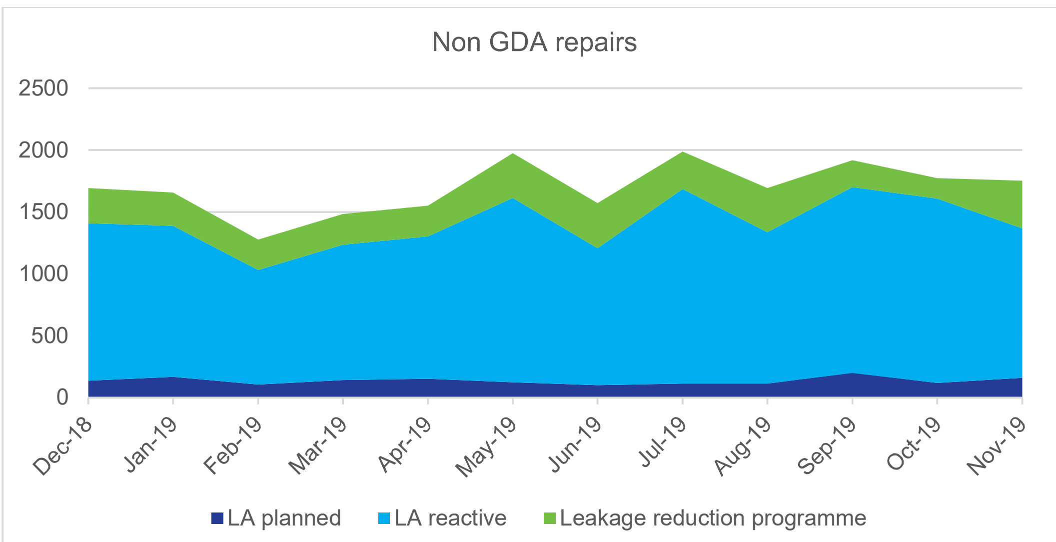

Figure 6.3 Non-GDA repairs

Overall, the number of outstanding repairs is considered to be relatively high for the size of Irish Water, however this has been relatively consistent. There is not sufficient data available at this stage to model the costs of reducing the level of backlog, however this is something that is recommended for further investigation.

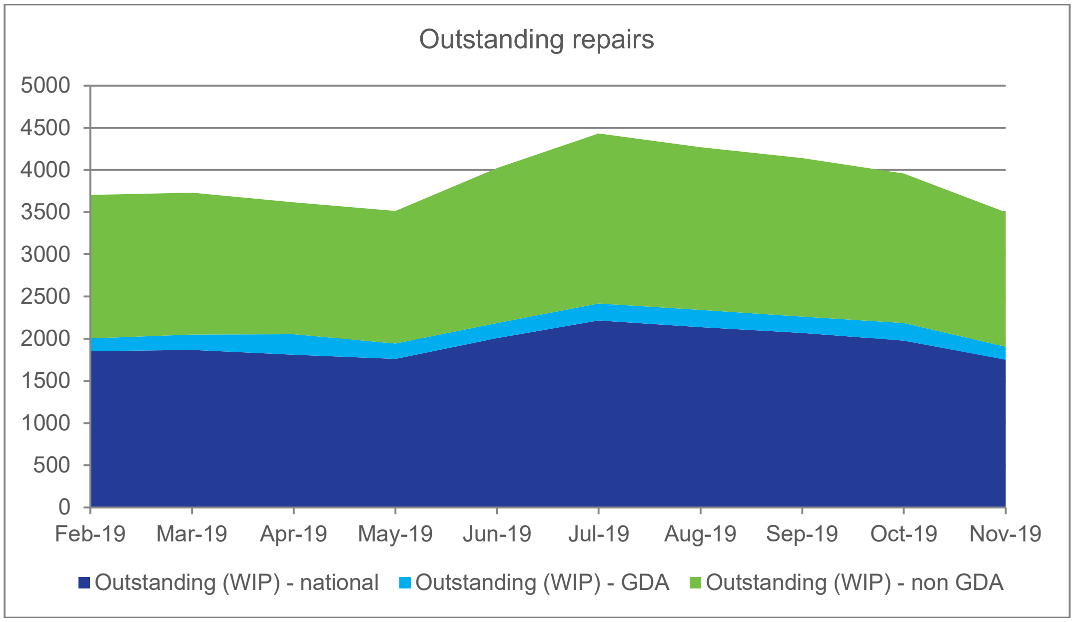

Figure 6.4 Outstanding repairs

The outstanding repair data for Dec 2018 and Jan 2019 was not available, however the repair backlog of outstanding repairs is relatively consistent over time. A working backlog is necessary for planning and effective use of resources, however the overall level of outstanding repairs is considered high and could be explored as a potential option to reduce leakage by maintaining a lower number. The repair run time should be factored into this. Irish Water are reporting repair performance from jobs recorded on the Maximo works management system. An extract of data provided by Irish Water shows this is around 24 days. The geographic factor of a sparsely populated area of supply and the relationships with LAs (Local Authorities) will need to be considered in exploring what improvements could be made, and at what cost.

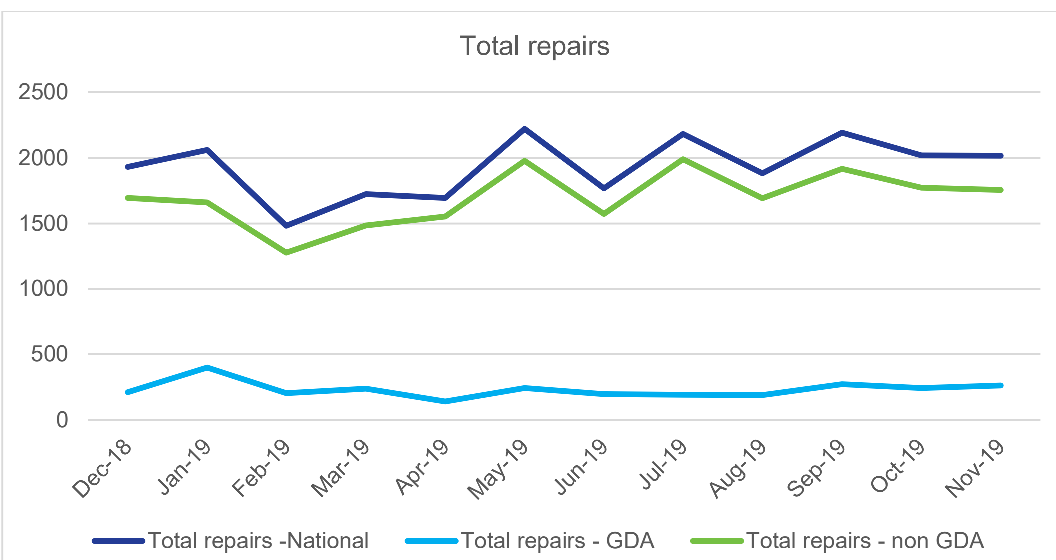

Figure 6.5 Total repairs for national, GDA and non GDA summary

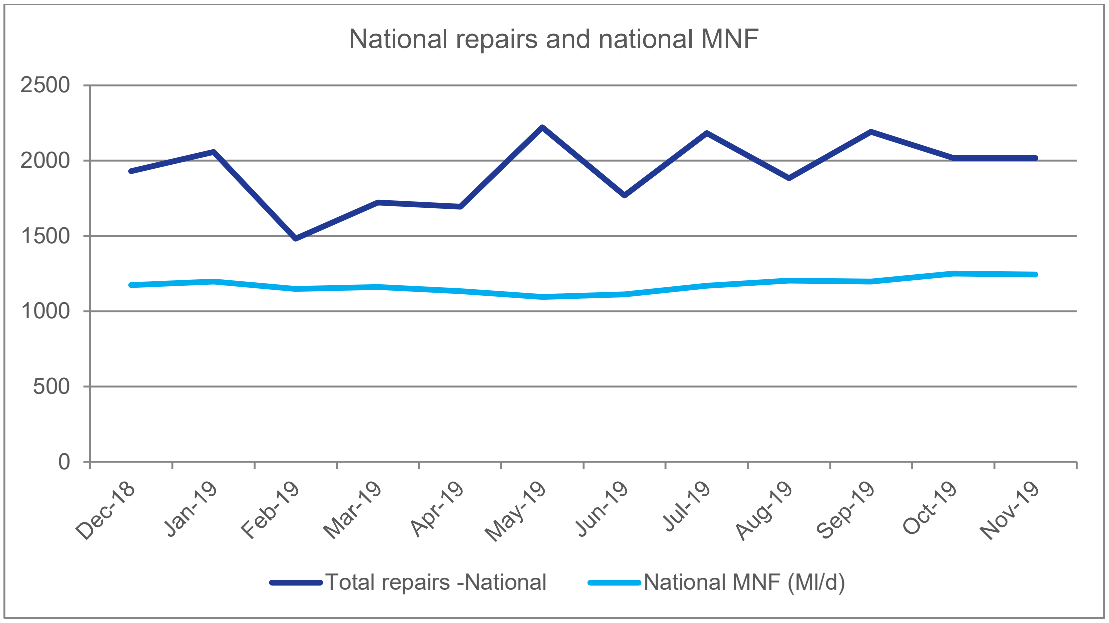

Figure 6.6 Total repairs nationally and MNF

Ideally, a longer-term dataset would have been used, but, given the relatively recent consolidation of disparate approaches to collecting data at the LA level and the implementation of Maximo as a works management system and the LMS, the steady state has been based on data for 2019. It would be typical to assess several years of data and explore periods of between 12 and 24 months of equivalent leakage to assess steady state. The LMS is not yet configured to report bottom up leakage for all DMAs, therefore the minimum night flow (MNF) has been used as a surrogate to assess whether the number of repairs carried out in 2019 was equivalent to an approximate steady state.

At a national level, the MNF is similar at the start and end of the year, and the number of repairs carried out in 2019 has therefore been assumed to represent steady state.

There is scope for improvement in the coming years by:

1. Re-running the assessment when there is 2-3 years of robust DMA leakage data in the LMS including robust night use data available.
2. Carrying out analysis of weather data to determine whether the year is typical or atypical.
3. Understanding the trends of steady state repairs over time and how this relates to asset condition, performance and renewal/rehabilitation programmes.

Table 6.1 Repair numbers to represent steady state

Repairs	Area	Number	Period
Reactive	National	17352	Dec 18 to Nov 19 total
Reactive	GDA	2100	Dec 18 to Nov 19 total
Reactive	Non GDA	15252	Dec 18 to Nov 19 total
Proactive	National	5812	Dec 18 to Nov 19 total
Proactive	GDA	728	Dec 18 to Nov 19 total
Proactive	Non GDA	5085	Dec 18 to Nov 19 total

This represents the best current view of the effort required to maintain current levels of leakage, although we note this assessment will improve over time, once more robust bottom up leakage estimation and a longer time series of data is available via the LMS.

7. Background Leakage

7.1 Introduction

Background leakage is one of, if not the single most important input into the SELL, and the parameter to which it is most sensitive. The definition of background leakage is the volume of leakage that cannot be resolved through current technology and active leakage control policy. There are two ways of estimating background leakage:

1. Use of a generic formula
2. Estimation based on the minimum achieved level of leakage from the bottom up leakage estimation in each DMA. This is also referred to as policy minimum and is representative of a company through using its own data.

Background leakage typically comprises of weeps and seeps that occur from the network, particularly joints and fittings, as opposed to more significant leaks. It can be problematic to detect, and also challenging to repair, and the only effective solution is through asset rehabilitation. It is worth noting that some of what is considered to be background leakage, can be consumption and/or night use which is not detected.

We have explored both approaches in this estimation of the SELL, and have utilised DMA data where possible, and described the approach later in this section. The use of company specific data is always considered preferable to using generic formulae, as it is representative of the company's network. Generic formulae are a useful cross-check and benchmark where there is concern about data quality or a complete absence of data. Whilst the time series data for Irish Water via the LMS is not particularly lengthy at the current time, there is data available that can be utilised.

7.2 Equivalent UK best practice

In the UK water industry, current industry best practice in relation to estimating background leakage would require:

1. A long time series of robust, valid DMA data;
2. A robust approach to the operational management of leakage through ALC, where leakage levels have been driven down during repeated interventions, to a level that is practically as low as feasible. This sets a meaningful benchmark for each DMA;
3. Analysis to identify outlier DMAs[7] and explanatory factors such as DMA size, pressure and asset type/condition;
4. Company specific data in relation to household and non-household night use; and
5. Investigation of specific DMAs with high levels of background leakage or negative leakage to determine if the level of background leakage or policy minimum is genuine or if there are parameters such as night use allowances or pressure that are affecting it.

7.3 Irish Water –current position

Irish Water are implementing the LMS system (Netbase) and the process of migrating DMAs from the different local authority areas into the system. Night use monitors are being introduced in 2020, and this is working towards robust bottom up leakage estimation at DMA level.

Previous estimates of SELL in 2015 and 2016, were prior to the LMS system being in place. There is some data in the system currently, but not a long time series. We do not have the historic time series

[7] UKWIR Factors affecting minimum achieved levels of leakage, 16WM0838, 2016

data to make a fully robust estimation of policy minimum at this time, however there is some data and merit in reviewing this.

7.4 Generic estimation of background leakage

There are two formulae that are used in the UK, one of which is used internationally:

1. UARL (unavoidable annual real losses)
2. UKWIR 2011 Managing Leakage estimation of background leakage.

The UARL is estimated using the following formula[8]:

$$\text{UARL (litres/day)} = (18 \times Lm + 0.8 \times Ns + 25 \times Lp) \times P$$

Where

Lm = mains length (km)

Ns = number of service connections (main to property line)

Lp = total length of underground pipes, property line to meter (km)

P = average pressure (metres)

The UKWIR Managing Leakage 2011[9] formula is based on the following flow rates:

Table 7.1 Managing Leakage flow rates for background leakage

Background Loss Component	Units	Low	Average	High
Distribution mains	l/km/hr	20	40	60
Communication on pipes	l/prop/hr	1.5	3	4.5
Supply pipes UGSP and PL	l/prop/hr	0.5	1	1.5
Plumbing losses	l/prop/hr	0.25	0.5	0.75

Using the average network condition, the formula is as follows:

Background losses =((40 x length of mains in km)+(3 x number of connections)+(0.5 x number of properties)) x (AZNP/50)^1.5

For use in the sensitivity analysis section for the GDA, the supply pipe leakage and plumbing loss component is excluded (section 10.2).

7.5 Assessment of policy minimum

When reviewing minimum night flow of DMAs, in the context of policy minimum there are a number of considerations:

1. The validity of DMA data;
2. Having a suitable time series of data during which intense ALC interventions have driven leakage down to an appropriate minimum achieved level;
3. Ensuring property counts and DMA boundaries are robust;
4. DMA operability issues e.g. data timing issues in multi feed DMAs, missing data etc.;
5. Night use allowances for domestic and non-domestic;
6. Network condition and performance; and

[8] https://www.leakssuitelibrary.com/uarl-and-ili/
[9] UKWIR Managing Leakage 2011 (report 4)

7. The age and performance of DMA meters.

It will take several years to establish robust policy minimums for every DMA, as intense ALC will be required to ensure the levels set in each DMA for targeting are robust and as low as can be achieved.

The LMS system is set up to produce reports that provide the minimum flow achieved in terms of the minimum night flow (Netbase report ran 11/12/19, Percentile Report of Minimum Historic Night flows and back-calculated ICF for use in the derivation of Minimum Historic Analysis, SD-NB-05). This report is based on valid data only and provides the lowest achieved minimum night flow per DMA. In order to compare this with UARL and Managing Leakage estimates of background leakage, it is necessary to remove the night use volumes from the minimum night flow. This results in an estimate of the minimum historic night flow losses (i.e. the best current estimate of policy minimum that we can achieve in 2019).

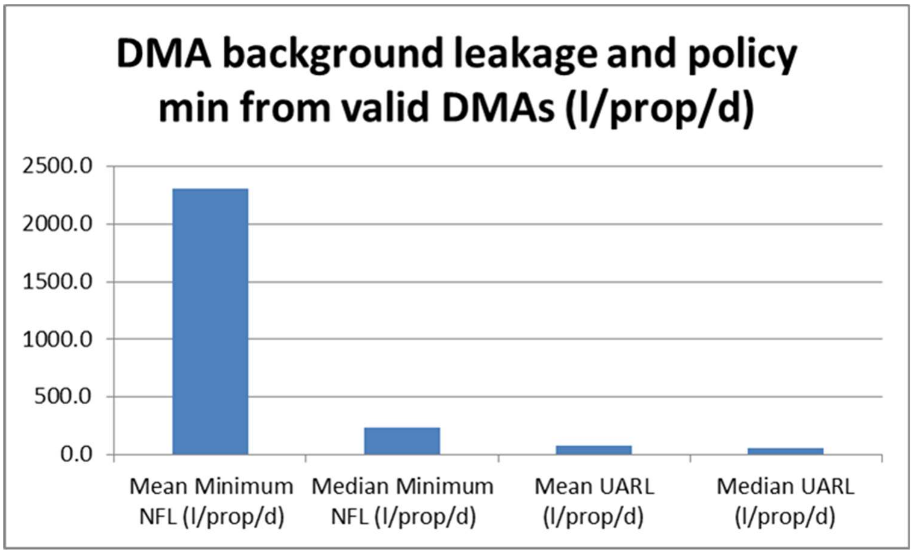

Figure 7.1 Background levels of leakage

As we would expect with a short dataset and Irish Water's current position, we do not have robust policy minimums for a significant proportion of DMAs yet. The Netbase report of minimum achieved was reviewed and checked by manually spot-checking sample DMAs, an example is provided in Figure 7.2.

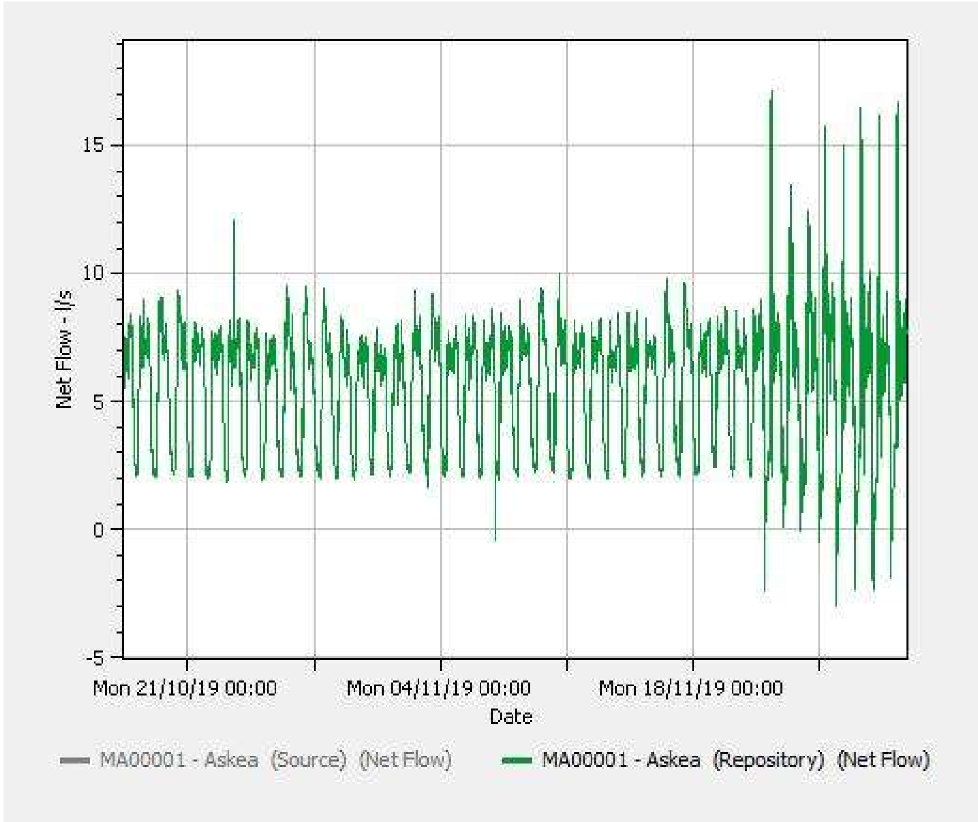

Figure 7.2 Example DMA from spot checks to demonstrate Netbase reporting was working correctly

The minimum night flow in the screenshot in Figure 18 is around 2 l/s and the value from the Netbase report was successful in providing this output, and not providing data from periods of inoperability where negative minimum night flow was recorded in the raw data.

A DMA can become inoperable and the system is designed with validation rules to ensure data quality is robust. The lowest minimum achieved levels generated by the report appear to be reasonable and sensible. Notwithstanding the considerations listed at the start of this section, taking the Netbase data for valid DMAs on face value, results in an estimate of policy minimum of 614 Ml/d based on data extracted on 11/12/19 for the period 01/10/18 to 11/12/19.

Comparing UARL to the minimum NFL for all DMAs with valid data highlights a significant discrepancy, if the total is summed for all DMAs. This is demonstrating that whilst improvements are being made in terms of the LMS, a longer time series of data is needed along with time to set robust policy minimum levels of leakage. When UARL and the minimum achieved NFLs are ranked and compared, we see that there are a significant number of DMAs that are considerably higher than UARL as shown in Figure 7.3.

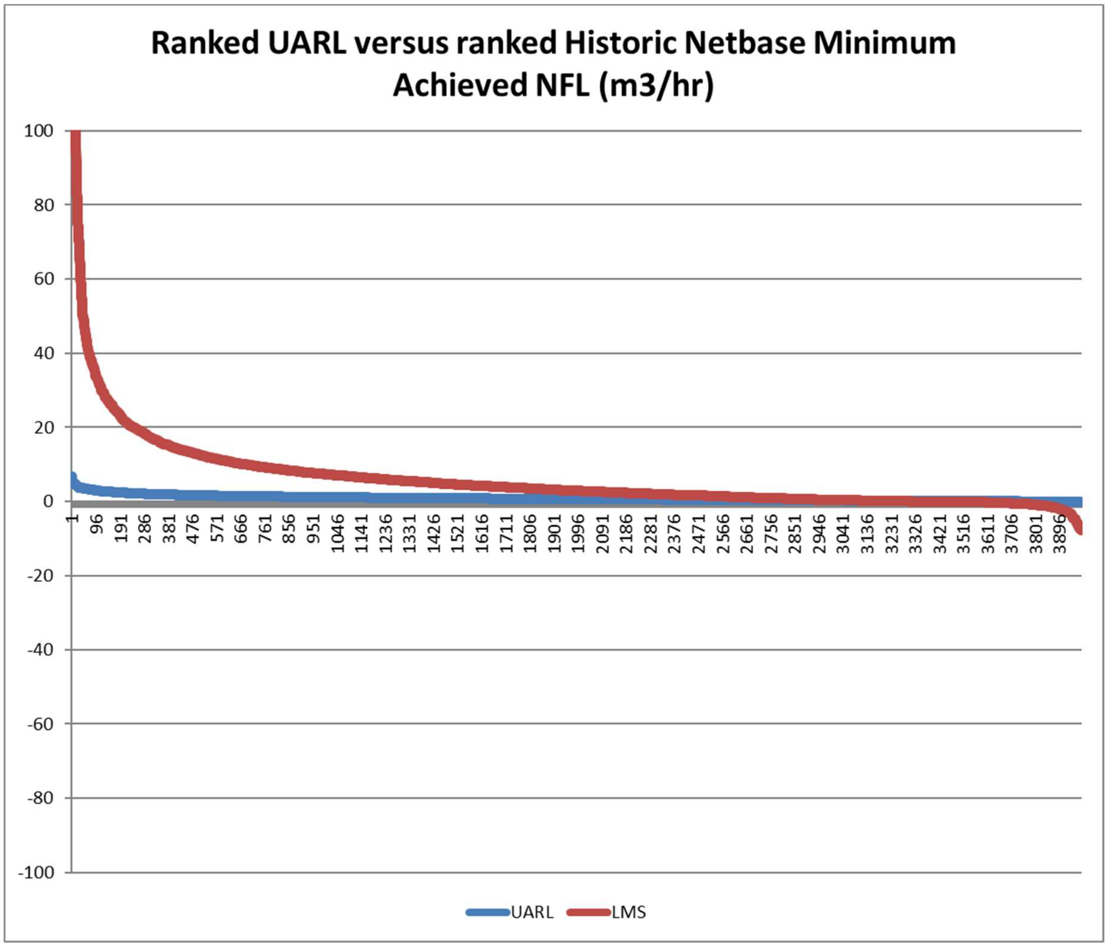

Figure 7.3 Ranked UARL versus ranked minimum achieve NFL

The mean minimum levels achieved are significantly higher than UARL, however the median is much closer to the median UARL. This suggests that there are a number of DMAs that are significantly higher than would be expected, and that these should be investigated and prioritised as leakage is targeted during the ongoing drive to reduce it.

Using the Netbase data for valid DMAs, ranking the minimum achieved levels with UARL supports this view, and a relatively small number of circa 200 DMAs could yield significant savings.

We currently do not have confidence in the robustness of our policy minimum from using the overall dataset with the sum taken for all DMAs. If this approach was taken, by using the full dataset, this would significantly overinflate the estimate of background leakage and result in a SELL that was too high. Figure 19 demonstrates that there is a reasonable proportion of DMAs where the policy minimum level in terms of NFL is reasonable, and therefore the approach adopted has been to calculate the NFL. The estimation of policy minimum has been based on the application of the 25th percentile of the minimum achieved for valid DMAs. This approach is described below.

Two Netbase reports were used to derive the level of background leakage:

1. Minimum Historic Report SD-NB-05 run on 11/12/19 for the period 01/10/18 to 11/12/19 to provide the 25th percentile. The 25th percentile was selected as three options were available (25th, 50th and 75th percentile). The 25th percentile was considered to be the most appropriate as it would select DMAs where policy minimum was the most robust and least likely to contain night use or other consumption.
2. DMA characteristics report CT-NB-01 run on 11/12/19 for November 2019 to provide property counts.

The estimation of background leakage has been calculated using the above reports via the following steps:

1. Using MS Excel and Index/Match functions to combine the two Netbase reports.
2. Where there is valid data, calculating the minimum achieved NFL using the MNF 25th percentile and night use.
3. Calculating the NFL for each DMA with valid data in litres per property per day.
4. Using the Excel array formula "{PERCENTILE(IF(T3:T4618,T3:T4618),0.25)}" where the cell range is the NFL in litres per property per day to calculate the 25th percentile of all DMAs excluding zeros in the dataset.

This approach has estimated background leakage to be **68.7** l/property/day and this has been used in the SELL for this 2019 update. This is shown for comparison in Figure 7.4.

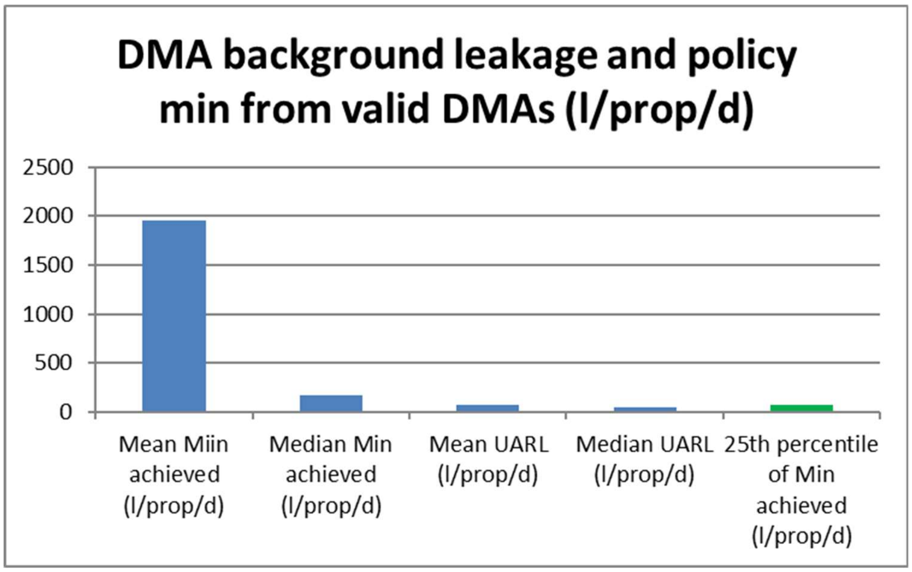

Figure 7.4 DMA background leakage (l/prop/d)

7.6 Future Work

The following will be required over time to improve the data quality and robustness of the estimate of policy minimum:

- Continue with the roll out and implementation of the LMS
- Work through DMAs to set robust policy minimums over the next 5 years
- Undertake a review of policy minimums in relation to explanatory factors such as pressure, DMA size and asset condition[10]

[10] UKWIR Factors Affecting Minimum Achievable Level of Leakage, 2016, WM0858

8. Unit Costs including externalities

8.1 Active Leakage Control

The unit cost associated with active leakage control is €29.83 per hour. This is based on an annual cost per FTE provided by Irish Water of €52,500 per annum including vehicles/equipment. The hourly rate is based on the assumption of 220 working days of 8 hours per day.

8.2 Repair Costs

Updated unit costs for repairs provided in December 2019 by Irish Water were:

- €3,024 for First Fix Free repairs of customer side leaks across all LAs
- €8,012 for find and fix repairs across all LAs.
- €397 per metre of distribution main replaced

We note that the find and fix repair costs are considerably higher than would be expected. Previous analysis for the SELL in 2015 and 2016 was provided with data demonstrating repair costs of €2000 to €3000. The repair costs provide in December 2019 potentially contain overheads or fixed cost elements that do not reflect the actual repair activity and include overheads. We have used the estimate of €2000 per repair cost to avoid over inflating this cost element. This estimate of €2000 was based on the average cost of fixing a leak on the distribution network. This was derived from Maximo data and taking an average if different schedule of rate costs for mains repairs, and unit costs for service repairs applied to service and stop tap repairs. It is recommended that improved data quality in terms of repair unit costs is sought in the future.

8.3 Externalities associated with leakage management

The assumptions associated with find and fix are provided in Appendix A. The following table 8.1 summarises the externalities per repair.

Table 8.1 externalities associated with leakage management

Activity	Impact	Component	Number	Units	Unit Cost	Cost/year
Find and fix	Social Cost	Vehicles delayed	51,049,689	No. of vehicles	0.23	€11,741,428
Find and fix	Social Cost	Pedestrians delayed	3,693,305	No. of pedestrians	0.53	€1,958,478
Find and fix	Social Cost	Low pressure	225,702	Properties	5	€1,128,510
Find and fix	Social Cost	Supply interruptions	75,234	Properties	5	€376,170
Find and fix	Social Cost	Total social cost – find and fix	N/a	€	N/a	€15,204,586
Find and fix	Social Cost	€/repair	N/a	€/repair	N/a	€556
Find and fix	Carbon Cost	Carbon from transport	215,443	Kg/CO2	11	€2,370
Find and fix	Carbon Cost	Carbon from work sites	7,824,336	Kg/CO2	11	€86,068
Find and fix	Carbon Cost	Carbon from disruption	1,368	Kg/CO2	11	€15,047
Find and fix	Carbon Cost	Carbon total	N/a	N/a	N/a	€103,484
Find and fix	Carbon Cost	€/repair	N/a	N/a	N/a	€4

The external costs associated with find and fix are based on assumptions from the SMC[11] study and using hourly rates for the general public from CSO Ireland (2018). The external costs per repair are €559.55.

[11] Calculation of the sustainable economic level of leakage and its integration with water resource planning, SMC, 2012

9. Sustainable Economic Level of Leakage

9.1 Methodology

There are two fundamental approaches in terms of deriving leakage cost curves for use in the SELL, known as Method A and Method B[12]. The Method A approach is based on varying the time between interventions, and the cost of each survey does not vary and is independent of the leakage level. This approach derives a steady state cost curve from the current leakage control costs and two asymptotes. Further costs are added in the form of transitional costs to lower levels of leakage.

The Method B approach is based on leakage rising at a theoretical constant rate, known as the Natural Rate of Rise (NRR) and interventions reduce this to maintain steady state. The Method B approach uses curve fitting, usually from DMA (District Metered Area) data to derive the cost and excess leakage.

From our experience in the UK, there are merits to both the Method A and Method B approaches. Both methods have been used by UK water companies, and the decision to use one method over another is largely driven by the data quality.

In Irish Water, DMA data has been managed disparately as a function of being managed by LAs, and DMA data is still being centralised and consolidated in Netbase (the Leakage Management System, or LMS). Assessing the NRR at DMA level requires several years of good quality and robust DMA data. At 2019, the time series is not sufficient to make a robust estimation of the NRR, therefore the decision was taken to update the SELL using Method A.

The key inputs into the Method A approach are:

- Marginal cost of water;
- Background leakage/policy minimum;
- ALC costs/unit costs;
- Steady State – number of repairs and cost to maintain;
- Transitional costs; and
- Externalities.

The principle of Method A is shown in Figure 9.1 below, where the increased frequency of intervention reduces the level of leakage. The time between the intervention of the red line is longer than that of the blue line, the average being represented by the dashed lines. Reducing the time between intervention, increases the frequency of intervention and reduces the overall level of leakage.

[12] UKWIR 11WM0846 Best Practice for the derivation of cost curves in economic level of leakage analysis

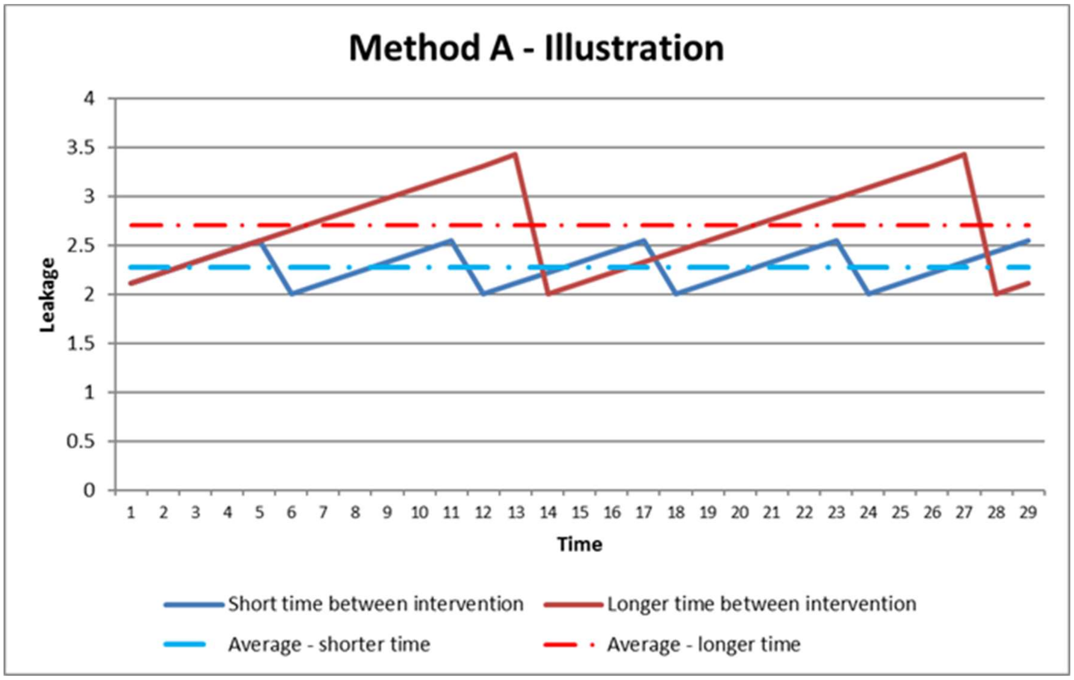

Figure 9.1 Illustration of method A SELL modelling

There are generic cost curve formulae that can be used to estimate the SELL, examples from the UKWIR 2011 project include the hyperbolic and logarithmic cost curves. Whilst these are reasonable starting positions, there is little scope to vary these cost curves other than via changes to background leakage/policy minimum. We have utilised a model that has been tailored for Irish Water to enable company specific inputs to provide a company specific output.

There are therefore three method A options that were considered:

1. Logarithmic cost curve – generic. This approach is not considered further due to the sensitivity to the passive level of leakage, and lack of clarity around how this should be estimated.
2. Hyperbolic cost curve – generic. This approach is considered a valid cross check for option 3, as the main inputs are policy minimum/background leakage and the current cost of ALC.
3. Irish Water SELL model – company specific Method A model. This is the preferred approach that has been taken forward and is summarised below. The leakage cost is based on a 1/T relationship and the level of leakage at each time step is derived as per Figure 26. The main advantage of using this simple method A model is that the gradient of the "saw tooth" can be varied and tailored specifically to a company whereas the generic cost curves do not allow for this.

Option 2, the hyperbolic cost curve, has been used as a cross check to validate the outputs. Both methods are detailed in this section for the GDA and Irish Water as a whole.

9.2 GDA

This section provides a summary of the approach, methodology and outputs for the GDA.

9.2.1 Hyperbolic cost curve (GDA)

This section presents the GDA SELL using the generic hyperbolic cost curve as per UKWIR13 methodology.

[13] Best practice for the derivation of cost curves in economic level of leakage analysis, UKWIR 11WM0846, 2011

$$C = \frac{k}{(L - Lpm)}$$

Where:

C = total variable active leakage control (ALC) cost at the given leakage level

L = leakage level

k= coefficient

Lpm = calculated policy minimum (or background leakage)

The coefficient is determined from:

$$k = Ca \times (La - Lpm)$$

Where:

Ca = the ALC cost at the actual/current level of leakage

La = the actual/current level of leakage

The following table summarises the key inputs used in the estimation of the SELL using the hyperbolic cost curve:

Table 9.1 SELL for GDA using hyperbolic cost curve summary table

Variable	Unit	Value	Source
Properties	number	683 778	Netbase Dec 2019
Mains length	km	6894	Netbase Dec 2019
Trunk mains length	km	1298	Netbase Dec 2019
Current level of leakage	Ml/d	213.5	Leakage target
Background leakage – 25th percentile of min achieved	Ml/d	46.97	Netbase Dec 2019
Fixed repair volume – reactive and first fix free	Ml/d	19.45	From repair data analysis
Trunk mains	Ml/d	19.47	UKWIR allowance
Ca	€/annum	260 460.74	Based on ALC resource cost and assumed 12 hours per leak
MCW – internal	€/Ml	€ 78.10	Based on more expensive GDA source from 2016, inflated to 2019 cost
MCW – with carbon	€/Ml	€ 89.15	MCW internal plus carbon
Lowest total cost	€	4 881 698	Calculated (minimum cost of water plus ALC)
SELL	Ml/d	120	Calculated – leakage level at lowest total cost
Total fixed volume	Ml/d	85.89	Sum of 47 Ml/d background, 10 Ml/d Trunck mains and 19 Ml/d FFF and reactive
K	n/a	332 374 477	Calculated Ca x (current level of leakage – total fixed volume of 85.89)

For different levels of leakage between the current level and the total fixed volume (background leakage, reactive leak repairs, first fix free and trunk mains leakage) the calculation is as follows:

1. Cost of water – MCW including carbon multiplied by the level of leakage at each interval multiplied by 365.25 days.
2. ALC cost – k divided by the level of leakage at each interval minus the total fixed volume (85.89 Ml/d).
3. Total cost – ALC cost plus cost of water (noting that repair costs are fixed and will not affect the steady state SELL).
4. The minimum total cost is identified and the corresponding level of leakage gives the SELL, **120 Ml/d** using this method.

The cost curves are presented in the Figure 9.2 below:

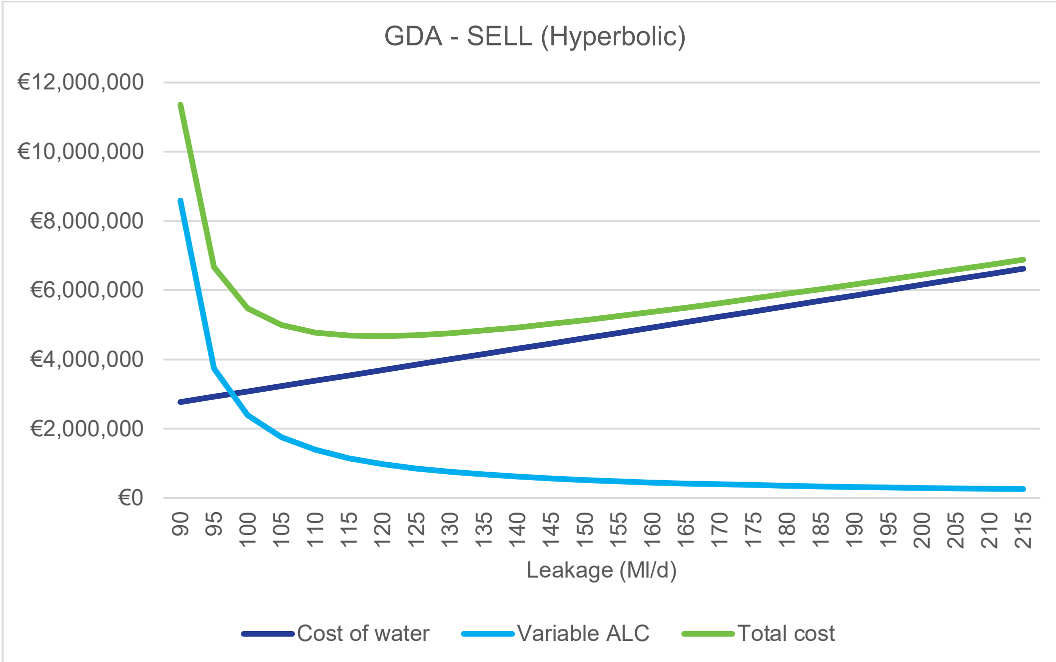

Figure 9.2 GDA SELL (hyperbolic cost curves)

The breakdown of the different components of the SELL is provided in Figure 9.3.

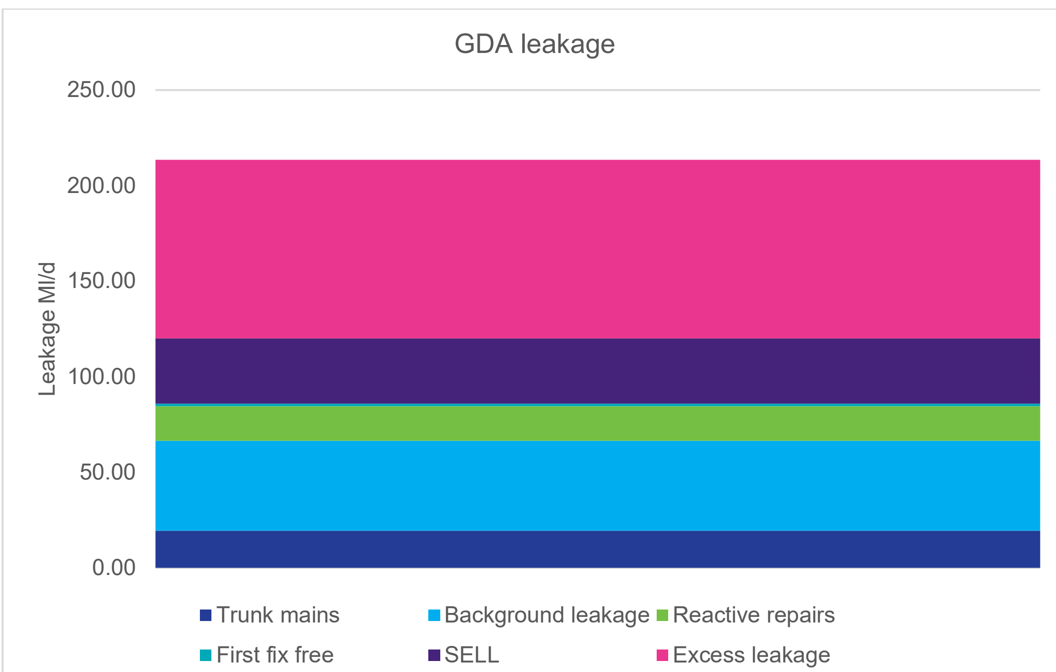

Figure 9.3 Breakdown of GDA leakage from SELL modelling

It is noted that not all of the excess leakage shown in Figure 9.3 is necessarily leakage. Over time with the implementation of the LMS, it may be that a proportion of this is consumption. Over time improvements in data as well as managing real leakage reductions will further improve the understanding of this.

9.2.2 Irish Water SELL model – GDA

The short run SELL is derived with a number of key inputs:

- Background leakage/policy minimum;
- Marginal cost of water (MCW);
- Externalities;
- Repair and ALC costs;
- Steady State; and
- Current leakage levels.

These have been covered in detail in other sections of this report. The Net Present Value (NPV) of the current position is then compared with the SELL, including the transitional cost of moving to the new level of leakage. The short run SELL is also assessed over time in relation to the increasing value of the shadow price of carbon over time.

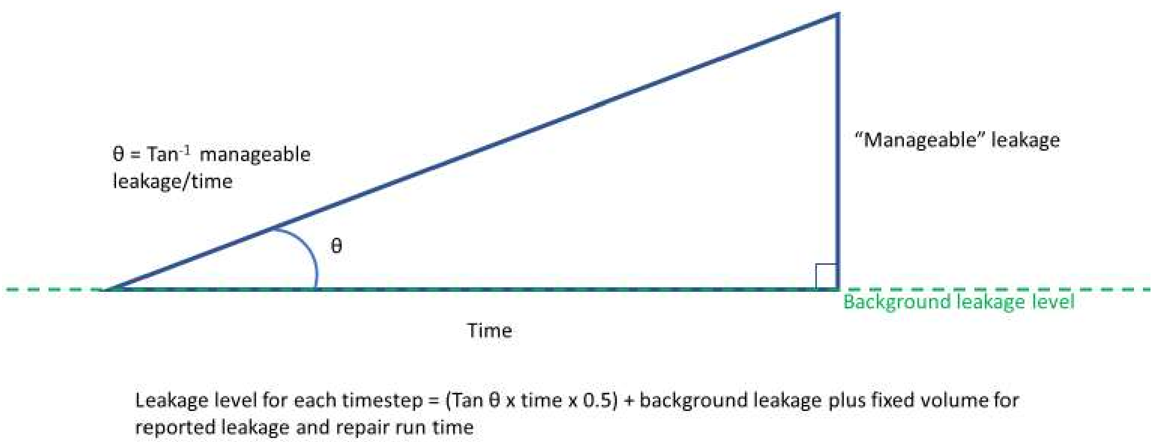

Figure 9.4 Principle behind derivation of leakage level from varying time between intervention

The inputs are consistent with Section 9.2.1 and summarised in the table below.

Table 9.2 Inputs for Irish Water SELL model for GDA

Variable ALC cost	€	Value	Source
Background leakage	Ml/d	46.97	Netbase Dec 2019
First fix free	Ml/d	1.39	Repair data analysis Dec 2019
Reactive repairs	Ml/d	18.06	Repair data analysis Dec 2019
Trunk mains	Ml/d	19.47	UKWIR allowance
Total fixed volume	Ml/d	85.89	Sum of the four lines above
Current level of leakage	Ml/d	213.5	2019 target
MCW	€/Ml	€ 78	MCW internal
MCW including carbon	€/Ml	€ 84	MCW internal plus carbon
Transition volume per repair	Ml/d	0.02	Assumed volume for transitional costs

The Irish Water SELL model provides an ELL of **120 Ml/d** for the GDA and a SELL of **119 Ml/d**. This is considered reasonable when compared to the generic cost curve approach outlined in Section 9.2.1.

The SELL of 119 Ml/d falls within a range of 113 Ml/d to 127 Ml/d, based on variance of 1% in the total cost. The SELL cost curves are presented in Figure 9.5 below.

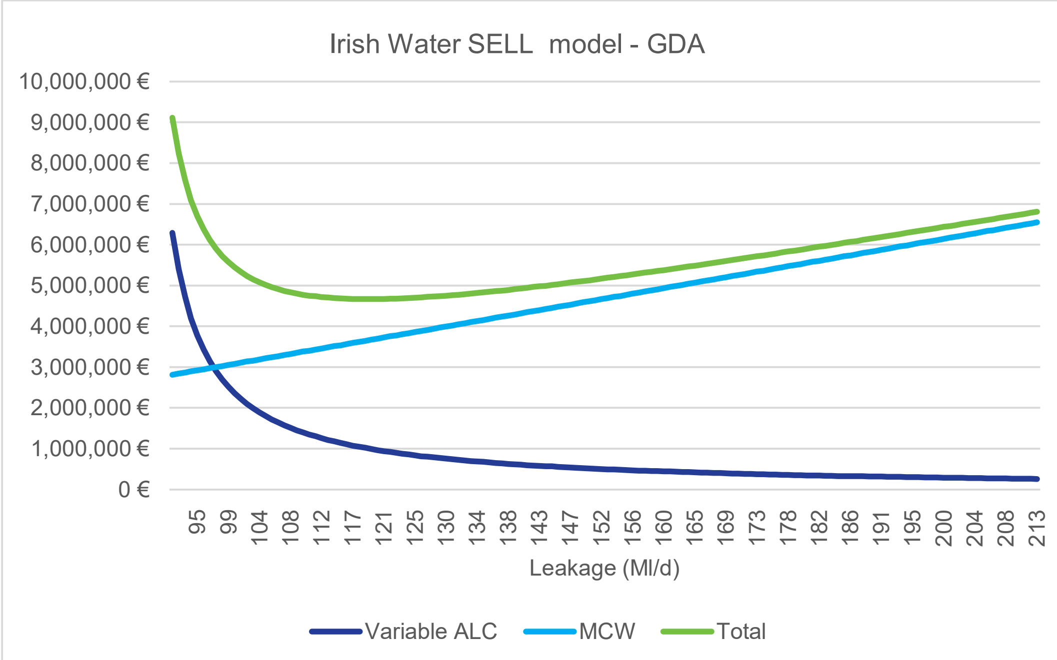

Figure 9.5 Irish Water SELL model – GDA

The impact of the shadow price of carbon increasing from 2025 onwards potentially has an impact on the SELL. We have modelled this impact over time and found that although the shadow cost of carbon more than doubles between 2025 and 2040, this has a very limited impact on the short run SELL, Figure 9.6 illustrates this.

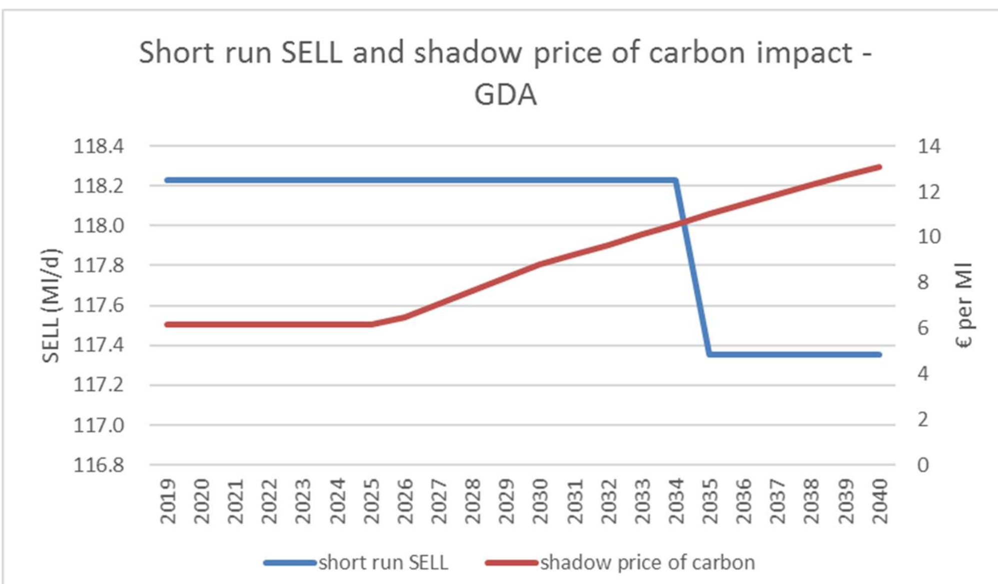

Figure 9.6 Impact of the increase in shadow price of carbon on short run SELL for the GDA

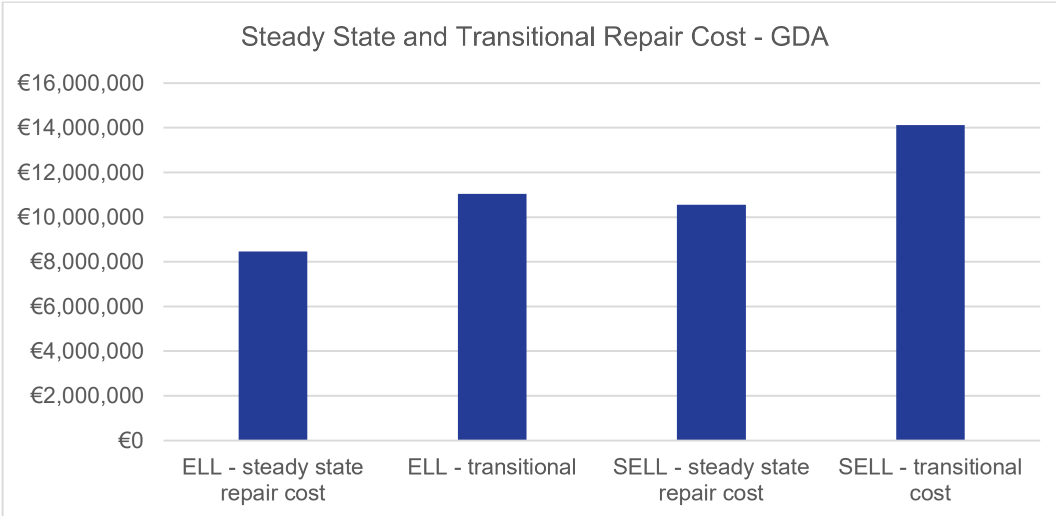

Figure 9.7 Steady state and transitional repair costs

Figure 9.7 provides the steady state ELL and SELL and transitional repair costs. The externalities are covered in detail in Section 7 of this report.

The steady state SELL and transitional cost of reaching the new level of leakage are compared to ensure that it is not uneconomic to achieve the lower level of leakage. The Net Present Value (NPV) has been calculated to compare the current position against the SELL for the period 2020 to 2040 using a discount rate of 4%:

Table 9.3 GDA NPV of SELL

Item	2020	2021	2022	2023	2024	2025
Maintain - steady state repair	€8,457,932	€8,457,932	€8,457,932	€8,457,932	€8,457,932	€8,457,932
Maintain - ALC	€260,461	€260,461	€260,461	€260,461	€260,461	€260,461
Maintain - MCoW	€6,572,750	€6,572,750	€6,572,750	€6,572,750	€6,572,750	€6,572,750
SELL - steady state repair	€8,457,932	€8,457,932	€8,457,932	€8,457,932	€8,457,932	€8,457,932
SELL - ALC	€1,020,725	€1,020,725	€1,020,725	€1,020,725	€1,020,725	€1,020,725
SELL - MCoW	€3,639,773	€3,639,773	€3,639,773	€3,639,773	€3,639,773	€3,639,773
SELL Transition	€11,043,243	€0	€0	€0	€0	€0
Total - Maintain	€15,291,142	€15,291,142	€15,291,142	€15,291,142	€15,291,142	€15,291,142
Total SELL	€24,161,672	€13,118,429	€13,118,429	€13,118,429	€13,118,429	€13,118,429
NPV - current	**€214,521,876**					
NPV -SEll	**€194,659,041**					

The NPV of the SELL is €195m compared to €215m if the current level of leakage is maintained. The transitional costs are not considered a barrier to achieving the SELL. The first part of the time series is shown in Table 9.3.

9.3 Irish Water – Sustainable Economic Level of Leakage

9.3.1 Hyperbolic cost curve (national)

The inputs for Irish Water (National) as summarised in Table 9.4 below.

Table 9.4 Hyperbolic cost curve inputs

Variable	Unit	Value	Source
Properties	number	1,917,212	Netbase Dec 2019
Mains length	km	66,799	Netbase Dec 2019
Trunk mains length	km	5,641	Netbase Dec 2019
Current level of leakage	Ml/d	746	Leakage target 2019 (Based on Q1-Q3 data 2019)
Background leakage – 25th percentile of min achieved	Ml/d	131.70	Netbase Dec 2019
Fixed repair volume – reactive and first fix free	Ml/d	164,88	From repair data analysis
Trunk mains	Ml/d	84,62	Using generic allowance
Ca	€/annum	2,080,562	Based on ALC resource cost and assumed 12 hours per leak
MCW – internal	€/Ml	€ 78.10	Based on more expensive GDA source from 2016, inflated to 2019 cost
MCW – with carbon	€/Ml	€ 84.29	MCW internal plus carbon
Lowest total cost	€	21,403,751	Calculated (minimum cost of water plus ALC)
SELL	Ml/d	540	Calculated – leakage level at lowest total cost
Total fixed volume	Ml/d	381.20	Sum of 132 Ml/d background, 84.6 Ml/d Trunk mains and 155 Ml/d FFF and reactive
K	n/a	758,996,585	Calculated Ca x (current level of leakage – total fixed volume of 372)

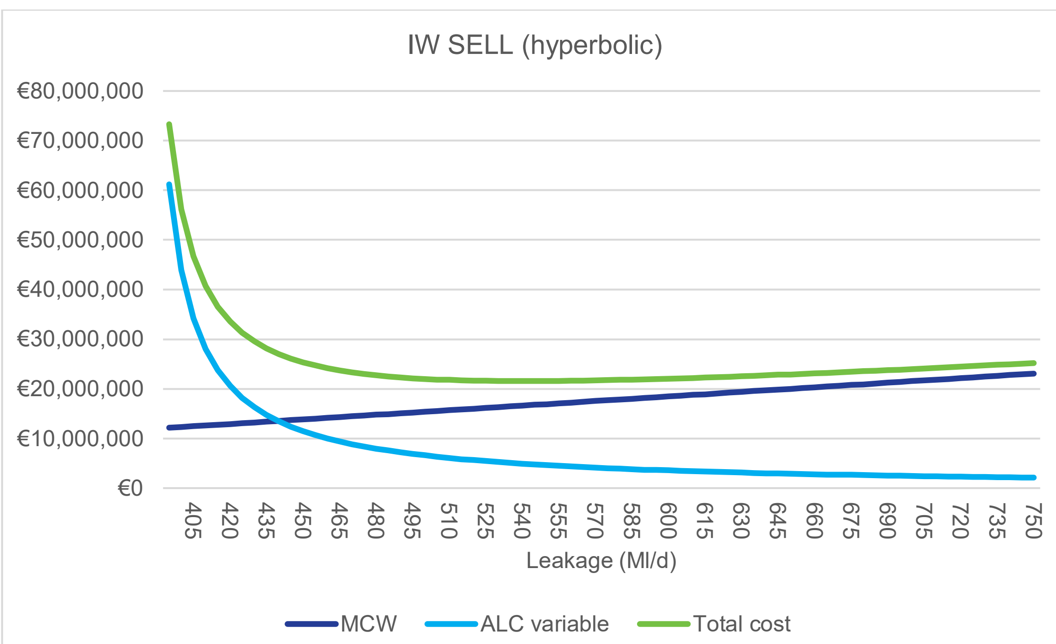

Figure 9.8 SELL using hyperbolic cost curve for GDA

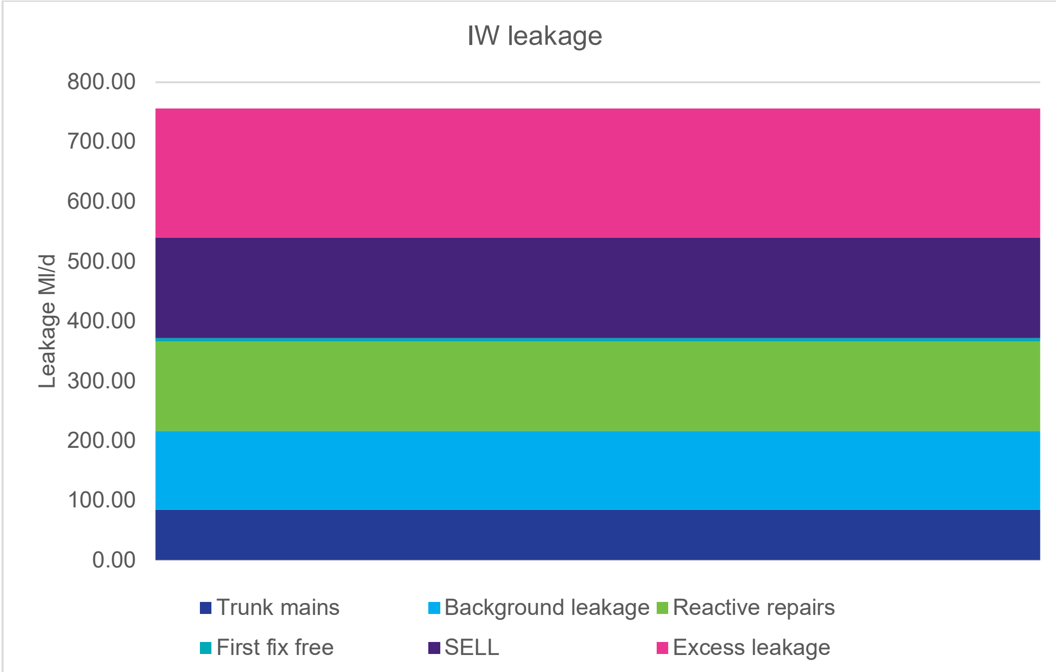

Figure 9.9 Breakdown of SELL

The same methodology for estimating the SELL using the generic hyperbolic cost curves as described for the GDA are summarised in Figures 9.8 and 9.9, with a resulting SELL of 539 Ml/d.

9.3.2 Irish Water SELL model – national

Using the same model as used for the GDA, the following Table 9.5 summarises the key inputs.

Table 9.5 Irish Water SELL model – national inputs

Variable ALC cost	€	Value	Source
Background leakage	Ml/d	131.7	Netbase Dec 2019
First fix free	Ml/d	6.29	Repair data analysis Dec 2019
Reactive repairs	Ml/d	149.25	Repair data analysis Dec 2019
Trunk mains	Ml/d	84.62	UKWIR allowance
Total fixed volume	Ml/d	371.86	Sum of the four lines above
Current level of leakage	Ml/d	746	2019 target (based on information Q1-Q3 2019)
MCW	€/Ml	€ 78	MCW internal
MCW including carbon	€/Ml	€ 84	MCW internal plus carbon
Transition volume per repair	Ml/d	0.02	Assumed volume for transitional costs

The SELL for Irish Water overall is 539 Ml/d as shown as the lowest total cost (ALC plus cost of water) in Figure 9.10 below. This falls within a range of 509 Ml/d to 576 Ml/d, representing the range within 1% of the total cost.

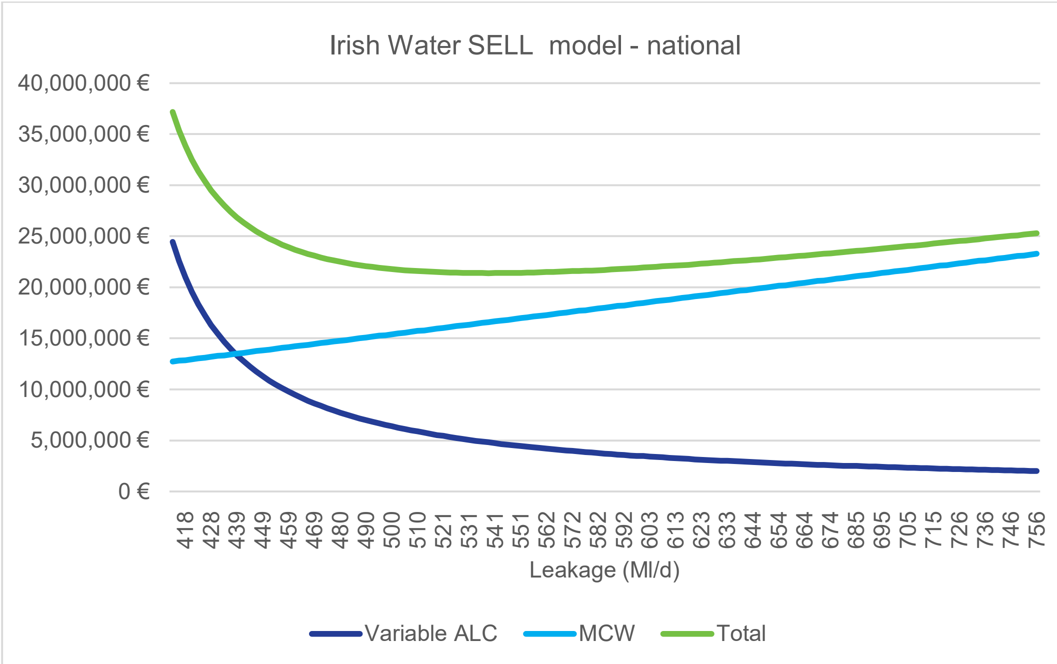

Figure 9.10 Irish Water SELL - national

The steady state costs and transitional costs are presented in Figure 9.11 below.

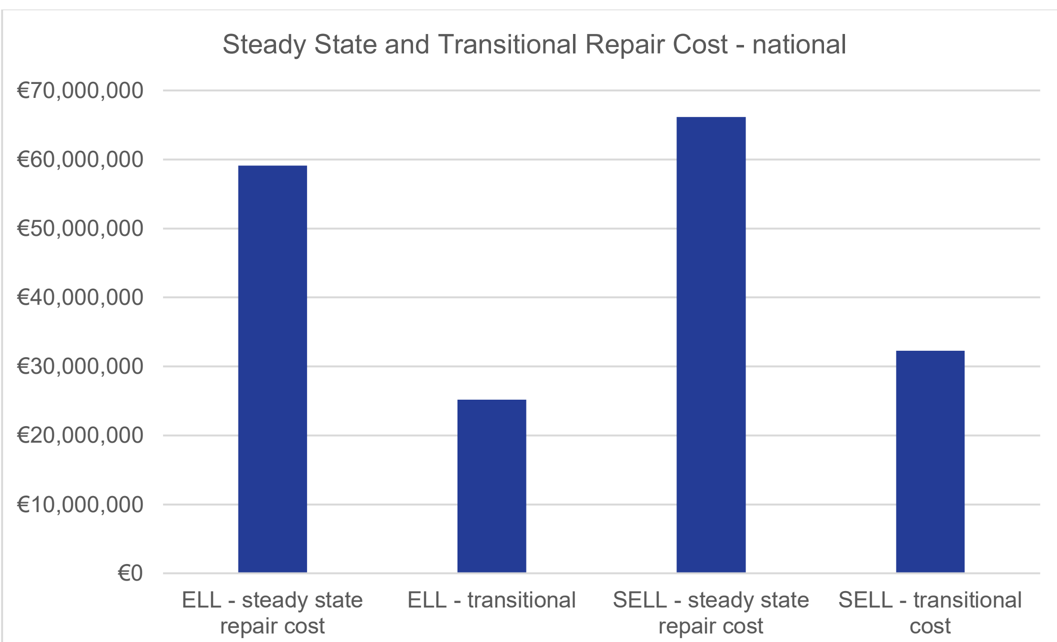

Figure 9.11 Steady State and transitional repair cost

The NPV over 20 years is less to reduce leakage to the SELL than to maintain the current position, using a discount rate of 4%, the first part of the time series is shown in Table 9.6.

Table 9.6 NPV of the short run SELL

Item	2020	2021	2022	2023	2024	2025
Maintain - steady state repair	€59,079,227	€59,079,227	€59,079,227	€59,079,227	€59,079,227	€59,079,227

Item	2020	2021	2022	2023	2024	2025
Maintain - ALC	€2,080,562	€2,080,562	€2,080,562	€2,080,562	€2,080,562	€2,080,562
Maintain - MCoW	€24,290,299	€24,290,299	€24,290,299	€24,290,299	€24,290,299	€24,290,299
SELL - steady state repair	£59,079;127	£59,079;127	£59,079;127	£59,079;127	£59,079;127	£59,079;127
SELL - ALC	€4,161,124	€4,161,124	€4,161,124	€4,161,124	€4,161,124	€4,161,124
SELL - MCoW	€16,279,936	€16,279,936	€16,279,936	€16,279,936	€16,279,936	€16,279,936
SELL Transition	€36,512,060	€0	€0	€0	€0	€0
Total - Maintain	€85,450,088	€85,450,088	€85,450,088	€85,450,088	€85,450,088	€85,450,088
Total SELL	€116,032,347	€79,520,286	€79,520,286	€79,520,286	€79,520,286	€79,520,286
NPV - current	**€1,198,792,945**					
NPV -SELL	**€1,150,710,567**					

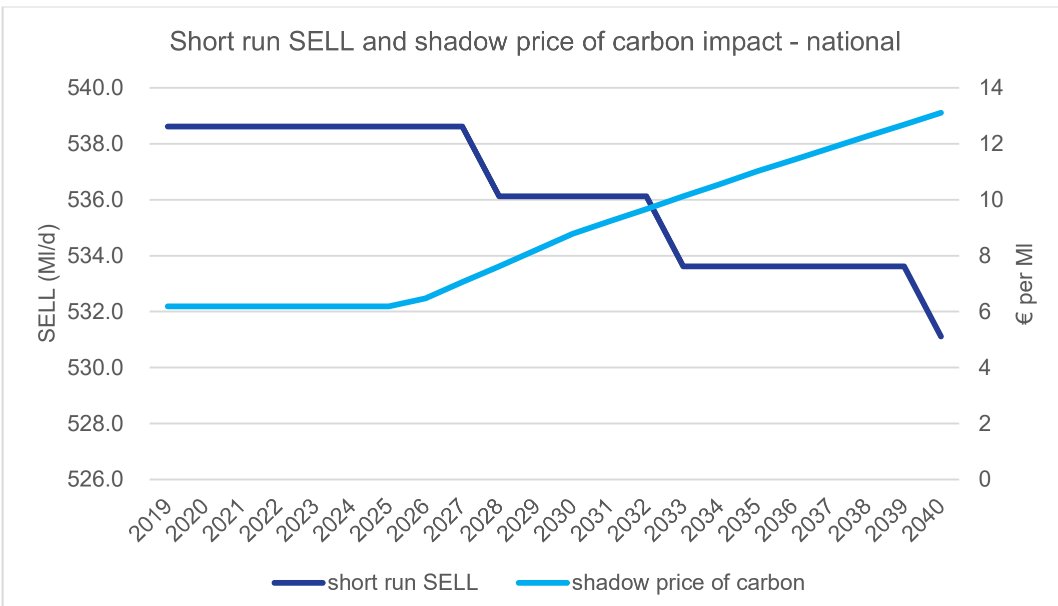

Figure 9.12 Impact of shadow price of carbon forecast on short run SELL

The longer-term increase in the forecast of the shadow price of carbon does gradually drive down the short run SELL, however this isn't forecast to impact on the SELL in the coming 5 years, as shown in Figure 9.12.

9.4 Apportioning National SELL to Water Resource Zones

There is insufficient data to be able to assess leakage by WRZ independently at this stage and, due to the large number of WRZs, it would not be practical to do so. As data quality improves over the coming years then this may be possible. It has therefore been necessary to apportion the residual/non-GDA SELL across the WRZs outside of the GDA. There were a number of potential options available to do this:

- Using property counts;
- Using mains length;

- Using Kilojoints (Kj) as a metric that combines both mains length and property counts; and
- Apportionment of leakage across WRZs with water resource zone drivers.

Apportionment of leakage based on water resource zone drivers was selected as the preferred approach. This brings increased focus for leakage reduction in the zones that are likely to benefit from demand reduction, in the absence of a robust SELL at WRZ level at the current time. The approach taken in apportioning the SELL across WRZs is qualitative but recognises that leakage reduction should be focused on areas with known issues or risks. The approach taken takes account of parameters that would constrain the achievable reduction in leakage, to ensure that the SELL is achievable and practical to deliver.

9.4.1 Methodology

Irish Water provided a list of WRZs with a flag for each zone against the following criteria:

1. The WRZ was in deficit for NYAA in 2019;
2. A WTP in the WRZ is abstracting greater than the UKTAG guidance volume; and
3. A WTP in the WRZ reported supply demand balance issues in the 2018 drought.

The flags for each WRZ were summed, giving a minimum score of zero for no flags, and a maximum score of 3 if a zone triggered against each flag.

The methodology for the split of the national SELL is as follows from the development of a spreadsheet tool:

1. Background leakage from the SELL for the GDA and non-GDA was apportioned across each WRZ. This includes the trunk mains/service reservoir/reported leakage volumes as well as background leakage from the distribution network.

   An of the estimate of background leakage for each zone was derived from the UKWIR Managing Leakage 2011 formula, with a scaling factor applied to include the allowance for the other fixed volume elements, and to ensure consistency with the short run SELL at the national level.
2. The number of flags were summed for each WRZ.
3. The 2019 leakage for each WRZ was calculated in Ml/d.
4. The GDA was separated out, with the SELL at 130 Ml/d.
5. A user input table was set up with four percentages to represent the percentage of leakage above background leakage, for 0, 1, 2 and 3 flags.
6. The percentage input was restricted not to be below 20%, as this is where the ALC cost curve becomes asymptotic to background leakage, and the total cost curve starts to steepen quite significantly. This constraint avoids setting unrealistic/unachievable SELL targets. The tool is set up to allow the user to vary the percentage above background leakage, with a lower percentage set where there is a greater number of flags and higher risk in terms of water resources.
7. A formula is set up to firstly check if the current level of leakage is less than the estimate of background leakage including the fixed volumes for trunk mains/service reservoir/reported leakage. Any GDA flags are removed, and the non-GDA zones background leakage and fixed volume is then increased by the percentage set by the user, through a nested if statement (see below).

L2 — fx

```
=IF(K2<J2,K2,IF(I2="GDA",IF((J2+J2*$S$2)<K2,J2+J2*$S$2,K2),IF(I2=0,IF((J2+J2*$S$3)<K2,J2+J2*$S$3,K2),IF(I2
=1,IF((J2+J2*$S$4)<K2,J2+J2*$S$4,K2),IF(I2=2,IF((J2+J2*$S$5)<K2,J2+J2*$S$5,K2),IF(I2=3,IF((J2+J2*$S$6)<K2,
J2+J2*$S$6,K2),""))))))
```

	C	D	E	F	G	H	I	J	K	L	M
1	Water Resource Code	1:WRZ in Deficit for NYAA in 2019	Criteria 2: A WTP in the WRZ is Abstracting > than the UKTAG guidance Volume or Aquator whichever is the lesser	Criteria 3: A WTP in the WRZ is Reported SDB difficulties in the 2018 drought	2019 UFW (m^3/day)	2019 UFW (%)	Priority	BL adjusted with reported leakage, TM/SR included (Ml/d)	2019 UFW (Ml/d)	UFW (Ml/d) - achieve SELL	Che
2	0100SC0001	FALSE	TRUE	TRUE	5,637	42%	2	3.603593738	5.64	5.636647531	
3	0100SC0002	FALSE	FALSE	FALSE	182	46%	0	0.124751212	0.18	0.182099808	

Figure 9.13 Extract from spreadsheet tool showing 'what if' statements

1. The user can adjust the percentages however noting that the non GDA is set as a residual, this adjustment is being carried out post-short run SELL and can skew the economics of leakage management. For example, if all zones were set at 20% above background leakage, costs would be significantly higher than if they were all set at 50%.
2. At the current time, the percentages have been set at 65% for 3 flags, 70% for 2 flags, 80% for 1 flag and 90% for no flags. This results in a non-GDA level of leakage of 404 Ml/d that is in line with the residual non-GDA SELL, but with some prioritisation based on the water resource drivers.

Whilst longer term the recommended approach would be to develop robust leakage management options for each individual WRZ, this was not possible at the current time. The non-GDA SELL is a residual, and therefore this means of apportionment of this residual SELL across the WRZs contains a qualitative element. The approach is considered reasonable as it allows for prioritisation of WRZs with the greatest water resource drivers and takes a balanced view in terms of the delivery being practical and achievable. Figure 9.14 demonstrates the rationale for setting the limit in the spreadsheet tool at 20% above background leakage. The total cost curves overall are relatively flat, the example below is derived from the Irish Water total cost curve.

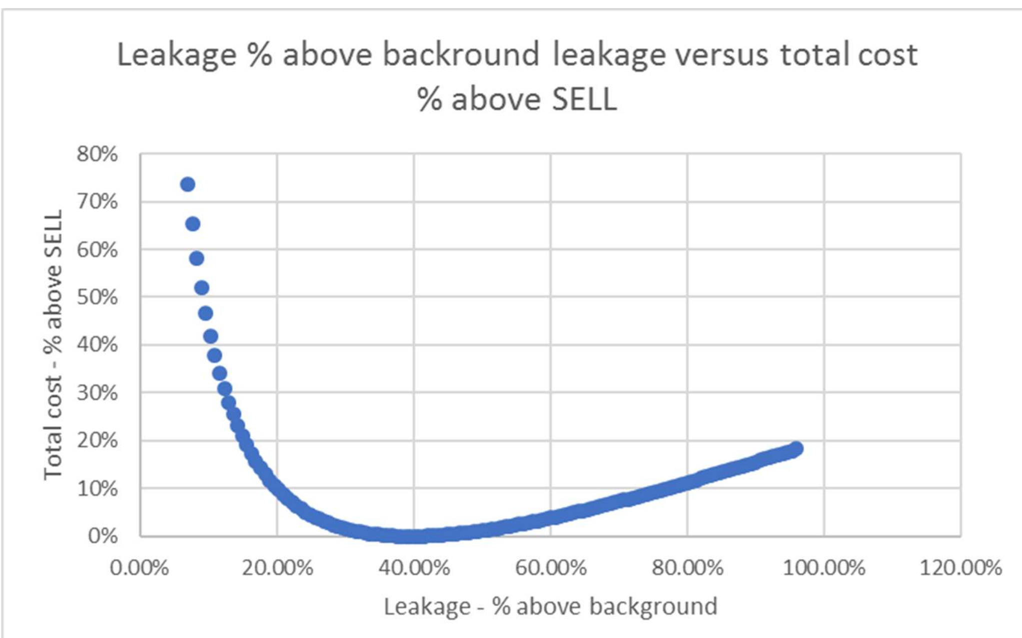

Figure 9.14 Total cost curve for Irish Water

Using the following percentages, the non-GDA SELL is achieved of 404 Ml/d.

Table 9.7 Percentages above background leakage

Flags	Priority	Percentage above BL	Comment
GDA	GDA	23.80%	Fixed so GDA = 130 Ml/d
Non GDA priority 0	0	90%	No triggers
Non GDA priority 1	1	80%	1 trigger
Non GDA priority 2	2	70%	2 triggers
Non GDA priority 3	3	65%	3 triggers

This results in the apportionment of SELL reduction across the priority zones and GDA as follows.

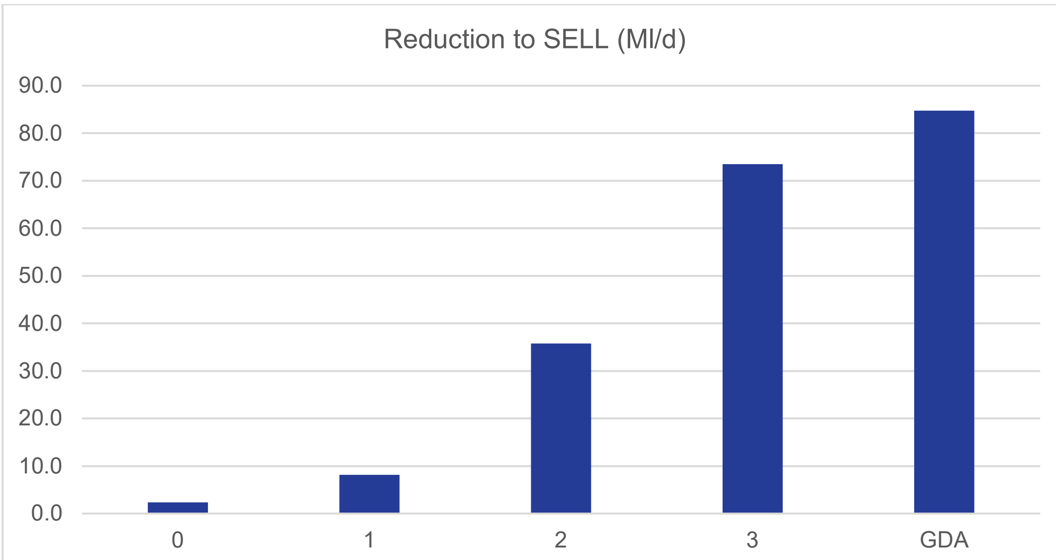

Figure 9.15 Apportionment of SELL reductions across WRZs

The greatest reduction overall is in the GDA, and then non-GDA zones with 2 or 3 flags are where the remainder of the reduction in leakage is being focused.

This approach is considered reasonable as it takes the short run SELL and prioritises the reduction in leakage across WRZs using a qualitative process, but balances this with the risk of setting unachievable or undeliverable targets in the long-term planning process.

9.5 Summary

The results from this update are presented in the table below. The short-run ELL for the GDA is 120 Ml/d, and the SELL for the GDA is 119 Ml/d. The short run SELL of 119 Ml/d is within a range of 113 Ml/d and 127 Ml/d, based on 1% of the total cost (ALC plus marginal cost of water). With further pressure management that is considered economic **the short-run SELL for the GDA is 114 Ml/d.** This represents a network leakage SELL in line with current leakage reporting methodology.

The short-run ELL for Irish Water (National) is 544 Ml/d, and the SELL is 539 Ml/d. The short-run SELL for Irish Water of 539 Ml/d is within a range of 509 Ml/d and 576 Ml/d, based on 1% of the total cost. With further economic pressure management in the GDA, **the short-run SELL for Irish Water (National) is 534 Ml/d**. The remainder of Irish Water has been taken as the difference, therefore **the non-GDA SELL is 420 Ml/d.**

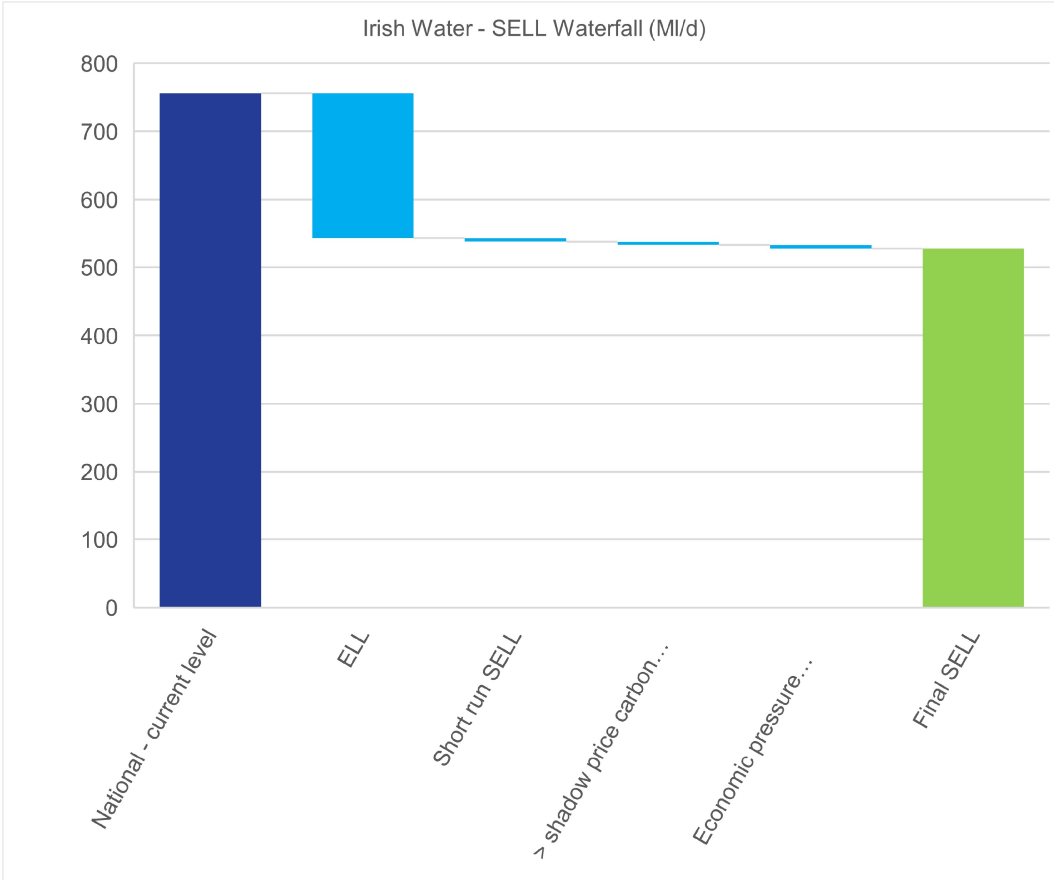

Figure 9.16 Waterfall chart of SELL

10. Sensitivity Analysis

The SELL is sensitive to a number of key inputs, and these have been assessed in terms of sensitivity analysis:

- MCW – SELL is inversely proportional to this and will decrease as this increases.
- ALC costs – higher ALC costs will increase the SELL.
- Background leakage/policy minimum – the SELL is highly sensitive to this as the ALC cost curve is asymptotic to background leakage and will decrease with reductions in background leakage.
- ALC efficiency – the model has been developed to allow this to be varied and SELL is sensitive to this. Improved ALC efficiency will reduce the SELL and the model allows for this to be varied.

10.1 SELL sensitivity at national level

The sensitivity parameters and ranges have been developed based on alternative assessments, or where there is a clear justification and range that could be calculated. For example, the marginal cost of water sensitivity is based on different WTP costs, as well as a scenario where energy prices hypothetically increased. Background leakage sensitivity is based on different managing leakage estimates for network condition between good and poor, and the UARL.

The sensitivity analysis is based on a number of scenarios that are considered realistic, for example using Managing Leakage 2011 estimates for background leakage to compare with the values estimated and used in the SELL. These are summarised in Table 10.1 below.

Table 10.1 Sensitivity analysis

Scenario	Justification	Model	MCW (€/Ml)	Background leakage (Ml/d)	ALC unit cost (€/hr)	ALC efficiency (hours per leak)	SELL (Ml/d)	ELL (Ml/d)2
Steady State SELL - national	Best estimate of SELL	National	77	131.7	29.83	12	539	544
Lower MCW to cheapest WTP	Based on lowest WTP cost, 65% of the cost of the highest	National	50.05	131.7	29.83	12	575	569.6
Increase MCW by 30%	To represent significantly > inflation cost increases in power/chemical cost	National	100.1	131.7	29.83	12	523	528.6
BL - 81 Ml/d	Managing leakage - good condition	National	77	81	29.83	12	498	502
BL - 161 Ml/d	Managing leakage - average condition	National	77	161	29.83	12	564	568
BL - 242 Ml/d	Managing leakage - poor condition	National	77	242	29.83	12	629	633
BL - 104 Ml/d	UARL	National	77	104	29.83	12	516	520
ALC unit cost >10%	Increase in unit costs relative to inflation	National	77	131.7	32.813	12	546	549

Scenario	Justification	Model	MCW (€/Ml)	Background leakage (Ml/d)	ALC unit cost (€/hr)	ALC efficiency (hours per leak)	SELL (Ml/d)	ELL (Ml/d)2
ALC unit cost <10%	Reduction in cost relative to inflation	National	77	131.7	26.847	12	534	536
ALC efficiency improved	10 hours per leak	National	77	131.7	29.83	10	528	534
ALC efficiency deteriorated	14 hours per leak	National	77	131.7	29.83	14	551	554
ALC efficiency improved significantly	6 hours per leak	National	77	131.7	29.83	6	500	505

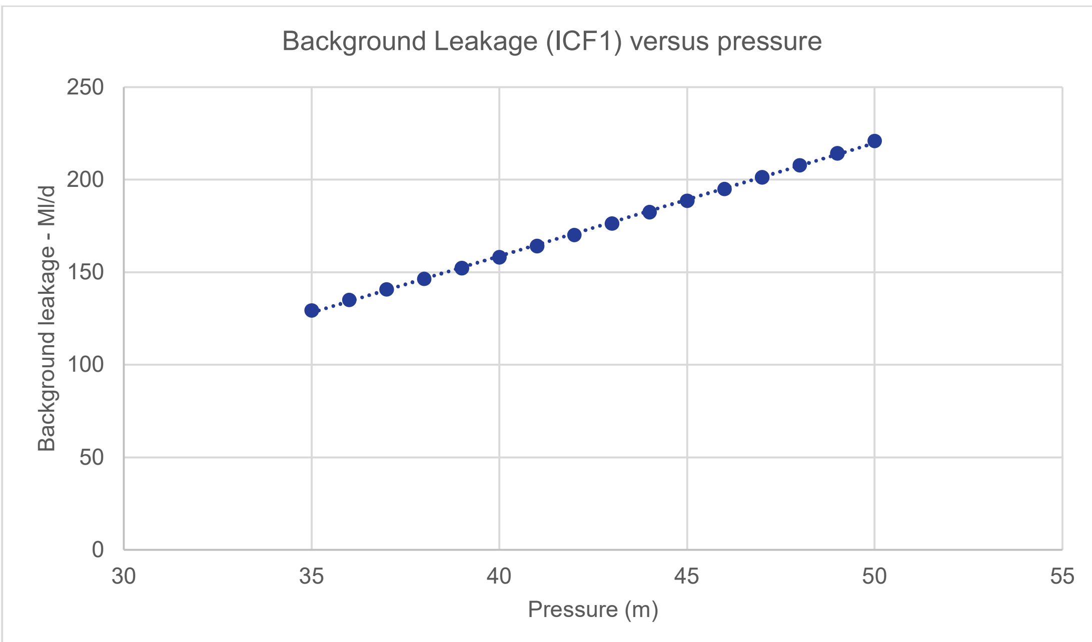

Figure 10.1 Impact of pressure on background leakage

Figure 10.1 above shows the sensitivity of the managing leakage estimate of background leakage to pressure. Figure 10.2 summarises the outputs from sensitivity analysis of the SELL at national level.

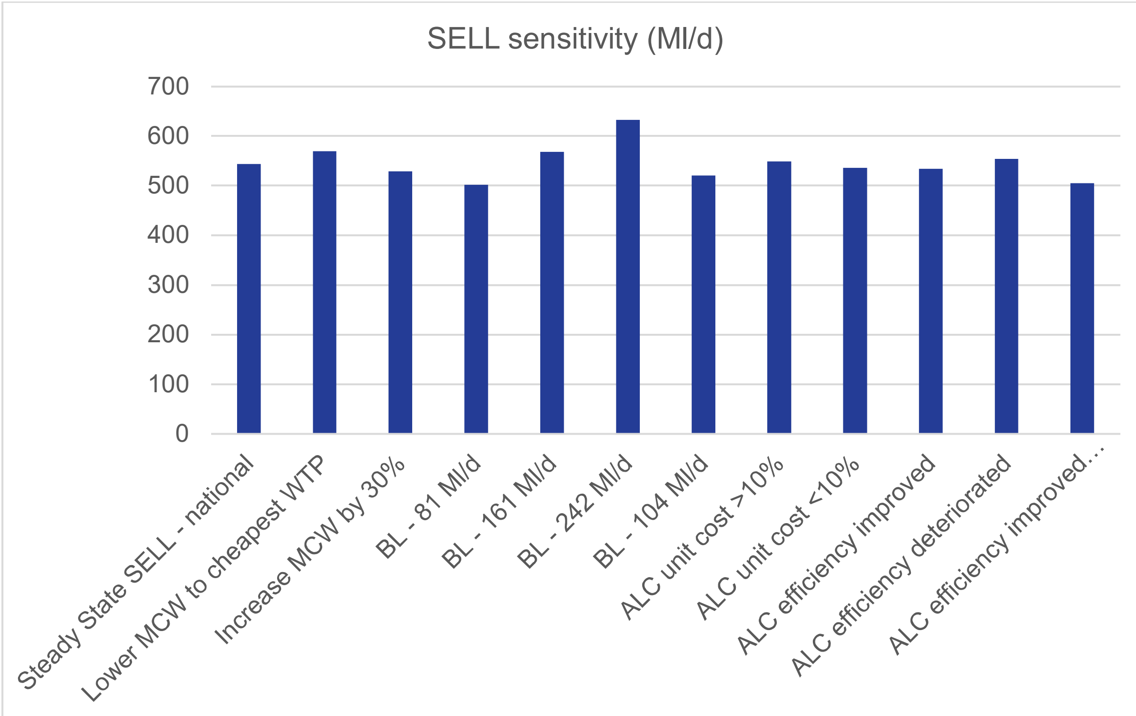

Figure 10.2 SELL sensitivity bar chart

Overall there are a number of variables and factors that could increase or reduce the estimate of the SELL. Background levels of leakage and ALC efficiency are two of the most important and over time data improvements will result in improved estimates of both of these variables. Overall with a SELL of 539 Ml/d before taking into consideration the increase in the shadow prices of carbon or the economic level of pressure management, the SELL could be as high as 633 Ml/d or as low as 502 Ml/d given the most extreme scenarios. It is considered highly unlikely that these extremes are realistic and planning within the range represented by 1% of the total cost is considered reasonable to allow for sensitivity.

10.2 SELL sensitivity for GDA

The short run SELL of 119 Ml/d for the GDA is considered the best estimate of the SELL based on the data available in late 2019. However, there remains considerable data uncertainty at this time, particularly with respect to active leakage control efficiency and in relation to background leakage estimation.

In light of the data uncertainties and to test the sensitivity of the estimates, we have also estimated SELL for the GDA using UKWIR Managing Leakage 2011 estimates of distribution network background leakage, and a less optimistic view of active leakage efficiency. The following scenario is therefore intended to present an alternative short-run SELL that can be compared, to understand the sensitivity of the estimate to be used in the long-term water resources planning context.

The following parameters were input into the SELL model for the GDA:

- Background leakage assuming 50m pressure and average network condition from the UKWIR Managing Leakage 2011 generic flow rates. For the GDA this is calculated as ((60 x 6893.9km)+(4.5 x 683,778) x (50/50)^1.5 in litres per hour for poor mains condition, or ((40x6893.9)+(3 x 683,778))x(50/50)^1.5. This is then converted to Ml/d = 55.85 Ml/d to 83.77 Ml/d excluding trunk mains and reported leak repairs. This is compared to the Netbase estimate of 47 Ml/d for background leakage that excludes trunk mains and reported leak repair volumes.
- The trunk mains and fixed repair volume/outstanding repair volume is 39.17 Ml/d.

- The total estimate for background leakage using Netbase is 86.14 Ml/d. The total estimate in this sensitivity testing is between 95.02 Ml/d and 122.94 Ml/d. This gives a total for background leakage including trunk mains and reported repair volume, and represents an increase of between 8.88 Ml/d and 36.80 Ml/d.
- Taking 50% of the increase from the Netbase 25th percentile estimate, associated with the poor distribution mains Managing Leakage 2011 estimate, excluding supply pipe leakage and plumbing losses, gives an estimate of 104.54 Ml/d.
- This is an **18.40 Ml/d** increase from the estimation of background leakage used in the best-estimate of the short run SELL for the GDA.
- Utilising a more pessimistic assessment of active leakage control efficiency, of 14 hours per leak, increases the SELL by **3 Ml/d.**

This results in **an alternative short-run SELL of 135 Ml/d** for the GDA. When additional economic pressure management is included this is reduced to **130Ml/d.**

The SELL of 119 Ml/d for the GDA is considered the best current estimate using available data from late 2019 with the limitations associated with active leakage control efficiency and in relation to background leakage estimation. The estimate of background leakage will improve over time, as a longer time series of data builds up within the LMS. It is recommended that improved data and visibility of active leakage control performance is something that is addressed in the near future, as this is a key area that requires more robust data and information.

The short run SELL is an input into the NWRP demand forecast, with long-run options being provided to further reduce leakage over time. The total cost curve is relatively flat, with a range of 14 Ml/d within 1% of the total cost. Sensitivity analysis has shown that there are a number of inputs that can result in the SELL both increasing and reducing.

It is recognised that the SELL is one of the key inputs when making strategic decisions in relation to long-term projects for the supply demand balance. In the interest of making “no regrets” decisions at this time, given the uncertainties in relation to input data associated with the SELL, taking a prudent view of SELL is advised. This will mitigate the risk associated with some of the key data uncertainties and give greater certainty for long-term planning.

11. Transition to SELL

When the steady state and transitional costs are considered over time, of maintaining the current level of leakage and reducing the level of leakage to the SELL, the optimum economic solution is to reduce leakage to SELL as quickly as possible. There are however a number of wider considerations that delay this for practical reasons. These reasons include:

- Existing budget constraints between 2020 and 2024.
- The availability of skilled and trained resources to undertake find and fix activity. It is not feasible to significantly increase the level of resource for a short duration, and this risk driving inefficiency into the leakage management process.
- Data improvements are necessary to improve visibility of active leakage control efficiency and key parameters such as background leakage.
- There are planning constraints to consider in relation to shut offs when carrying out repairs, to maintain supply and pressure to customers.
- Repairs carry a social cost and impact particularly in relation to traffic delays, therefore spreading the impact over time manages this impact.
- Technology and innovation improvements are likely to improve ALC efficiency over time, and a number of trials in areas such as permanent acoustic sensors/smart networks may offer more cost-effective solutions in the near-future.

11.1 SELL glidepath for GDA

Taking the factors above into account, it is therefore proposed that leakage reduction takes place from 2020 to deliver the GDA SELL of 130 Ml/d by 2034. The proposed SELL glidepath is shown in Figure 11.1 below.

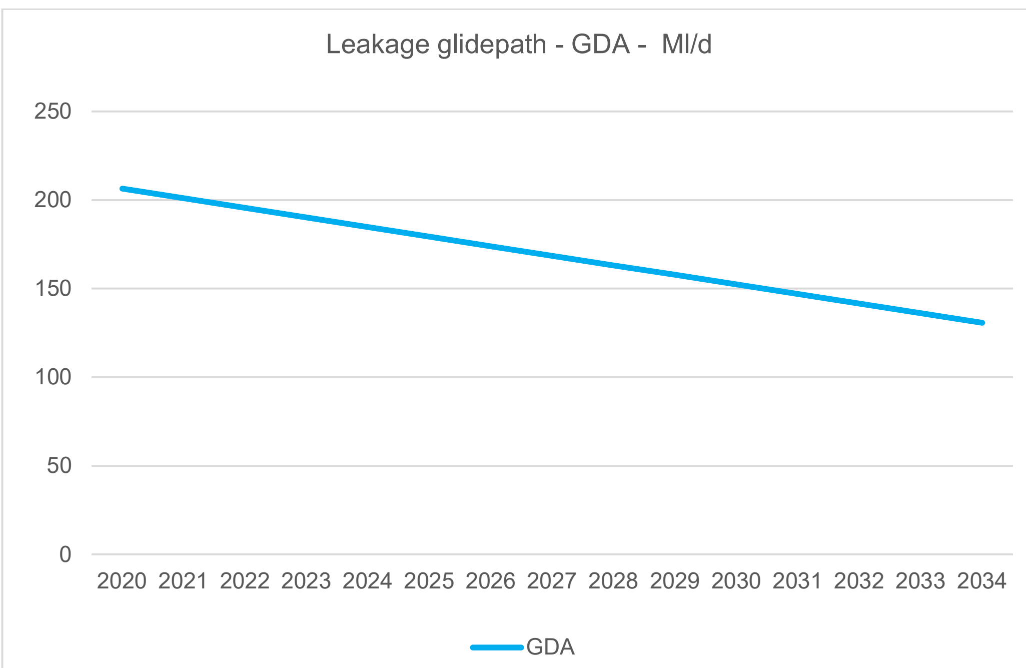

Figure 11.1 Glidepath to achieving SELL in the GDA

11.2 SELL glidepath for non-GDA WRZs

For non-GDA WRZs, the current level of leakage remains until 2023 and then leakage reductions bring leakage in line with the SELL by 2034. The proposed SELL glidepath for non-GDA WRZs is shown in Figure 11.2 below.

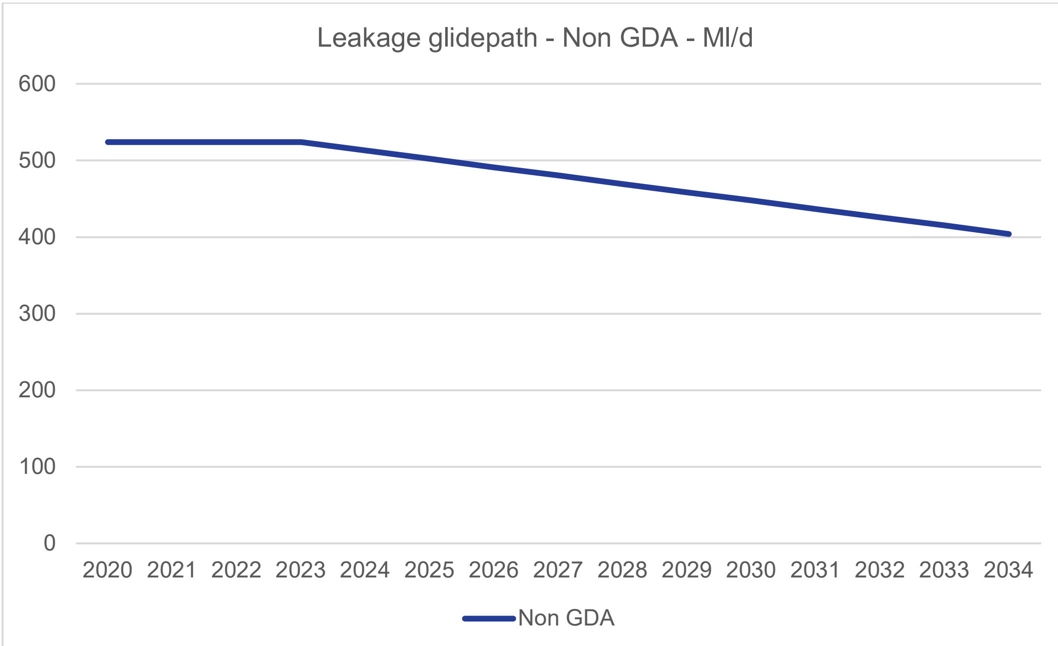

Figure 11.2 Glidepath to achieving SELL in the non-GDA WRZs

12. Data Improvement

Irish Water have taken considerable steps in moving forward with data improvements since the previous estimates of the SELL in 2015 and 2016. The implementation of Netbase (the LMS) is going to yield significant improvements in data that will feed into to future updates of the SELL. At the current time, there is only a relatively short time series of around 18 months or less, and this varies by DMA. Once a longer time series of data is collected this will:

- Allow for more robust estimation of DMA policy minimum.
- Enable Irish Water to better understand the relationship between ALC interventions in terms of time/cost and the associated saving in leakage.
- Enable robust assessments of the Natural Rate of Rise.
- Bring improvements in the bottom up estimate of DMA leakage that will help separate leakage from consumption and help improve the estimation of steady state.

The key areas for continued focus include the following:

- In terms of the LMS, Irish Water have taken positive steps that will result in significant improvements in data quality once the time-series of data is available. This is considered pivotal in terms of improving not only the SELL, but the overall estimation and reporting of leakage over time.
- Repair data appears to be improving significantly, and with Maximo, Irish Water have the ability to generate consistent reports in terms of repair numbers, repair run times and outstanding leaks. There was only a very short time period available for this assessment of SELL however positive improvements have been made, and benefits will be realised over time once a longer time series of data is collated. It will be important to ensure that data quality within Maximo is improved, particularly with regards to tagging bursts/leaks to mains or ensuring that the easting and northing co-ordinates are accurate along with other key data such as repair dates.
- The current reporting and management of costs of producing water can be improved with more rigorous management of the running costs of individual works, and this improvement in granularity will benefit the assessment of the SELL in the future.
- One of the main areas for Irish Water to consider for improvement in data quality, is in relation to the time/cost and benefit of active leakage control. The current processes and relationship with the Local Authorities is not providing consistency and visibility in terms of the time spent on site carrying out active leakage control. The granularity of data is not available and this visibility needs to be improved. This will become more pressing as leakage levels continue to reduce. From the sensitivity analysis, one of the variables that is most likely to reduce the SELL considerably is ALC efficiency, and for this reason this is an important area to improve upon.
- Maintaining DMA operability will be a key area to ensure has focus, as these assets are a core building block of the SELL. It is also considered vital to improve the understanding of the performance and condition of PRVs and associated equipment such as PRV controllers.
- We have not produced a separate option for reducing the backlog or repair run times. Given the current arrangements with LAs, this option will require considerable time and thought by Irish Water to work out what the costs, benefits and risks might be to deliver benefits. This has not been included at this time but could be explored longer-term.
- One of the key areas to improve is the unit repair costs. These appear to include significant overheads and are considerably higher than we would expect. In the estimation of the SELL using Method A, the repair costs are fixed, and only become material in terms of the transition. The repair costs at €2000 are not a barrier to delivery of the SELL when a longer term NPV

assessment is made. However, for internal operational control and efficiency, this is considered an area to prioritise to collect better data and understanding of the true costs.

13. Conclusions

The SELL has been split pro-rata across Water Resource Zones (WRZs) using property data. The short-run ELL for the GDA is 120 Ml/d, and the SELL for the GDA is 119 Ml/d. The short run SELL of 119 Ml/d is within a range of 113 Ml/d and 127 Ml/d, based on 1% of the total cost (ALC plus marginal cost of water). With further pressure management that is considered economic, **the short-run SELL for the GDA is 114 Ml/d.**

The short-run ELL for Irish Water (National) is 544 Ml/d, and the SELL is 539 Ml/d. The short-run SELL for Irish Water of 539 Ml/d is within a range of 509 Ml/d and 576 Ml/d, based on 1% of the total cost. With further economic pressure management **the short-run SELL for Irish Water (National) is 534 Ml/d**. The remainder of Irish Water has been taken as the difference, therefore **the non-GDA SELL is 420 Ml/d.**

The SELL of 114 Ml/d for the GDA is considered the best current estimate using available data from late 2019. However, there remains considerable data uncertainty at this time, particularly with respect to active leakage control efficiency and in relation to background leakage estimation. The estimate of background leakage will improve over time, as a longer time series of data builds up within the LMS. It is recommended that improved data and visibility of active leakage control performance and efficiency is something that is addressed in the near future, as this is a key area that requires more robust data and information.

The short run SELL is an input into the NWRP demand forecast, with long-run options being provided to further reduce leakage over time. The total cost curve is relatively flat, with a range of 14 Ml/d within 1% of the total cost. Sensitivity analysis has shown that there are a number of inputs that can result in the SELL both increasing and decreasing.

In light of the data uncertainties and to test the sensitivity of the estimates, we have also estimated SELL using UKWIR Managing Leakage 2011 estimates of distribution network background leakage, and a less optimistic view of active leakage efficiency. This results in a **short-run SELL of 130 Ml/d** for the GDA and 534 Ml/d for Irish Water overall with the non-GDA SELL of 404 Ml/d.

It is recognised that the SELL is one of the key inputs when making strategic decisions in relation to long-term projects for the supply demand balance. In the interest of making “no regrets” investment decisions at this time, given the uncertainties in relation to input data associated with the SELL, taking a prudent view of SELL is advised. This will mitigate the risk associated with some of the key data uncertainties and give greater certainty for long-term planning.

Irish Water should seek to update the SELL in the mid-2020s, if not before, when data improvements have been completed.

The results from this update are presented in the table below.

Table 13.1 Summary table

Line	Description	GDA	National	Remainder (non GDA)	Note
1	Short run ELL, steady state	120 Ml/d	544 Ml/d	424 Ml/d	Internal costs only
2	Short run SELL, steady state	119 Ml/d	539 Ml/d	420 Ml/d	Including externalities
3	Short run SELL with economic pressure management in GDA	114 Ml/d	534 Ml/d	420 Ml/d	As line 2 minus 5 Ml/d of pressure management in GDA
4	Lower bound of short run SELL with a total cost within 1% of the minimum	113 Ml/d	509 Ml/d	396 Ml/d	Lower bound of line 2

Line	Description	GDA	National	Remainder (non GDA)	Note
5	Upper bound of short run SELL with a total cost within 1% of the minimum	127 Ml/d	576 Ml/d	449 Ml/d	Upper bound of line 2
6	Alternative short run SELL	**135 Ml/d**	**539 Ml/d**	404 Ml/d	Using Managing Leakage 2011 estimate for background leakage and a less optimistic view of ALC efficiency
7	Alternative short run SELL plus pressure management in GDA	**130 Ml/d**	**534 Ml/d**	404 Ml/d	Using Managing Leakage 2011 estimate for background leakage and a less optimistic view of ALC efficiency and 5Ml/d of pressure management reduction

For the purposes of the National Water Resources Plan – Framework Plan, the Short Run SELL plus pressure management, highlighted in “Green” in table 13.1 has been used as the Target SELL values for the GDA and Nationally, for the draft Framework Plan.

14. Glossary of Terms

Abbreviation/term	Definition
DMA	District metered area – discrete areas of the network where all in/out flows are measured.
RZ	Resource Zone – referring to water resource zones
GDA	Greater Dublin Area
MCW	Marginal cost of water- the variable cost associated with saving 1 Ml of water.
ALC	Active leakage control – field-based activity on the network to locate hidden leaks.
Background leakage	The estimated level of leakage that cannot be resolved through repairs i.e. find and fix
Policy minimum	The lowest level of leakage that can be attained and achieved through current leakage policy and practice
ELL	Economic level of leakage – the lowest total cost (ALC plus MCW) using internal costs only
SELL	Sustainable Economic Level of Leakage (SELL) – as per ELL but with the inclusion of externalities such as the cost of carbon.
Steady state	The effort required to maintain the current level of leakage
Transitional cost	The one-off effort required to move to a new level of leakage
LMS	Leakage Management System – used to collate DMA, property, volume, pressure, flow and other relevant data for leakage operations, targeting and reporting purposes. The LMS implemented is the Netbase system.
UARL	Unavoidable annual real losses
AMR	Automated meter reading
AMI	Advanced Meter Infrastructure

Appendix A: Assumptions - leakage management externalities

Find and Fix	Number	Unit/description	Comment
Number of vehicles			
Traffic flow rate	311	number of vehicles, mid point of range	
Duration per repair	6	hours	
Delay per vehicle	36	seconds per vehicle	
Average hourly rate Ireland 2018 (CSO)	€ 23	per hour	
Pedestrians delayed			
Pedestrian flow rate	22.5	pedestrial flow rate, mid point	
Duration	6	hours	
Delay	83	seconds per pedestrian	
Average hourly rate	€ 23		
Low pressure			
Leaks causing low pressure	10%	Leaks causing low pressure	
Properties affected	7.50%	% of properties in average DMA size	
DMA properties - average affected	1100		
Cost per property	€ 5		
Supply interruptions			
Leaks causing interruption	5%		
Properties affected	5%		
Cost per property	€ 5		
Noise pollution			
Pedestrial flow	22.5		
Duration of equipment use	1.46	hours, midpoint of range	
Active leakage control			
Transportation			
Carbon emissions per km	175	gCO2/km	Per km, maximum allowed - EU 2017 for new vans
Shadow price of carbon	€ 11	per tonne - may need to vary over time	
Properties	1719973	number	
DMAs	4600	number	
Repairs - steady state	27358	number	
Find and Fix - Carbon			
Transport	45	km per repair	
Site	286	kg/CO2/repair	
Disruption	50	kg/CO2/repair	