

## Policy Position Statement

# Water distribution system leakage in the UK

### Purpose

This policy position statement outlines the key issues associated with leakage between the point of input to the treated water distribution system and the limits of underground supply pipes within customers' properties. This loss of water, known colloquially in UK as 'total leakage', consists of distribution leakage on water company pipes up the point of delivery and underground supply pipe leakage on customers' pipes. This PPS should be read in conjunction with the Water Supply Pipes PPS.

### CIWEM's Position on Leakage:

#### General

1. All water supply distribution systems suffer some leakage. It is generally accepted that it is not technically possible currently, or indeed desirable economically, to achieve zero leakage. CIWEM recognises and applauds the considerable reductions in leakage made by water companies in England and Wales since 1995, and in Scotland since 2006. In Northern Ireland, leakage targets have been established and the 2013/14 target was outperformed.
2. CIWEM supports a holistic approach to leakage control, by considering the components of leakage on each part of the distribution system, and the selection of appropriate policies and techniques, such as management of excess pressures and pressure fluctuations to reduce leak flow rates and burst frequencies and to extend asset life.

#### Customers

3. CIWEM recognises that few customers are aware that around one quarter of 'total leakage' reported by UK companies occurs on customer-owned underground supply pipes, although the proportion varies between Companies. Following a public consultation in 2013 on policy options regarding future management and ownership of water supply pipes, Defra does not intend to carry out further work on transferring ownership of supply pipes at the current time, in the interests of keeping household bills down. Companies should continue to implement and evaluate policy options to reduce supply pipe leakage.
4. CIWEM appreciates that customers' opinions on leakage should be taken into account in setting targets and in prioritising the investment for which they are willing to pay. Research by the Consumer Council for Water (CCWater) shows that leakage is a top priority issue for 28 per cent of customers with the perception that water companies are not doing enough, although they are generally not aware of the substantial investment

which is already being made. The research also shows a link between the company level of leakage and customers' willingness to support water conservation measures.

5. CIWEM recommends that in the long term, all water delivered to customers should be metered for the purposes of water conservation and more reliable assessment of leakage. Most companies are installing new meters at the property line, which will assist in rapid identification and repair of leaks on private supply pipes.

#### Economic level of leakage and leakage targets

6. CIWEM supports the sustainable economic level of leakage (SELL)<sup>iii</sup> approach by which the targets set for leakage reduction by water companies take greater account of the views of all stakeholders including environmental, social and other factors as well as economics.
7. Water companies should be encouraged to work towards the lower end of the assessed economic range, particularly where new resources are required in a zone within the planning horizon. Economic demand management including leakage reduction should take priority over supply side options.
8. CIWEM recognises that the impact of leakage varies greatly between and within areas supplied by individual water utilities, and leakage measures for individual systems need to be judged on several criteria. Differences such as the ecological impact of over abstraction and the carbon cost of both treatment and distribution should be reflected when prioritising reduction measures.

#### Performance measures

9. CIWEM supports the conclusion of a 2015 EU Reference Document<sup>iii</sup> that there is no single leakage performance indicator that is suitable for all purposes, and measures used should be fit for the particular purpose. For expressing targets and tracking progress, MI/day and litres/property are traditionally used in the UK; m<sup>3</sup>/km mains is acceptable for very low connection densities. Infrastructure Leakage Index (ILI) used in conjunction with some measure of pressure is more reliable for international comparisons of technical performance. CIWEM recommends that leakage should definitely not be quoted in terms of percentages of system input volume; it is misleading for comparisons because of differences and changes in consumption, and it is a zero-sum calculation which cannot identify true reductions in leakage and consumption in the same time period.
10. UK, European and other international evidence suggest that an ILI between 1 and 3 is appropriate for the majority of water resource zones in a high income country. Where the estimated sustainable economic level of leakage is an ILI of below 1 or above 3, the local circumstances should be reviewed to ensure that the methodology and data are robust. Whilst measures of total water lost are useful they should not be the sole criteria on which water utilities are judged.

#### Environment

11. CIWEM recognises that although water lost from buried water pipes does return to the environment through the hydrological cycle, this may not be to the same river or aquifer

from which it was originally abstracted. Also, the treatment process may mean that the water chemistry of potable water can be substantially different from that in the river or aquifer to which it returns.

12. CIWEM recognises that a considerable amount of energy is used to abstract, treat and pump potable water and as a result leakage contributes to the carbon footprint of water supply, as does the detection and repair of leaks.

#### New technology, research and development

13. CIWEM encourages the use of new technologies which enable new leaks to be identified, located and repaired more quickly and cheaply, and in technology for pressure management systems to reduce the recurrence rate of leaks, to the extent that they can be justified economically. Long term leakage targets should be reviewed accordingly.
14. CIWEM acknowledges the on-going work by the water companies, consultants, IWA and UKWIR to research the mechanics and economics of leakage, and to find more efficient and effective control techniques. CIWEM encourages such research to be continued.

**CIWEM is the leading independent Chartered professional body for water and environmental professionals, promoting excellence within the sector.**

## Context

Leakage is an important element in the supply-demand balance for most water supply companies. In the recent past droughts have exposed the vulnerability of some UK companies in maintaining supplies such that the question of what levels of total leakage should be accepted has been raised by the media, the public and specialist groups such as the All Party Parliamentary Group for Water.

UK water companies are legally obliged to produce a Water Resource Management Plan (WRMP) every five years demonstrating how they will:

- Manage the needs of future populations.
- Deal with climate change.
- Develop demand management options including water efficiency and leakage management measures and, where needed, new water supply resources.

These plans include forecasts of total leakage levels. Most water companies published the final version of their latest plans (covering 2015 to 2040) late in 2014.

Currently water companies set their own annual targets which are agreed with the economic regulator Ofwat, based on achieving or maintaining an assessed sustainable economic level of leakage (SELL)<sup>1</sup>. Most companies have now reached these targets and some companies are already committed to maintaining leakage levels below their SELL.

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<sup>1</sup> Sustainable Economic Level of Leakage (SELL) can be defined, for the purpose of this position paper, as that level of leakage at which any further reduction would incur costs in excess of

In the final determinations for the review of prices in England and Wales by Ofwat for the period 2015 to 2020<sup>iv</sup>, some companies have agreed financial and non-financial Outcome Delivery Incentives (ODI's) which relate directly and indirectly to leakage levels with a system of penalties for missing targets and rewards for outperforming them<sup>v</sup>. The impact of ODI's on future leakage targets, and the place of the SELL methodology in future, is being appraised by the industry. In Scotland, the Water Industry Commission (WICS) has set Scottish Water a target for the period 2015 to 2020 based on SELL, but with additional financial incentives that will challenge Scottish Water to accelerate reductions in its level of leakage to reach the lower end of the assessed economic range.

The high profile of leakage in the UK media and the visibility of some leaks has led to a high level of public and customer awareness. The profile of water utilities is, to a significant degree, judged by their behaviour on leakage. International comparisons using ILI<sup>vi</sup> suggest that economic leakage levels of UK water utilities are not the lowest in Europe and internationally, but lie within a leading group of technically advanced countries.

## Measuring leakage

Comparison of levels of leakage in Europe and internationally has always been problematical because of the wide range of performance measures used in different countries. The recommendations of an EU Reference Document<sup>vii</sup> of 'fit for purpose' leakage performance indicators are summarised in the table below.

OBJECTIVE	GOOD PRACTICE PERFORMANCE INDICATOR FOR LEAKAGE, FIT FOR PURPOSE						
	Volume per year	litres/ service connection	m <sup>3</sup> /km mains	litres/ billed property	% of System Input Volume	% of Water Supplied	Infrastructure Leakage Index, with Pressure
SET TARGETS AND TRACK PERFORMANCE, FOR AN INDIVIDUAL SYSTEM	YES, for large systems	YES*	YES*	YES (UK)	NO	NO	Only if all justifiable pressure management completed
TECHNICAL PERFORMANCE COMPARISONS OF DIFFERENT SYSTEMS	NO	NO	NO	NO	NO	NO	YES
DRAW GENERAL CONCLUSIONS FROM SINGLE OR MULTIPLE SYSTEMS	NO	NO	NO	NO	NO	NO	YES, together with other context factors

\* Choose services connection density > 20/km; if not, choose mains; or base choice on country custom and practice

Table showing the fitness for purpose of each performance indicator for leakage by comparing if they meet the objectives in the left hand column. Based on EU Reference Document 'Good Practices on Leakage Management' 2015.

Company total leakage levels are now quoted by Ofwat only in MI/d which is the total leakage per year expressed as a daily average. The UK is the only European country to use litres/property/day, others use Mm<sup>3</sup>/year, m<sup>3</sup>/service connection/day or year or m<sup>3</sup>/km mains/year, day or hour. Litres/property and litres/service connection are appropriate for medium and high connection densities in urban and semi-urban contexts, where most of the

the benefits derived from the savings, taking into account environmental and social costs as well as direct costs to the utility.

annual volume of leakage usually occurs on service connections. In a diminishing number of countries leakage is still expressed as a percentage of System Input Volume. This is very misleading as % leakage is a Zero Sum indicator which is distorted by changes and differences in consumption, and cannot show reductions for both leakage and consumption in the same year.

The Infrastructure Leakage Index (ILI) was developed by the IWA Water Loss Task Force in 1999 for international comparisons, and is commonly used in Europe and elsewhere. ILI is the ratio of actual leakage divided by an assessed technical minimum leakage which allows for system infrastructure parameters and pressure. In combination with pressure and other context factors, ILI is also useful for comparing performance between zones in the same Utility. In Malta, where all practical pressure management has been completed, ILI is used for regulatory targets, and has helped in persuading stakeholders to support leakage initiatives; snapshot ILI is also used for prioritising active leakage control interventions.

There have been significant reductions of leakage achieved by UK water companies in recent years. However what is not widely recognised is that, if left unattended, leakage rises steadily. Research demonstrates that the level of ongoing resource required for pressure management and active leakage control increases progressively at lower leakage levels. Water may be lost through leakage from the Treatment Works output to the point of delivery to the customer (and beyond).

## Leakage Management

The primary components of leakage management are:

### Pressure management

Reducing excess pressure, reduces the volume of water lost through leaks (including customer-side leaks). Lowering or stabilising pressure (including reducing transient effects) can also help to reduce bursts. Pressure can be managed using valve and pump controls. Small reductions in average and maximum pressures over large areas are likely to be more beneficial in reducing burst rates, on both mains and services, than large pressure reductions over small areas.

### Active Leakage Control (ALC)

The process of proactively looking for un-reported leaks and bursts (in order to reduce their run time) and pinpointing those leaks that come to the surface and are reported to the water company. ALC consists of two distinct stages:

- Leak monitoring and localisation.
- Leak location and pinpointing.

### Repairing known leaks

Repairing those which have been reported to the company and those found by active leakage control promptly and effectively is one of the simplest and most cost effective ways of reducing leakage. Allowing them to run adds to the overall volume of water loss without any financial benefit.

Companies' policies for undertaking repairs on private pipes, and pipes on private land should ensure a balanced approach between the cost of repair, the impact on customers, and the impact on overall leakage levels.

### Customer metering

This should consider the benefit to leakage management in terms of meter location, and the frequency of meter readings.

### The configuration of the distribution system

Some sectorisation of the system is essential to good leakage management. This will affect the efficiency of leakage management measures, and of measures to ensure that the propensity for new leaks is reduced. New extensions to the distribution system should be designed to operate with future leakage management in mind; e.g. relatively low, steady pressures and sectorised for efficient leak monitoring and rapid detection.

### Infrastructure management

This includes asset renewal to reduce the rate of occurrence of new leaks, and investment in facilities such as district meter areas (DMAs) and telemetry to improve the efficiency of ALC operations.

### Benefits of leakage reduction

The benefits of leakage reduction include, but are not limited to the following, which will change in priority depending on local circumstances:

- reduced abstraction and therefore environmental improvement,
- increased reliability of water supplies,
- deferment of capital expenditure on water resources and supply schemes,
- reduced operating costs,
- improved public perception of water companies and encouragement to conserve water themselves,
- reduced energy and chemicals for treatment and pumping which will reduce carbon emissions,
- reduced infrastructure damage (e.g. weakened road foundations),
- reduced flow and headloss, facilitating pressure to be stabilised and optimised.

It is currently neither technically viable nor indeed economically desirable to achieve zero leakage. Although water lost from buried water pipes does return to the environment through the hydrological cycle, this may not be to the same river or aquifer from which it was originally abstracted. Also, the treatment process may mean that the water chemistry of potable water can be substantially different from that in the river or aquifer to which it returns.

## Key Issues

UK water companies assess total leakage (distribution leakage plus underground supply pipe leakage) using two approaches. 'Top-Down' is based on a water balance, and 'bottom-up' uses leakage derived from minimum night flow measurements in DMAs, adjusted for 24-hour

pressure variations, and then aggregated with trunk mains and service reservoir leakage for the whole system. Each of the approaches has inherent uncertainties, and the two assessments are reconciled using a statistical approach known as MLE (Maximum Likelihood Estimation). Total leakage estimates are therefore built upon components and statistical methods which themselves are subject to potentially large errors in estimation, so the results need to be independently audited.

Around one quarter of total leakage occurs on customer owned underground supply pipes which convey water onwards from the curtilage of the property (the point of delivery) (see terminology on page 9). The lack of universal customer metering at the property boundary means that the frequency and flow rates of significant underground supply pipe leaks (which tend to occur on a small percentage of supply pipes) are difficult to identify and assess. Also, if there is no apparent impact on the property or the supply of water, it can be difficult to persuade the owner to repair the supply pipe especially when the companies no longer have powers to shut off supplies.

Although some water companies offer subsidised repair and/or replacement schemes, this approach has clouded the matter of responsibility. The debate regarding future ownership of customer supply pipes has stalled following Defra's 2014 decision not to carry out further work on transferring ownership of supply pipes at the current time, in the interests of keeping household bills down. Installation of new meters at the point of delivery should assist in more rapid identification and repair of significant supply pipe leaks.

In the 'Top-down' Water Balance, leakage is, simply expressed, the difference between the annual volume input (after allowing for volume exported) and the volume which is being legitimately consumed. However the majority of household consumption in most cases remains unmeasured and has to be estimated thus giving rise to uncertainty in leakage estimates. The main source of error is seen, by the regulators in particular, as the estimate of unmeasured per capita consumption (PCC). At present the most common way for water companies to estimate PCC is to measure the detailed consumption for a small sample of 'representative' customers, then use statistical methods to assess consumption on a company-wide basis.

As UK companies (except Scottish Water) gradually increase the proportion of households that are metered, the inherent uncertainties of unmeasured per capita consumption estimates should gradually reduce. However, uncertainties of underground supply pipe leakage will remain for households which are metered internally. There will also be uncertainties associated with meter lag – the fact that not all customer meters can be read on the last day of the 'Water Year'. International experience shows that universal customer metering will reduce, but not eliminate, uncertainties in 'top-down' assessment of annual leakage volume.

For leakage assessments based on 'bottom-up' interpretation of night flows, the wider introduction of advanced pressure management causes larger diurnal variations in pressure and therefore also in the Hour-Day Factor, which is used to convert night leakage ( $m^3$ /hour) into daily leakage ( $m^3$ /day). These uncertainties may tend to increase as leakage reduces.

Although there has been a substantial degree of research into methods of determining current and future SELL, methodologies for deriving SELL for the short and longer term, continue to rely on estimates and assumptions for key parameters which create uncertainty in the SELL

values. SELL is the minimum point on a total annual cost curve, but the economic range taking account of these uncertainties in data can be quite wide.

The evaluation of the long term SELL is dependent on the cost and timing of other means of maintaining an adequate surplus of water supply over demand, such as demand management and water resource and supply enhancement. In undertaking an holistic approach to the costs and benefits there is a requirement to include social as well as environmental costs, and the cost of leakage management in comparison to other methods of bridging any forecast headroom deficit between supply and demand, including resource augmentation and water efficiency. There remains uncertainty as to the factors to include and how to cost them.

SELL, and what this means for leakage investment, is often analysed separately from investment to maintain a supply-demand balance as part of the Water Resource Management Plan (WRMP). Some companies already adopt a more holistic view of leakage economics within the wider context of water resources planning.

It has been known for many years that pressure influences leak flow rates, and the FAVAD (Fixed and Variable Area Discharges) concept can be used for such predictions<sup>2</sup>. More recently relationships between maximum pressure and burst frequencies have been identified which permit improved forecasting of the wider benefits of pressure management, including extension of infrastructure life, which is improving the economics and opportunities for further advanced pressure management. Despite pressure control being widespread in most UK water companies, opportunities for advanced pressure management continue to be identified by some companies. Previous concerns about availability of firefighting water do not now appear to be a significant issue.

As pipes deteriorate there is a theoretical point at which the cost of replacing the pipe is less than the ongoing cost of repairing leaks. However, this point may lead to an unacceptably high level of interruptions in supply to certain customers. Therefore any replacement programme must consider capital investment costs, operational costs, environmental and social costs for both repairs and placement as well as customer service.

## Discussion

CIWEM recognises the importance of leakage reduction in the management of water supplies and its contribution to the sustainable management of water resources. In this context it supports the efforts of all stakeholders in the water industry to manage both company leakage and customer leakage effectively and economically.

### Securing water supplies

CIWEM is concerned, however, that because of the high political and media interest in leakage, the role that future leakage reduction can play in securing reliable water supplies may be over-

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<sup>2</sup> The Fixed and Variable Area Discharges (FAVAD) concept was proposed in 1994. The velocity of flow of a leak varies with a Coefficient of Discharge (Cd) and the square root of pressure, but the area of some leakage paths may also vary with pressure, and influence these relationships. The most basic FAVAD equation is shown at: <http://www.leakssuite.com/concepts/favad/>

played in some parts of the UK, and the cost to achieve and maintain low leakage levels needs to be understood by stakeholders. In particular it has little impact on the ability to meet summer peak demands due to increased customer use in dry weather. Winter peaks in demand can also occur due to freeze-thaw action causing damage to both company and customer pipework which results in additional leakage management effort.

### Measuring performance

There is a requirement to communicate effectively the measurement of leakage performance, the economics of leakage and how leakage targets are set and expressed. The approach of monitoring rolling averages is sensible to ensure that any exceptional weather conditions do not lead to inappropriate regulatory action. The more consistent approach promoted by the European River Basin Water Managers and EurEau within Europe is a welcome development.

CIWEM recognises the difficulties of quantifying the components of SELL, especially the environmental and social externalities. In particular a consistent methodology is needed for the valuation of water abstracted from the environment. CIWEM supports recent initiatives to clarify how leakage targets should be set and realises that all the interests need to be balanced<sup>viii</sup>.

The Institution believes that a long term view needs to be taken which has due regard to the long term protection of the water environment and the need to conserve and make best use of water. These have to be addressed in the face of the uncertainties of the impact of climate change, including its effects on the availability of water resources and demand, and the need to minimise waste from the use of chemicals and fossil fuels to treat and distribute water. Leakage economics should be integrated with all other aspects of the economics of balancing supply and demand.

In addition to the repair of leaks as they become apparent, it is essential that a long term deterioration of mains and services is not allowed to develop through inadequate rates of renewal. CIWEM is aware of the costs to customers of mains and service pipe renewal, and understands the need for companies to assess customer willingness to pay, but believes that companies should not allow assets to deteriorate in the long term.

### Leakage targets

CIWEM takes the view that future leakage targets may be tighter for some water utilities than those currently set in order to take a long term view of the environmental and social issues, and in recognition of the levels achievable by the best performing companies. However there needs to be recognition of the practicalities of meeting these targets, the uncertainties in the analytical models and the practicalities of leakage measurement. In addition it is important that a rate of mains and services renewal is funded which ensures that leakage levels in the future can be controlled at economic levels.

Companies currently exchange information through the Water UK Leakage Network, but this data is now not published by Ofwat and is not available for other leakage practitioners to access. Activities initiated by professional organisations such as CIWEM cannot compensate for lack of publicly available data. It is essential that the continued co-operation of all leakage professionals be promoted and supported and that comparative or actual competition does not obstruct this activity.

CIWEM supports the guidance from Environment Agency and Ofwat that targets should be set for companies so as to ensure that wider social, environmental and other practical issues are taken into account. In 2012 the Environment Agency, Defra and Ofwat cooperated and worked with consultants to review the approach taken by companies in England and Wales to their estimation of SELL<sup>ix</sup>. Further work is ongoing to establish a framework under which the Environment Agency will review the SELL approach taken at a local level for the next WRMPs. The Government will need to be advised by experts in the industry in doing so.

In Scotland, WICS has employed an independent Leakage Reviewer since 2010 to report on the SELL approach taken by Scottish Water, which has been part of the regulatory leakage target setting process.

## Pressure management

CIWEM supports the introduction of pressure management systems where these are shown to be cost effective as this helps in the creation of 'calm' systems with lower burst frequencies and extension of asset life in some cases, whilst ensuring a consistent standard of service to customers throughout the day. However, it is recognised that discussion with all customers, including the fire service, is required before the introduction of any new pressure management scheme.

CIWEM recognises that there are several mechanisms by which leakage can be reduced, such as by pressure reduction, district metering and associated programmes of active leakage control, and online monitoring, "find and fix" and leakage helplines. All such measures should be pursued to their economic level and best practice developed and shared amongst water undertakers.

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*Note: CIWEM Policy Position Statements (PPS) represents the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review and that previously held views may alter and lead to revised PPS's. PPSs are produced as a consensus report and do not represent the view of individual members of CIWEM.*

## Terminology

### Total Leakage

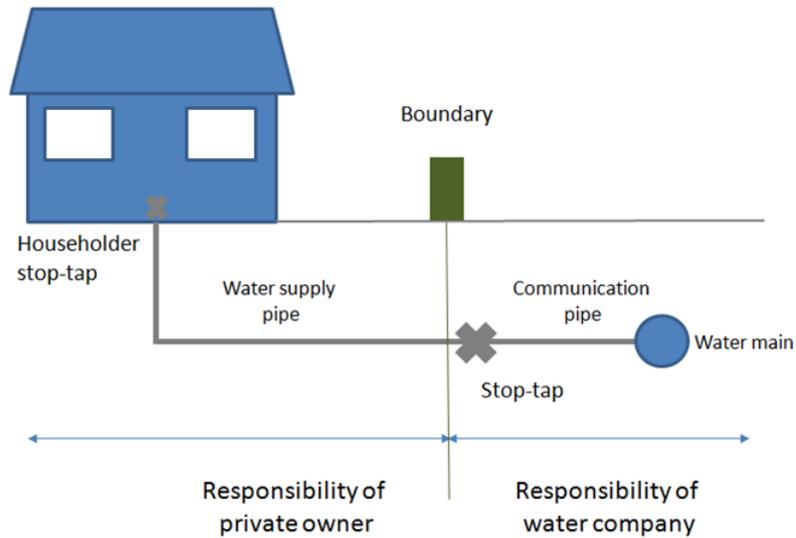
Comprises Distribution Losses and Underground Supply Pipe Leakage.

### Distribution Losses on Company assets

- ◆ Treatment works output through trunk mains up to and at service reservoirs
- ◆ From service reservoirs through mains and communication pipes to the point of delivery

### Customer supply pipe leakage, from point of delivery onwards

- ◆ *Underground supply pipe leakage* is a component of total leakage
- ◆ *Total plumbing losses* is leakage from above-ground supply pipes or internal plumbing such as dripping taps, faulty WC cisterns, and is part of customer consumption rather than leakage



### System or Network?

Both these words are used interchangeably in the UK to describe the mains, service connections and other infrastructure. However, in most of Europe 'Network' relates only to mains, so 'System' has been used in this PPS.

### Water mains

These large water company pipes distribute water around the network. They are often, but not always, laid under roads.

### Service pipes

This a general name for the pipes leading between the mains and the property, normally consisting of the *communication pipe* and the *water supply pipe*. These are defined as follows.

### Communication pipes

These pipes carry water between the water mains and the boundary of private property. If a company stop-tap has been fitted, this will normally mark the division between pipework that is the responsibility of the company and the pipework that is the responsibility of the property owner. Not all properties will have their own stop-tap in the footpath but where one has been fitted, this is normally the responsibility of the water company to maintain.

### Water supply pipes

These pipes carry water from company pipework into the property. Supply pipes run from the boundary of the property (where there may be a company stop-tap) up to the first water fitting or stop-tap inside the property.

### Underground supply pipe

The part between the property boundary through to its emergence above ground through the floor or in an external wall box.

## Further reading

UKWIR 1999. NERA The environmental and social value of leakage reduction.

UKWIR. 2002. Capital Maintenance Planning: A Common Framework.

WRc. 2009. Code of Practice for the Self Laying of Water Mains and Services – England and Wales. WRc Swindon UK.

## References

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- i Ofwat. 2007. RPS Providing Best Practice Guidance on the inclusions of Externalities in the ELL Calculation
  - ii Environment Agency, Ofwat and Defra by Strategic Management Consultants. 2012. Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning.
  - iii European Commission. 2015. EU Reference document Good Practices on Leakage Management WFD CIS WG PoM. Main Report <http://bit.ly/16dZX9f> and Case Study document <http://bit.ly/1K6K8BK>
  - iv Ofwat. 2012. Consultation on wholesale incentives for the 2014 price review. Appendix 1: Outcome delivery incentives
  - v Environment Agency, Ofwat and Defra by Strategic Management Consultants. 2012. Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning.
  - vi WRlandA. 2014. Global ILIs <http://www.leakssuite.com/global-ilis/>
  - vii European Commission. 2015. EU Reference document Good Practices on Leakage Management WFD CIS WG PoM. Main Report <http://bit.ly/16dZX9f> and Case Study document <http://bit.ly/1K6K8BK>
  - viii WRc. 2008. Leakage Target Setting – A Frontier Approach WRc (Main Report and Guidance)
  - ix Environment Agency, Ofwat and Defra by Strategic Management Consultants. 2012. Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning.