Reporting guidance – Leakage[1]

Objective

The guidance has been developed to enable all companies to report annual average leakage for the defined year following good practice and a reasonable level of accuracy, applying consistent and reliable methods and common assumptions. This is to facilitate consistency of reporting by companies and comparisons of performance by customer representatives, regulators and other companies with reasonable confidence.

Key Principles

There are several key principles applied in the compilation of the guidance:

- Reporting of annual average leakage forms part of each company's assurance process applied to all measures reported annually by companies;
- Where this guidance specifies expected ranges for estimates this does not preclude the need for a company to justify all estimates used.
- A company needs to have a written methodology or procedure in place for reporting total leakage. This procedure is reviewed annually and updated as required;
- The reporting guidance for annual average leakage reporting is set out as a consistent good practice baseline for the industry which companies should achieve now or in the short and medium term;
- The guidance sets out the good practice concepts of a consistent approach companies are expected to comply with, a focus on data quality and application of valid statistical approaches. They are not intended to prescribe approaches to leakage reporting. Where a company is not able to meet any part of the good practice methods then it is required to explain any shortfalls and its plans to address this;
- The measure assumes a clear approach to be applied through defined regulatory periods;
- There is an assumption of continuing improvement in analysis by all companies in the short and medium term through innovation, new technology and data quality improvements. The context of consistency of reporting for this measure does not preclude companies from applying more innovative measures based on improving

[1] This is the same guidance as included in the March 2018 report for Ofwat and Water UK: "Targeted review of common performance commitments".

data quality. Some areas of reporting including the calculation process can be addressed now or in the short term. Improving data quality is likely to be achieved over a longer period;

- The established water balance concept is applied to balance estimated leakage with the other components. Re-balancing is applied to close any gap in the sum of components;
- The focus of the guidance is on annual average leakage reporting. It is not intended as a definitive guide to leakage operational management, targeting or in-year reporting although many elements of the guidance would be applicable so there are 'no surprises' between operational and annual reporting.

Applying this methodology is likely to change reported leakage and comparisons of historic data may no longer be valid.

Background information on preparing this guidance is included in the UKWIR Report 'Consistency of Performance Reporting Measures[2].

Measure Definition

Annual average leakage is defined as the sum of distribution system leakage, including service reservoir losses and trunk main leakage plus customer supply pipe leakage. It is reported as the annual arithmetic mean (referred to as 'average' in the guidance) daily leakage expressed in mega-litres per day (Ml/d).

A company is required to report against this definition and:

- Report a post-MLE average leakage value expressed as Ml/d to one decimal place;
- Disclose where its methodology does not comply with this guidance using the checklist in Annex A;
- Explain the reasons for any non-compliance;
- Set out its plans and programme to comply with the guidance; and
- Disclose any other factors which have an impact on the methodology for reporting leakage.

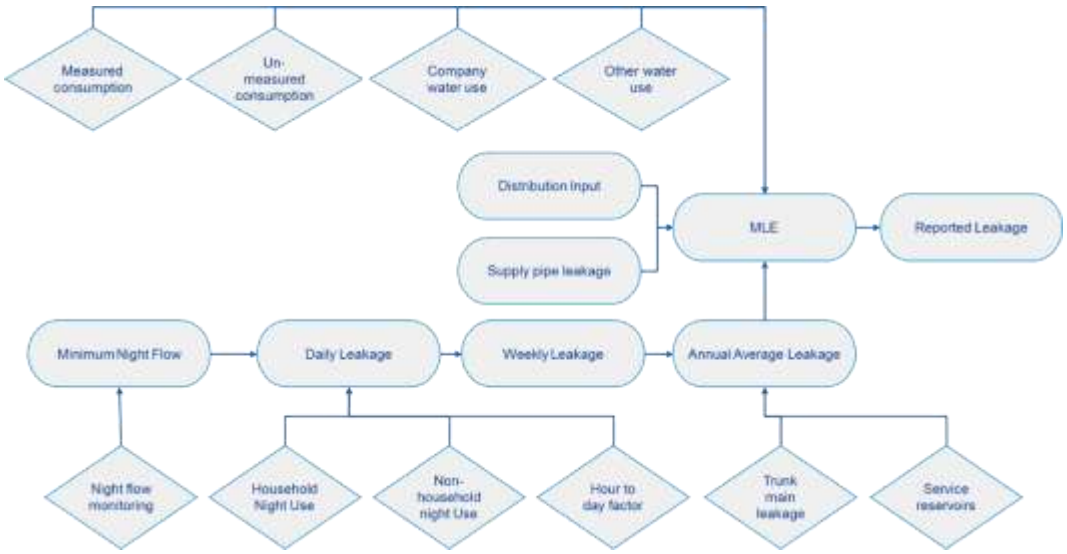
Reporting Process

The guidance is structured in the way that leakage is normally estimated and comprises:

- Components of leakage estimation (commonly referred to as bottom-up) in Section 5.
- Components of the water balance (commonly referred to as top-down) in Section 6.
- The water balance reconciliation using the MLE methodology and adjustments in Section 7.

[2] Consistency of Performance Reporting Measures, UKWIR 2017

The process is shown in the following diagram.



Components of Leakage Estimation

Reporting level

The main objective is to achieve and maintain a high level of valid data to report a statistically robust measure of annual average leakage.

A company can select to estimate leakage based on different reporting levels:

- District Meter Area (DMA) using district meters;
- Water resource zone level using distribution input meters; or
- An intermediate zone level using meters installed on reservoir outlets or trunk mains within the distribution network.

It is for a company to decide the level of reporting based on its own network characteristics and risk of meeting operability targets as defined below.

The subsequent sections of the guidance are addressed mainly to DMA monitoring although the principles may equally apply to reporting at zone level.

Night Flow Monitoring

Reporting of leakage from water networks is based on the concept of monitoring flows at a time when demand is at a minimum which is normally during the night. Allowance is made for legitimate night use for household and non-household customers. Companies have configured their networks to be able to continuously monitor night flows using district meters. Flow data is recorded on meters and normally transmitted daily to a data centre. Data is analysed to confirm its validity and used to derive continuous night flow in each monitored area. Software systems have been developed to analyse this data, apply adjustments for legitimate night use

and report daily leakage. Companies are able to set assumptions for this analysis within the software packages.

A company is expected to comply with the essential principles of the leakage reporting process for estimates of annual average leakage.

- At least 95% coverage of all properties served by a company within networks having continuous night flow monitoring through the year;
- At least 90% of all properties within continuous night flow monitoring networks shall be available for reporting night flow data through the year;
- Valid data for reporting leakage shall be derived using available night flow data and estimates of legitimate night use and a company's own validity assessments;
- Assessments of legitimate night use for households and non-households shall be applied as detailed in Sections 5.5 and 5.6;
- The statistical assumptions for determining night flows, legitimate night use and hence leakage shall be based on good practice statistics and consistently applied;
- The components of reporting shall be based on a company's own data.

To apply these principles, definitions of 'Coverage' and 'Availability' need to be applied.

Coverage is defined as: 'The percentage of a Company's billed households and non-households within designated network areas where night flows can be continuously monitored and reported on a regular frequency. Coverage is measured as an annual average for the whole company.'

This represent the extent of the coverage of networks with designed import and export meters, boundary valves, counts of households and non-households and other asset and performance data.

Availability is defined as: 'Where the designated network area is available to report a reliable estimate of night flow for leakage reporting; the installed meters and loggers are working correctly, the boundary is watertight and continuous data is provided. Availability is measured as a property-weighted annual average for the whole company. Trunk mains should not be included in the measure of availability.

A company is expected to apply its own automated validity checks, or Operability tests, within its leakage analysis software to accept or reject data for reporting. This is expected to be supported with manual detailed checks to detect any data inconsistencies on at least a weekly basis. A company must set out the operability rules (the methods and thresholds) they use and provide supporting justification for these during annual assurance.

Operability is defined as: 'Where leakage data derived from night flow monitoring and the application of legitimate night use data is within a company's accepted validity criteria for use in leakage reporting.'

Where a company is not able to meet the Availability measure because, for example, of DMA or zone remodelling or capital works then it is to disclose this in its supporting statement.

An estimate of leakage in areas not covered by continuous monitoring can be extrapolated using leakage per property from the adjacent monitored area on the assumption that a similar level of leakage management activity is applied in these areas; otherwise a separate

assessment is needed. Leakage in monitored areas failing validity checks is expected to be infilled using guidance defined in Section 5.4.

Properties

Household and non-household properties are used in the estimation of total night use in any DMA or zone. Properties are also used as a denominator in leakage comparisons and for data infilling where DMAs or zones are not operable. Any inconsistencies could impact on DMA or zone operability and hence reliable reporting.

A company is expected to:

- Map all properties to defined zones or DMAs using geo-location or similar methods available in the industry;
- Check the consistency of property numbers contained within DMAs or zones against its company's billing system to minimise any under- or over- counting. Valid differences shall be explained;
- Exclude properties that are defined as void from night use allowances unless a company can evidence any use or losses from illegal occupation;
- Apply leakage allowance for properties not within DMAs or monitored zones consistent with other leakage estimates;
- Update property data at least annually.
- Ensure the classification of properties as either household or non-household is consistent with the retail market definition of eligibility.

Void properties should be accounted for consistently in all aspects of the leakage calculation.

A company should justify the number of void properties each year and how this is derived. If consumption is assigned to a proportion of void properties (illegal occupation) then the evidence base to support this must be considered during the assurance process. Estimates of void properties should be updated annually.

Night Flow and Leakage

Night Flow Period

There is a requirement to analyse night flow at a time when it is possible to apportion flow with confidence between leakage and customer use using consistent and valid statistical methods.

This analysis can be achieved at a time during the night when customer use is predictable and relatively low. This may not necessarily be at a time of minimum night flow into a DMA or zone.

Estimates of DMA or zone night inflow and household (HHNU) and non-household (NHHNU) customer night use need to be aligned. The UKWIR Report 'Managing Leakage 2011'3 recommended using a fixed hour period. This approach allows average flows to be compared with average night use. While this may give rise to exceptional low or high values of leakage in particular periods, over the reporting year these are expected to average out.

For current good practice, the only practical way is to use a fixed-hour statistic for both night flow and HH and NHH night use. This was confirmed in a UKWIR Report[4]. A company may extend this period to two hours. A company must justify their choice of fixed hour or fixed two hours, ensuring it aligns with the NU period, and demonstrate why this period is appropriate for their circumstances.

A company is expected to derive night flow data using the following criteria.

- Night flow data frequency shall be at least every 15 minutes;
- Leakage shall be derived from a fixed period during the night of at least a one hour period although up to two hours may be used;
- The fixed period can be varied during the year for some or all DMAs or zones to address significant changes to night use patterns such as during Ramadan. Changes to the fixed period must be justified.

Night Flow Analysis

The analysis of night flow needs to be carried out using a consistent and valid statistical methodology. Both household and non-household night use are used to derive estimates of daily leakage. The estimates of HHNU and NHHNU night use are based on average (arithmetic mean) values over time and applied to night flows. Night flows therefore also need to be average (arithmetic mean) values to derive statistically valid estimates of leakage. The use of any alternative percentile assumption is not statistically valid.

A company is expected to apply the following assumptions for night flow analysis:

- The average values of night flow data over the period defined above shall be used with average values of HHNU and NHHNU data for the same time period to derive an estimate of leakage representative for the DMA or zone;
- The value of HHNU shall be derived using methods set out in Section 5.5 and the number of properties defined within the DMA or zone;

[3] Managing Leakage 2011, 10/WM/08/42: UKWIR 2011

[4]Improved Household Night Use Allowances; 14/WM/08/53: UKWIR 2014

- The value of NHHNU shall be derived from estimates of night use by group and the number of properties in each group defined as within the DMA or zone as set out in Section 5.6;
- Apply leakage allowance for properties not within DMAs or monitored zones consistent with other leakage estimates.

The analysis will derive values of leakage for each DMA or zone expressed as leakage per hour for every day of the year. Leakage is then expressed as leakage per day following the methodology set out in Section 5.6.

Data Infilling

Where a DMA or zone is inoperable a software package will normally infill data following defined rules using historic data from the same DMA or zone or average data from adjacent DMAs. To achieve a high operability target, infilling of weekly values shall be limited to short periods of preferably no more than a month and certainly no greater than six months. While rules vary across companies, for consistency a company is expected to follow the following guideline or disclose where it has not been able to comply.

- Data infilling for a single DMA or zone shall not use more than six months of historic data before moving to area average;
- Data infilling taking the area average in which the DMA is located is valid if historic data is not available;
- When a DMA is restored to operability, for the purposes of annual average reporting, the subsequent leakage data should be used to update retrospectively the data infilling interpolating between pre- and post- data over at least one month. This is because a non-operable DMA is unlikely to be subject to detection processes and there is likely to be a natural rise in leakage over time. It is recognised that this may take time to achieve, as and when leakage software packages are updated. There is one exception where a DMA is inoperable at the end of a reporting year where alternative data infilling, using the last valid weekly value may be used;
- Where NHH properties are continuously monitored, the actual values of flow over the night flow period shall be used in place of estimates within the night flow analysis.

Seasonal Variation in Night Use

Fixed night use allowances are not appropriate for many companies who observe rising night flows during warm summer periods or spring planting. There is clear evidence that customer night use increases over these periods due to a small proportion of households using overnight sprinklers or night time irrigation of golf courses and plant nurseries. A fixed night use allowance through the year is not appropriate in capturing variations in night flow.

Some companies may use advanced modelling or enhanced logging methods to improve estimates of night use although this is not a requirement for current good practice.

A company is expected to make allowance for seasonal variance in night use:

- The night use allowance shall be adjusted regularly through summer months to allow for variable customer night use based on sample logging over the period or night use models;
- Weekly leakage estimates shall be used for annual reporting with no exclusions for summer months.

A company must justify any seasonal adjustments they make. Evidence based on data and or studies should support this.

Negative Leakage Values

Average customer night use is normally applied equally to all DMAs although actual use can be higher or lower than across individual DMAs. The impact, particularly in small or low-leakage DMAs, is that negative calculated leakage values may be reported. While this may appear anomalous, combining leakage values at zone or company level will offset these negative values while maintaining the overall value of average household use. It is therefore appropriate to include negative leakage in collating leakage data to area or company level. Capping leakage to zero would artificially reduce the resulting average value of night use and is not appropriate. This issue is not observed in larger DMAs or zones.

A company is expected to make allowance for negative leakage values:

- Where average night use values are applied across all DMAs, it is appropriate to include negative leakage values when compiling values of annual average leakage;
- The reasons for any prolonged periods of negative leakage need to be investigated and explained.

Household Night Use

Estimates of household night use are deducted from measured night flows in estimating of leakage using the method described in Section 5.4. A company can estimate night use using either an Individual Household Monitor (IHM) or a Small Area Monitor (SAM) or a combination of both. The choice of method is likely to be related to the preferred method for deriving estimates of unmeasured household consumption.

A Company shall use its own data and application of national default values is not valid. This is because these default values were derived from limited data over 25 years ago. In addition, ‘Socrates’ loggers are no longer maintained or supported and hence are not best practice.

In the case of IHMs, these were originally designed to derive estimates of unmeasured per capita consumption and usually comprise about 1000 selected properties. This is a relatively small sample for night use assessments given the likely frequency and flow of intermittent and high volume large night use customers. The IHM needs to be continually monitored to ensure any failed meters are replaced and periods of continuous night flow are quickly identified and resolved to minimise any supply pipe leakage.

SAMs normally provide a larger household sample size than IHMs and are appropriate for night use and unmeasured household consumption assessments. SAMS may be part or full DMAs; whatever size, they shall be selected and designed to give substantial coverage of households and minimise non-household properties. A company using SAMs for the

estimation of HHNU should apply the recommendations of the recent UKWIR *report*[5] on the application of a fast logging methodology for continuing monitoring and maintenance.

The HHNU survey needs to have a sufficient number of samples, representative of a company's demographic factors, to identify both continuous and a significant number of intermittent flow events. The sample size of an IHM is unlikely to be sufficient to capture intermittent use with sufficient frequency. This is because intermittent use could be attributable to a small number of customers.

A company is expected to derive weekly or monthly values of HHNU and shall retrospectively recalculate leakage each week or month as new data becomes available. Some software systems automate this process within their existing leakage data analysis.

HHNU has a significant impact on reported leakage. There is a need to continually improve the coverage of properties with a focus on the factors having greatest impact on night use; for example the impact of seasonal variations in use, increasing SAMs coverage and use of enhanced metering methods.

A company is expected to derive an estimate of average (arithmetic mean) household night use applying the following criteria:

- The values of HHNU night flow shall be used with values of night flow and NHHNU for the same time period and on the same statistical basis to derive an estimate of leakage representative for the DMA or zone;
- It shall use its own data or shared data with proximate companies. National default values are not valid;
- Plumbing losses shall be included and based on the company's own data;
- It shall demonstrate that its survey is representative of the company as a whole; disaggregation of the sample by demographic factors, property type or similar represents good practice;
- It shall demonstrate that the sample size is sufficient to capture continuous and intermittent night use with reasonable confidence;
- The application of IHMs, SAMS or a combination of both. It is unlikely that the IHM on its own will be of sufficient size to capture a valid sample of intermittent use;
- Continual monitoring and maintenance of IHM and SAMs monitors;
- HHNU shall be derived daily with regular, adjustment of values on a weekly or monthly frequency to reflect actual seasonal use. This may need to be done retrospectively.

Non-Household Night Use

Estimates of non-household night use are deducted from measured night flows in estimating leakage using the method described in Section 5.4. Most companies use the 1999 UKWIR methodology[6] which sets out a methodology for deriving relationships between average night

[5] Fast Logging for improved estimation of household night use, UKWIR 2017
[6] Estimating Legitimate Non-household Night Use Allowances, 99/WM/06/26: UKWIR 1999

use and annual billed volume (ABV). Some companies are reviewing the form of this relationship to improve the confidence of this methodology.

The methodology stratifies non-household customers by groups of industry types and range of consumption. A representative sample of the variable characteristics of non-households by group and consumption shall be identified. Data logging of these sample customers shall be carried out for at least two weeks to derive model coefficients for each group.

Continuous monitoring of some non-households is carried out although companies apply varying thresholds of consumption above which they will install continuous monitoring. The objective for leakage reporting is to take full account of water use in the night flow analysis where total flow is significant in relation to DMA night flows or the likely variation in flow has a significant impact on DMA analysis and presents a risk to deriving valid data. The target threshold for continuous monitoring is where average demand of an individual non-household is greater than 24 to 48 m^3/day (or night flow >1000 to 2000 l/hr) or 25% of a DMA night flow. A company should define its criteria, reflecting the impact of night use on the ability of a DMA to produce consistent and valid leakage estimates.

For water and sewerage companies, the 1999 UKWIR methodology shall also be applied to sewage treatment works and other company sites using significant water volumes. The guidance for continuous monitoring of non-households shall be similarly applied to these sites.

The introduction of competition in the non-household market may impact on the source and availability of measured volumes.

A company is expected to derive estimates of non-household night use applying the following criteria:

- The values of NHHNU night flow shall be used with values of night flow and HHNU for the same time period and on the same statistical basis to derive an estimate of leakage representative for the DMA or zone;
- It shall use its own data or shared data with proximate companies. National default values are not valid;
- Application of the 1999 UKWIR methodology with the appropriate time window as used for the night flow and the published outcome of further methodology development;
- It shall demonstrate that the stratification of non-households to a number of groups and consumption bands is representative of the varying characteristics of commercial and industrial properties;
- It shall demonstrate that the sample size is sufficient to capture night use by stratification with reasonable confidence;
- Development of a reliable and representative average billed volume (ABV) model based on data logging of the representative sample sufficient to capture demand variations with further seasonal logging where relevant. Continuously logged properties are unlikely to form part of the sample as these generally have greater consumption than the stratified samples;
- Direct linkage of the ABV model to a company's billing system or replacement database of billed volumes. Update the average billed volumes at least annually;
- Continuous monitoring of selected non-households shall be carried out where average demand of an individual non-household has a material impact on the ability for a DMA or zone to provide valid and consistent data within operability limits; and

- For water and sewerage companies, apply the same ABV methodology as a separate group and continuously monitor sewage treatment works and other sites using the same criteria as for non-households.

Supply pipe leakage

HHNU and other components of the water balance are sensitive to the supply pipe losses estimate used. There is inconsistency in how companies estimate SPL and how they keep the estimates up to date. Some use separate allowances for internally metered properties and others just use one estimate for all properties. A robust methodology to determine this is required. In the meantime a company must state the supply pipe leakage allowances it uses and present the evidence on which this is based.

Hour to Day Conversion

An hour to day correction is required to take account of diurnal pressure variation in each DMA or zone. Leakage is monitored during the night when actual pressure is normally greater than other parts of the day. Daily leakage is estimated from night flow when actual pressure is likely to be greater than the average for a defined DMA unless pressure management is in place. Night leakage therefore needs a correction factor to convert to the average daily leakage rate. As leakage varies with pressure, the daily leakage flow needs to reflect the diurnal variation in flow.

A company shall take into account the findings from the UKWIR Report 'Assessment of Key parameters for Leakage Analysis[7] which addresses average zone pressure, average zone night pressure (AZNP) and hour to day factor (HDF).

A company is expected to derive the hour to day conversion using the following criteria:

- The hour-to-day factor shall be derived separately for each DMA or zone using pressure logging within each DMA. The factors shall be updated at least annually or where there are any significant changes to pressure regimes;
- As an alternative, hydraulic models can be used provided they have been updated to reflect the latest network reconfiguration and any pressure changes, and provided it is dis-aggregated in sufficient detail at sub-zone level;
- An N1 value of 1.0 to 1.2 in the leakage – pressure power law relationship[8] unless a company is able to demonstrate a higher or lower value would be more appropriate using its own data. A company should set out its approach to deriving its N1 value.

Annual Distribution Leakage

Annual average distribution leakage expressed in Ml/d shall be derived from operable data with minimal data infilling. Historically there have been various rules used to derive annual average leakage expressed as Ml/d using a variety of statistical assumptions applied to weekly

[7] Assessment of Key Parameter for Leakage Analysis, 17/WM/08/59, UKWIR 2017
[8] Leakage (L) is proportional to pressure P^{N1} where N1 can vary locally between 0.5 and 1.5, but at DMA level is typically between 1.0 and 1.2.

or monthly data. The approach set out below is to make best use of operable data. It takes into account variable daily data, captures weekly trends and minimises the extent of statistical adjustments. The weekly leakage value is used as the base measure taking an average value of daily data in the week. There may be outliers in the data which is expected in taking average values. Over the reporting year these outliers should be balanced and not impact on average annual leakage. The method captures the variance in weekly data through an average of the 52 weekly values. Monthly reporting may be appropriate for internal reporting but has no value in moving from weekly to annual average values.

A company is expected to derive the annual average distribution leakage using the following criteria:

- The average weekly data shall be derived from all available valid daily values of leakage using data points which are representative of the week. Valid data must be available for at least 3 days of the week for the DMA to be considered operable. In this instance the weekly data should be backfilled using the methods described in Section 5.4 – night flow analysis. Where there is less than 3 days of valid data for the week then that DMA data is not considered operable and should not be used. In this instance the DMA data should be estimated;
- The annual value of leakage expressed as Ml/d shall be derived from an average of the 52 week data.

Trunk Main and Service Reservoir Losses

Trunk Mains

For some companies who monitor leakage at zone level, trunk mains losses are included in reported leakage. A separate assessment of trunk main losses is therefore not required.

For companies estimating leakage at DMA level they must derive estimates of trunk mains leakage and service reservoir losses separately.

A proportional approach in estimating leakage shall be applied. A company with a relatively high proportion of trunk main losses to total leakage should take a proactive leakage monitoring approach with a combination of field inspections, analytical techniques, and flow balancing methods. Other companies with relatively low proportions of estimated trunk main leakage (<5% of total leakage) may apply less intensive methods but all should use their own data and not rely on national default values. It is recognised that trunk main leakage is difficult to measure; the relatively low confidence of this estimate shall be reflected in the confidence intervals applied in the MLE methodology.

Compilation of flow balances within sections of the trunk mains network is an important element to the proactive approach. Flow balances may identify either meter error or unknown connections, but in some instances they may identify significant trunk mains leakage. Flow balances should be carried out between upstream and downstream meters or groups of meters, where

- The upstream meters may be distribution input meters or trunk main network meters, or groups of such meters; and
- The downstream meters may be trunk main network meters or district meters, or groups of such meters.

Companies should follow the advice given in UKWIR report 'Leakage Upstream of District Meters[9]', which describes two alternative methods for quantification of trunk main leakage.

(i) A flow balance approach, as described above. This method is dependent on sufficient operational meters being installed. The method allows for a sample of meters and for the findings to be extrapolated. The disadvantage of this method is that it is using the difference between two or more meters with potential meter inaccuracies; or

(ii) A BABE component approach, using data on numbers of leakage with estimated flow rates and durations, together with an estimate of background leakage.

The choice between these two methods depends on what data is available to a company. If one of these methods can be applied meaningfully on a sample of the trunk mains network, this can be extrapolated to the whole network. Company-specific data shall be used to assess the value of trunk main leakage; national default values should not be used.

A company is expected to derive values of trunk main leakage using the following criteria:

- Company-specific data shall be used to assess the value of trunk main leakage;
- A proactive leakage monitoring approach shall be applied where trunk main losses form a significant element (>5%) of total leakage or the MLE water balance gap is greater than +/-2%. This approach shall be a combination of field inspections, analytical techniques, and flow balance methods. The selection of methodology and level of leakage monitoring activities shall reflect the proportion of estimated losses in relation to total leakage and the characteristics of the network;
- Companies with trunk main losses greater than 5% of total leakage shall review and refresh estimates annually.

Service Reservoir Losses

A proportionate approach to estimating losses is appropriate. Leakage can occur through the structure and valves; overflows may be passing water. Losses are generally less than other areas of leakage; hence the lower frequency of leakage surveys. Drop tests have been used for many years as an acceptable and proportionate method for identifying any material leakage. Estimates are expected to be updated annually but this does not require a company to undertake annual drop tests of all service reservoirs. Where a new drop test has been done that year the results should be included in the overall estimate.

A company is expected to estimate service reservoir leakage using the following criteria:

- Company-specific data shall be used to assess the value of service reservoir losses;
- Reservoirs with known high leakage, structural deficiencies or are at risk of water quality failures shall be investigated on an individual basis;
- Drop tests are an appropriate approach and normally carried out every five or ten years in parallel with ongoing routine reservoir inspection programmes. Drop tests shall be

[9] Leakage Upstream of District Meters, 15/WM/08/55, UKWIR 2015

carried out for at least 12 hours depending on the size of the reservoir. All valves should be checked to ensure they are closed tight; and

- The extent of losses through reservoirs overflows should be investigated. Where reservoirs are shown to be at risk of overflowing, appropriate monitoring arrangements shall be put in place to control and minimise overflow events.

Annual Average Leakage

Annual average leakage is reported as the sum of distribution leakage from continuous DMA or zone monitoring, areas not covered by continuous monitoring, trunk main leakage and service reservoir leakage. These values shall be applied with differing confidence intervals in the MLE methodology.

Water Balance Components

Distribution Input

Distribution input (DI) is a measure of the volume of potable water input to the distribution network at treatment works, boreholes and bulk supply locations. DI is reported as an annual average Ml/d.

A company is expected to report Distribution Input using the following criteria:

- Distribution input to the system shall be metered with at least daily readings at all defined locations;
- Meters shall be an appropriate size for the flow to be measured and located at appropriate inputs to the network confirmed by record plans. Any treatment works take-off downstream of a meter shall be excluded from the DI calculations;
- Data validity checks shall be carried out at least monthly;
- Any missing data shall be infilled using both pre- and post- data for the location over at least one month, extrapolated from pump hours or use of upstream or downstream meters; and
- The data transfer systems from meter output to central database shall be checked and validated on a risk-based frequency from one up to two years.

Measured Consumption

The volume of measured consumption shall include for measured household and measured non-household water use excluding supply pipe leakage and including estimates of meter under-registration.

Measured data shall be derived from the meter readings within the company's billing system including estimated reads and an adjustment for meter under-registration should be applied.

For externally metered properties an allowance for supply pipe leakage should be deducted from the metered volumes.

Companies must undertake a process of accruing consumption at year end to account for meter reading frequency cycles. A company should justify with evidence its approach to accruals.

New guidance on the estimation of unmeasured household consumption[10] proposes a measured household monitor to enable the nature of consumption patterns to be better understood. If a company uses a measured household consumption monitor it must set out its approach and justify its use in this methodology.

For non-households all water delivered is assumed as consumption and is billed by the wholesaler to the retailer. No allowance is made for any supply pipe losses.

A company is expected to derive measured consumption using the following criteria;

- Metered data as derived from a company's own billing system or from CMOS for non-households;
- A deduction for supply pipe losses for externally metered properties consistent with the company's current assumption of supply pipe losses;
- Adjustments to metered data for leakage allowances applied to individual customers can be included where a rebate has been applied to a customer's bill;
- Meter under-registration shall be applied consistent with a company's own estimates.

Unmeasured Consumption

The volume of unmeasured consumption shall include for unmeasured household and unmeasured non-household water use excluding supply pipe leakage.

Unmeasured household consumption

There is a separate performance commitment for PCC (per capita consumption) and this has its own guidance (Consistency of Reporting Performance Measures, Reporting Guidance – Per Capita Consumption). That is based on an average PCC derived from the sum of measured household consumption plus unmeasured household consumption divided by total household population. The guidance for the PCC performance commitment includes detail around estimation of unmeasured household consumption and is consistent with this guidance for deriving the leakage estimate.

For the water balance it is not necessary to derive PCC. It is the total volume of unmeasured household consumption which is to be derived. For households this should be based on per

[10] Future Estimation of Unmeasured Household Consumption, 17/WR/01/16, UKWIR 2017

household estimates which removes the need for occupancy data. The following guidance is repeated from the PCC guidance. Further detail is included in the separate PCC guidance.

The volume of unmeasured household consumption should include water used by each unmeasured household excluding supply pipe leakage. Dependent on the level of meter penetration a company has this can be a significant component of the water balance and therefore needs continual focus to maintain and improve the estimate. For the purposes of this PC unmeasured household consumption should be based on PHC (per household consumption).

In general, companies are expected to use company specific data for unmeasured household consumption except for companies with high meter penetration where it may be impractical to establish and maintain a sufficiently robust sample of unmeasured properties. In this case sharing of unmeasured data with neighbouring companies or companies with similar demographics may be appropriate. Companies with high meter penetration must set out their approach to estimating unmeasured household consumption.

In most cases (except perhaps where a company's meter penetration is high) it is expected that unmeasured household consumption shall be estimated from a company's own consumption monitor following good practice as defined in the UKWIR Report 'Best Practice for unmeasured per-capita consumption monitors 1999'. Good practice has improved since this report with innovation and new technologies now available although the basic principles of the monitors is unchanged. Companies can use individual household monitors (IHMs) or Small Area Monitors (SAMs).

Further work is required to determine current good practice for sample size and stratification for IHMs and SAMs. Until this is concluded companies should continue to base their approach on a sample of at least 1000 for IHMs. Representation may be by demographic group, property type or other recognised statistical group. Companies must set out the evidence to demonstrate their sample is representative of their area.

Individual monitors should have a high resolution meter and associated logger to transmit data to a control centre. Data is expected to be collected at least at hourly intervals and regularly downloaded. The IHM needs continual monitoring to limit the level of any supply pipe losses or other continuous flows. Any other continuous flows are attributable to customer use or plumbing losses and should be included in estimates for consumption at household level.

While an allowance is made for meter under-registration it is expected that meters used for these consumption monitors will have an enhanced specification compared with normal domestic meters and as they are continually monitored meter failures and drift will be identified earlier than for normal domestic meters. Meters are expected to be selected and maintained to minimise meter under-registration. A phased meter replacement programme should be in place.

Until further guidance is developed companies should continue to base SAMs on a representative sample of areas of DMAs or smaller whole DMAs which are specifically designed with one meter and permanent data loggers. They should include minimal numbers of non-household properties and have minimal measured households (no more than 50% where practical).

Consumption for non-household properties within SAMs should be deducted from the area total consumption based on metered data or where unmeasured non- households are included

using the unmeasured non-household consumption allowance. Companies should set out how they have deducted non-household consumption;

Consumption for measured households within SAMs should be deducted from the area total consumption based on metered data. Companies should set out how they have deducted household consumption;

The total sample size for SAMs is dependent on the acceptable uncertainty applied to consumption estimates and assumptions on SAM outage. There is currently no specification for number of properties included in SAMs for consumption estimates. This should be included in future guidance following further work. In the meantime, a company should set out its evidence to demonstrate the representativeness of its sample.

The IHM monitoring requirements for continual monitoring and meter under-registration shall be equally applied to SAMs.

Data will not always be available from IHMs or SAMs for a range of reasons. In these cases, data can be infilled using the following guiding principles; where a SAM or IHM property is inoperable data can be infilled using historic data from the same SAM or IHM property or average data from a SAM or IHM property with similar characteristics (from the same stratification).

Supply pipe leakage should be excluded from data for unmeasured households externally metered as part of IHM surveys. For SAMs estimates of supply pipe leakage must also be removed from the data. A company should use its own estimates of supply pipe leakage which are updated annually. A company must set out how these estimates have been derived and its approach to excluding supply pipe leakage from IHM or SAM data used in the calculation for unmeasured household consumption. This is also linked to estimates of plumbing losses. A robust methodology to determining this is required. A recently started UKWIR study is looking at plumbing losses and may help with this.

A company is expected to derive unmeasured household consumption using the following criteria:

- Unmeasured household consumption (Ml/d) for the whole company shall be calculated from average per household consumption (PHC measured as l/h/day) multiplied by the number of unmeasured households.
- Average unmeasured household consumption (PHC) shall be derived from a company's own IHM or SAM except where meter penetration is high and this makes this impractical.
- The PHC for the IHM or SAM sample shall be extrapolated to an average for the whole company based on stratification.
- The IHM or SAM shall follow the principles set out in the UKWIR Report 'Best Practice for unmeasured per-capita consumption monitors' 1999 and the more recent report 'Future Estimation of Unmeasured Household Consumption', UKWIR 2017;
- IHMs and SAM monitors shall be continually monitored and maintained;
- A company shall demonstrate that its IHM or SAM is representative of the company as a whole; disaggregation of the sample by demographic factors, property type or similar factors represents good practice. Valid data from the survey shall be from at least 80% of monitors as an annual average measure. A company may develop and use an alternative monitor as defined in the 2017 UKWIR Report but it must set out the approach taken and demonstrate why this is appropriate;

- In general, it is expected that where the proportion of metered properties in a SAM exceeds 50% of total properties then the area should not be included in the estimation of unmeasured consumption. Companies with high meter penetration may not be able to comply with this and this should be considered when deciding their approach to estimating unmeasured household consumption;
- Quantify the uncertainty allocated to unmeasured household consumption and provide evidence to justify the uncertainty value used;
- Meters shall be selected to provide sufficient granularity to detect low continuous flows indicative of plumbing losses or leakage short duration flow variations. The value of meter under registration should be less than the company's average meter stock;
- Estimates of supply pipe leakage shall be based on a company's own data which is updated annually; and
- Estimates of meter under-registration shall be based on a company's own data which is updated annually.

New guidance on the estimation of unmeasured household consumption[11] has been published. This provides further guidance on monitoring processes in particular the impact of adopting models to increasing meter penetration. The report sets out several potential options for estimating unmeasured households and a framework for selection of an alternative method. For companies with high meter penetration their approach to estimating unmeasured household consumption must be consistent with this guidance and they should set out their approach.

Unmeasured non-households

This component is normally a small proportion of total non-household demand. Unmeasured non-household consumption should be derived from a study of the consumption of measured non-households of similar categories and applying a recognised statistical approach.

A company is expected to report unmeasured non-household consumption using the following criteria:

- Where the reported volume is less than 2% of total non-household demand, data from a per property consumption study shall be refreshed every five years;
- Where reported volumes are greater than 2% of non-household demand, data from a property study shall be refreshed every two years.

Company Own Water Use

Many water and sewerage companies have significant water use at their sewage treatment works and other major assets. The driver for metering is not only accounting for water in the

[11] Future Estimation of Unmeasured Household Consumption, 17/WR/01/16, UKWIR 2017

balance but to allow use as part of leakage monitoring and reporting. Many companies have water efficiency targets to meet and metering is an enabler to achieve these.

Distribution system operational use comprises water knowingly used by a company to meet its statutory obligations particularly those related to drinking water quality. This includes, amongst other things, mains flushing, air scouring, swabbing, service reservoir cleaning, discharge to control pH and other chemical parameters in distribution. Water taken for commissioning of assets or as part of other legitimate network use shall be included. A proportionate approach is appropriate. An industry average can be applied. A company must justify and evidence the estimate it uses.

A company is expected to report using the following criteria:

- All sewage treatment sites and other key assets using greater than 10 m^3/d (0.01 Ml/d) shall be metered;
- An estimate of total company own use shall be included in the water balance, based on a clear methodology and actual data;
- Where an estimate of distribution operational use is greater than 0.6% of distribution input then this value needs to be clearly stated and justified. There should be no change to current assumptions unless clearly evidenced.

Other Water Use

This component comprises water delivered both legally and illegally.

Water taken legally unbilled shall include all water supplied to customers that is unbilled and not reported as water delivered to billed customers. It can include public supplies for which no charge is made such as some sewer flushing, uncharged church and other supplies, fire-fighting and training where not charged. The measure excludes leakage allowance rebates for measured customers. A proportionate approach is appropriate. An industry average can be applied. Where use is greater than 1.2% of distribution input (based on 20% above current industry average) this is to be clearly evidenced and justified.

Water taken illegally unbilled should only be reported here if it is based on actual occurrences using sound and auditable identification and recording procedures. This includes water use in void properties. A proportionate approach is appropriate. An industry average can be applied. Where use is greater than 0.6% of distribution input (based on 20% above current industry average) this is to be clearly evidenced and justified.

A company is expected to report Other Water Use using the following criteria:

- Other use components should be based on a company's own data;
- A company must justify and evidence the estimate it uses; and
- Estimates should be updated when there is a material increase or decrease to volumes.

Meter under-registration (MUR)

Within the calculation of leakage metered data is taken from:

- DI meters

- Customer meters
- Night use monitor meters
- PCC monitor meters
- Night flow meters

Therefore, there is potential for MUR to impact on estimates for night flow, HHNU, NHHNU, unmeasured consumption, measured consumption and the water balance.

Dependant on meter technology and flow through the meter there may be no bias in either direction and therefore there should be no MUR applied. Calibration and verification should still be undertaken. For other meters where there is a bias for under registration then this should be accounted for in calculations.

A company should include estimates of meter under-registration for all meters where there is a bias for under registration. A company should justify the MUR figure used and how it has been derived. MUR should be reviewed annually.

For water delivered measured meter under-registration can be applied to measured volumes. A company is expected to use its own data on under-registration. Where a metering programme has recently been completed or ongoing, a company is expected to revise its assumptions. It is recognised that information on under-registration is limited and there is a need for further work to derive statistically representative values. It is expected that meter under-registration greater than 3% would need to be robustly evidenced.

A company should set out its approach to stopped meters and demonstrate that there is no double counting between stopped meters in consumption from billing data and MUR.

For DI, a company should set out its approach to meter verification. As a minimum, flow checks shall be carried out on DI meters consistent with the principles of the document 'EA Abstraction Good Metering Guide'[12] and in particular the frequency of flow checking defined in Table 6.2 of the EA guide. This does not require all DI meters to be verified annually: there may be a

[12] EA Abstraction Good Metering Guideline, EA February 2002

rolling programme which feeds into overall MUR where a portion of meters are verified each year.

MLE Adjustment

Concept

The basic assumption is that: Distribution Input shall equal the sum of water delivered to customers or used for other purposes and leakage from a company's network.

As this is averaged over a year, any change in service reservoir storage is not material.

The methodology for estimating water balances set out in the Demand Forecasting Methodology report[13] shall be applied. An initial balance of all components shall be applied to identify the extent of any water balance gap. The distribution is carried out by reference to the size and uncertainty surrounding each component of the water balance.

The water balance gap is defined as: 'The difference between distribution input and the sum of water delivered to customers, a company's own water use, water delivered unbilled, distribution system use and leakage. The water balance gap is positive where distribution input is >the sum of components and negative where distribution input is < the sum of components.'

A gap of ±2% is considered good practice. A water balance gap >5% or < -5% indicates a significant inconsistency in one or more of the major components. A company is required to explain the reasons for any water balance gap of greater than a lower threshold of +/-3%. A water balance gap >5% or < -5% is too wide for a valid MLE adjustment to be carried out. In this instance, any water balance gap in excess of the +5% gap, expressed as Ml/d, shall be added to the leakage component. In addition, for any water balance gap >5% or < -5% a review of all material components of the water balance is required.

A company is expected to:

- Set out its approach to MLE
- Apply the MLE methodology and identify any water balance gap;
- Disclose and explain the reasons for any water balance gap exceeding 3% of distribution input;
- Any water balance gap in excess of the +5% gap, expressed as Ml/d, shall be added to the leakage component;
- Revisit all material components of the water balance where the water balance gap is >5% or < -5%.

[13] Demand Forecasting Methodology, NERA for UKWIR 1995: 95/WR/01/1

No elements of the water balance should be excluded from the MLE. The expected components of the MLE are as listed below:

For companies estimating leakage at DMA level:

- Measured household consumption (excl SPL)
- Unmeasured household consumption (excl SPL)
- Measured non-household consumption (excl SPL)
- Unmeasured non-household consumption (excl SPL)
- Distribution system operational use
- Water taken legally unbilled consumption (excl SPL)
- Water taken illegally unbilled
- DMA leakage
- Supply pipe leakage
- Trunk mains leakage
- Service reservoir leakage
- Distribution input

For companies estimating leakage at zonal level:

- Measured household consumption (excl SPL)
- Unmeasured household consumption (excl SPL)
- Measured non-household consumption (excl SPL)
- Unmeasured non-household consumption (excl SPL)
- Distribution system operational use
- Water taken legally unbilled consumption (excl SPL)
- Water taken illegally unbilled
- Distribution losses
- Supply pipe leakage
- Distribution input

Confidence Intervals

The MLE methodology applies a confidence interval to each component of the water balance. This is to reflect the accuracy of each of the components. Best practice is to derive a statistical measure of accuracy for each component although this is difficult in practice. Applying a relative accuracy is an alternative approach.

Applying differing confidence intervals very often has a significant impact on the water balance, particularly for leakage and per capita consumption. There is therefore a need to be

more prescriptive in the approach to defining the range of confidence intervals. A range of confidence intervals can be applied to each group of components.

A company must justify the confidence intervals it uses and provide evidence of how these have been derived. It is expected that most companies' confidence intervals will fall within the following ranges:

Fully measured components such as distribution input should have a range from 2% to 4%;

- Mainly measured with some estimated adjustments such as measured volumes with supply pipe losses and meter under-registration: from 2.5% to 5%;
- Estimated using detailed and reliable methods such as distribution leakage and unmeasured household (including PCC): from 8% to 12%;
- Broad estimates not fully detailed or reliable such as trunk main leakage and water delivered unbilled components: from 20% to 50%.

Reported Total Leakage

Total leakage is taken as the sum of the post MLE values for distribution leakage, including supply pipe leakage, and trunk main / service reservoir leakage. It is expressed as an annual average Ml/d value to one decimal place, consistent with the performance commitment measure.

Glossary

ABV	Annual billed volume
AZNP	Average zone night pressure
BABE	Burst and background estimating methodology
DI	Distribution input
DMA	District Meter Area
EA	Environment Agency
HDF	Hour to day factor
HHNU	Household night use
IHM	Individual household monitor
MUR	Meter under-registration
MLE	Maximum likelihood estimation
NHHNU	Non household night use

Ml/d	Mega-litres per day
PCC	Per capita consumption
SAMs	Small area monitors
UKWIR	United Kingdom water industry research

Annex A: Compliance Checklist

A company is required to complete this checklist for submission with its value of annual average leakage.

The elements of each component to be assessed separately based on the following rules:

Compliance for elements is reported against:

R	Not compliant with the guidance and having a material impact on annual average leakage
A	Not compliant with the guidance and having no material impact on annual average leakage. For example, a material impact might be assessed as more than 1% of the reported value. A company should set out its approach to assessing whether an impact is material or not.
G	Fully-compliant with the guidance

An overall RAG to be assigned for each component based on the following rules:

Compliance for overall components is reported against:

R	There are one or more red elements in the component or the combined effect of amber elements is considered to produce a material impact.
A	Half or more of the elements in the component are amber and the combined effect of the amber elements is considered not to produce a material impact.
G	More than half of the elements in the component are green

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant components	Confidence grade
1	Coverage	R/A/G			

1a	95% of all properties have continuous night flow monitoring through the year		R/A/G		
2	**Availability**	R/A/G			
2a	At least 90% of all properties within continuous night flow monitoring networks available for reporting night flow data through the year		R/A/G		
3	**Properties**	R/A/G			
3a	All properties mapped to defined zones or DMAs using geo-location or similar methods		R/A/G		
3b	Consistency of property numbers contained within DMAs or zones with company billing system. Valid differences explained		R/A/G		
3c	Properties that are defined as void excluded from night use allowances unless evidence for use or losses from		R/A/G		

	illegal occupation is available				
3d	Leakage allowance applied for properties not within DMAs or monitored zones consistent with other leakage estimates		R/A/G		
3e	Property data updated at least annually		R/A/G		
4	**Night flow period and analysis**	R/A/G			
4a	Night flow data frequency at least every 15 minutes		R/A/G		
4b	Leakage derived from a fixed period during the night of at least a one hour period and up to two hours		R/A/G		
4c	If the fixed period is varied during the year for some or all DMAs or zones to address significant changes to night use patterns such as during Ramadan evidence for this is provided.		R/A/G		
4d	Leakage allowance applied for		R/A/G		

	properties not within DMAs or monitored zones consistent with other leakage estimates				
4e	Data infilling for a single DMA or zone does not use more than six months of historic data before moving to area average		R/A/G		
4f	Data infilling where historic data is not available uses the area average in which the DMA is located		R/A/G		
4g	When a DMA is restored to operability, the subsequent leakage data is used to retrospectively update the data infilling interpolating between pre- and post- data over at least one month		R/A/G		
4h	Where NHH properties are continuously monitored, the actual values of flow over the night flow period are		R/A/G		

	used in place of estimates within the night flow analysis				
4i	Weekly leakage estimates are used for annual reporting with no exclusions for summer months		R/A/G		
4j	Negative leakage values are used in compiling values of annual average leakage		R/A/G		
4k	The reasons for any prolonged periods of negative leakage are investigated and explained.		R/A/G		
5	**Household night use**	R/A/G			
5a	he time period for HHNU is the same time period as used for night flow and NHHNU.		R/A/G		
5b	Own data or shared data with proximate companies is used for HHNU.		R/A/G		
5c	Plumbing losses are included and based on own data		R/A/G		

5d	Evidence that survey is representative (based on demography, property type or other factors) of the company as a whole		R/A/G		
5e	Sample size is sufficient to capture continuous and intermittent night use with reasonable confidence		R/A/G		
5f	Continual monitoring and maintenance of IHM and SAMs monitors		R/A/G		
5g	HHNU is derived daily with regular, adjustment of values on a weekly or monthly frequency to reflect actual seasonal use. This may be done retrospectively		R/A/G		
6	**Non household night use**	R/A/G			
6a	he time period for NHHNU is the same time period		R/A/G		

	as used for night flow and HHNU				
6b	Own data or shared data with proximate companies is used for NHHNU		R/A/G		
6c	1999 UKWIR methodology with the appropriate time window as used for the night flow and the published outcome of further methodology development is applied		R/A/G		
6d	Stratification of non-households to a number of groups and consumption bands is representative of the varying characteristics of commercial and industrial properties		R/A/G		
6e	Sample size is sufficient to capture night use by stratification with reasonable confidence		R/A/G		
6f	Reliable and representative average billed volume (ABV)		R/A/G		

	model based on data logging of the representative sample sufficient to capture demand variations with further seasonal logging where relevant. Continuously logged properties not part of the sample.				
6g	ABV model linked to billing system or replacement database of billed volumes. Average billed volumes updated at least annually		R/A/G		
6h	Continuous monitoring of selected non-households is carried out where average demand of an individual non-household has a material impact on the ability for a DMA or zone to provide valid and consistent data within operability limits		R/A/G		
7	**Hour to day conversion**	R/A/G			

7a	The hour-to-day factor is derived separately for each DMA or zone using pressure logging within each DMA or zone. The factors are updated at least annually or where there are any significant changes to pressure regimes		R/A/G		
7b	As an alternative, hydraulic models reflecting latest network configuration and pressure changes, are used if they dis-aggregate in sufficient detail at sub-zone level		R/A/G		
7c	Evidence based N1 value used. Expected range is 1.0 to 1.20		R/A/G		
8	**Annual distribution leakage**	R/A/G			
8a	Average weekly data is derived from valid daily values of leakage using data points which are representative of the week.		R/A/G		

	Backfilling using the methods described in Section 5.4 – night flow analysis - is done when valid data is not available for three or more data points.				
8b	The annual value of leakage expressed as Ml/d is be derived from an average of the 52 week data.		R/A/G		
9	**Trunk main losses (only applicable if DMA level leakage assessment used**)	R/A/G			
9a	Company-specific data is used to assess the value of trunk main leakage		R/A/G		
9b	roactive leakage monitoring approach applied where trunk main losses form a significant element of total leakage or the MLE water balance gap is greater than +/-2%.		R/A/G		
9c	If trunk main losses greater than 5% of total leakage		R/A/G		

	estimates reviewed annually				
10	**Service reservoir losses (only applicable if DMA level leakage assessment used)**	R/A/G			
10a	Company-specific data is used to assess the value of service reservoir losses;		R/A/G		
10b	Reservoirs with known high leakage, structural deficiencies or at risk of water quality failures are investigated on an individual basis		R/A/G		
10c	Drop tests (12 hour duration depending on size) carried out every five or ten years. All valves checked for tight close; and losses through overflows investigated. Appropriate monitoring arrangements in place to control and minimise overflow events.		R/A/G		
11	**Distribution input**	R/A/G			

11a	Distribution input to the system is metered with at least daily readings at all defined locations		R/A/G		
11b	Meters are appropriate size for the flow to be measured and located at appropriate inputs to the network confirmed by record plans. Any treatment works take-off downstream of a meter are excluded from the DI calculations		R/A/G		
11c	Data validity checks are carried out at least monthly		R/A/G		
11d	Missing data is infilled using both pre- and post- data for the location over at least one month, extrapolated from pump hours or use of upstream or downstream meters		R/A/G		
11e	The data transfer systems from meter output to		R/A/G		

	central database are checked and validated on a risk-based frequency from one up to two years				
11f	Flow checks are carried out on DI meters consistent with the principles of the document 'EA Abstraction Good Metering Guide' and in particular the frequency of flow checking defined in Table 6.2 of the EA guide		R/A/G		
12	**Measured consumption**	R/A/G			
12a	Metered data is derived from own billing system or from CMOS for non-households		R/A/G		
12b	Estimate of supply pipe losses is included for internally metered properties consistent with own current assumption of supply pipe losses		R/A/G		
12c	Inclusion of any leakage allowance is included where a		R/A/G		

	rebate has been applied to a customer's bill				
12d	Meter under-registration is applied consistent with own estimates. Evidence of MUR available especially for MUR above 3%.		R/A/G		
12e	Meter replacement consistent with own replacement programme		R/A/G		
13	**Unmeasured consumption**	R/A/G			
13a	PMonitors follow principles set out in the UKWIR Report 'Best Practice for unmeasured per-capita consumption monitors 1999' and the more recent report 'Future Estimation of Unmeasured Household Consumption', UKWIR 2017		R/A/G		
13b	Consumption is derived from own individual household monitor or small area surveys		R/A/G		

13c	Evidence that survey is representative (based on demography, property type or other factors) of the company as a whole; Valid data available from at least 80% of monitors as an annual average measure.		R/A/G		
13d	For companies using SAMs - SAM comprises a representative sample of customer' characteristics. The sample size is sufficient to provide a statistically representative sample after allowing for outages. Where the proportion of metered properties in an area exceeds 50% of total properties then further data validity tests are applied For companies using IHMs – IHM comprises representative sample of customer		R/A/G		

	characteristics. The sample is at least 1000 properties.				
13e	Uncertainty allocated to unmeasured household consumption is estimated and justified		R/A/G		
13f	There is continual monitoring and maintenance of IHMs and SAM monitors		R/A/G		
13g	Meters are selected to provide sufficient granularity to detect low continuous flows indicative of plumbing losses or leakage short duration flow variations. The value of meter under registration is less than the company's average meter stock		R/A/G		
13h	Estimate of plumbing losses is based on own data		R/A/G		
13i	Where unmeasured non-household reported volume is less than		R/A/G		

	2% of total non-household demand, data from a per property consumption study is refreshed every five years				
13j	Where unmeasured non-household reported volumes are greater than 2% of non-household demand, data from a property study is refreshed every two years		R/A/G		
14	**Company own water use**	R/A/G			
14a	All sewage treatment sites and other sites and assets supplied downstream of the DI meters using greater than 10 m3/d (0.01 Ml/d) are metered		R/A/G		
14b	An estimate of total company own use is included in the water balance, based on a clear methodology and actual data		R/A/G		
14c	Estimate of distribution operational use is		R/A/G		

	evidence based and not greater than 0.6% of distribution input.				
15	**Other water use**	R/A/G			
15a	Other use components are based on own data		R/A/G		
15b	Estimate of water delivered unbilled (legally and illegally) is evidence based and not greater than 1.8% of distribution input.		R/A/G		
15c	Estimates are updated when there is a material increase or decrease to volumes.		R/A/G		
16	**Water balance and MLE**	R/A/G			
16a	Fully measured components have a range from 2% to 4%		R/A/G		
16b	Mainly measured with some estimated adjustments have a range from 2.5% to 5%		R/A/G		

16c	Estimated using detailed and reliable methods have a range from 8% to 12%		R/A/G		
16d	Broad estimates not fully detailed or reliable have a range from 20% to 50%.		R/A/G		
16e	Water balance discrepancy <2% = G >2% and <3% = A >3% = R		R/A/G		

For each component on the checklist, and for the overall performance measure, companies will report a confidence grade.

Confidence grades provide a reasoned basis for companies to qualify the reliability and accuracy of the data. Companies should employ a quality-assured approach in the methodology used to assign confidence grades, particularly if sampling techniques are in place.

The confidence grade combines elements of reliability and accuracy, for example:

- A2 Data based on sound records etc. (A, highly reliable) and estimated to be within +/- 5% (accuracy band 2)

Reliability and accuracy bands are shown in the tables below.

Reliability Band	**Description**
A	Sound textual records, procedures, investigations or analysis properly documented and recognised as the best method of assessment.
B	As A, but with minor shortcomings. Examples include old assessment, some missing documentation, some reliance on unconfirmed reports, some use of extrapolation.
C	Extrapolation from limited sample for which Grade A or B data is available.

D	Unconfirmed verbal reports, cursory inspections or analysis.

Accuracy band	Accuracy to or within +/-	But outside +/-
1	1%	-
2	5%	1%
3	10%	5%
4	25%	10%
5	50%	25%
6	100%	50%
X	Accuracy outside +/- 100 %, small numbers or otherwise incompatible (see table below)	

Certain reliability and accuracy band combinations are considered to be incompatible and these are blocked out in the table below.

Compatible confidence grades				
Accuracy band				
	A	B	C	D
1	A1			
2	A2	B2	C2	
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5			C5	D5
6				D6
X	AX	BX	CX	DX