Experiences in Real Loss Assessment
10-years after implementing the ILI as decisive Key-PI in Austria

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HISTORY
INFRASTRUCTURE LEAKAGE INDEX (ILI)

ILI = CARL / UARL

CARL Currant Annual Real Losses  (litres/day)
UARL Unavoidable Annual Real Losses  (litres/day)

UARL = \((18 \times Lm + 0.8 \times Ns + 25 \times Lp) \times P\)

Lm... Total mains length (km)
Ns ... No. of service connections
Lp ... Total length of service connections from property boundary to customer meter (km)
P ... Current average operating pressure (m)
### Losses from Water Supply Systems: Standard terminology and Recommended Performance Measures

- **IWA Water Balance**
- **Infrastructure Leakage Index (ILI)**

<table>
<thead>
<tr>
<th>System Input Volume</th>
<th>Authorised Consumption</th>
<th>Billed Authorised Consumption</th>
<th>Billed Metered Consumption (including water exported)</th>
<th>Revenue Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>M³/year</td>
<td>M³/year</td>
<td>M³/year</td>
<td>M³/year</td>
<td>M³/year</td>
</tr>
<tr>
<td>Water Losses</td>
<td>Apparent Losses</td>
<td>Unbilled Authorised Consumption</td>
<td>Unbilled Metered Consumption</td>
<td></td>
</tr>
<tr>
<td>M³/year</td>
<td>M³/year</td>
<td>M³/year</td>
<td>M³/year</td>
<td></td>
</tr>
<tr>
<td>Real Losses</td>
<td></td>
<td></td>
<td>Unbilled Unmetered Consumption</td>
<td></td>
</tr>
<tr>
<td>M³/year</td>
<td></td>
<td></td>
<td>M³/year</td>
<td></td>
</tr>
<tr>
<td>Metering Inaccuracies</td>
<td></td>
<td></td>
<td>Unauthorised Consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M³/year</td>
<td></td>
</tr>
<tr>
<td>Non-Revenue Water**</td>
<td></td>
<td></td>
<td>Leakage on Transmission and/or Distribution Mains</td>
<td>M³/year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leakage and Overflows at Utility’s Storage Tanks</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Leakage on Service Connections up to point of Customer metering</td>
<td>M³/year</td>
</tr>
</tbody>
</table>

**SUMMARY**

The quality of water use is an important indicator of the position or neglect of water resource and conservation management. It is a vital resource for economic development and the need for its efficient and effective use is increasing. The objective of this paper is to introduce the following key concepts that are important for understanding water losses in water supply systems:

- **Water balance**
- **Infrastructure Leakage Index (ILI)**

This paper presents the methodology of the Water Losses Task Force, which provides a comprehensive framework for assessing and improving water balance, including loss measurement and control. The methodology is based on the principles of water balance and includes the following steps:

1. Identification of loss sources and mechanisms
2. Measurement of water losses
3. Analysis of loss causes
4. Development of loss control strategies
5. Implementation and monitoring of loss control actions

The Water Losses Task Force is part of the IWA Water Balance Project, which aims to promote the implementation of water balance principles in water supply systems worldwide. The methodology and key performance indicators developed by the Task Force are intended to be used by water utilities, researchers, and other stakeholders to improve water balance and reduce losses in water supply systems.

• IWA Water Balance
• Clear statement against use of % as technical PI
• Infrastructure Leakage Index (ILI) as decisive PI
  • Best indicator in terms of considering network parameters
    • length of mains
    • number of connections
    • length of connections
    • pressure
• Class limits (A, B, C, D) same as World Bank Institute Bands (WBI)
WATER LOSS ASSESSMENT

According WBI classification scheme:

<table>
<thead>
<tr>
<th>ILI</th>
<th>Class $q_{AL}$</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>till 2</td>
<td>A</td>
<td>very little till little water losses, further reduction could be counter productive; further analysis before any action should be executed.</td>
</tr>
<tr>
<td>2 to 4</td>
<td>B</td>
<td>medium water losses, potential for noticeable loss reduction existing, improvement in leakage control and infrastructure management.</td>
</tr>
<tr>
<td>4 to 8</td>
<td>C</td>
<td>high water losses, volume and reasons for losses have to be analyzed and attempts to reduce the volume of lost water has to be intensified.</td>
</tr>
<tr>
<td>greater than 8</td>
<td>D</td>
<td>very high water losses, volume and reasons for losses have to be analyzed, distinct leakage control and leakage reduction has to be executed immediately.</td>
</tr>
</tbody>
</table>

Source: OVGW W 63 (2009)
GOOD PRACTICES ON LEAKAGE MANAGEMENT WFD CIS W POM (2015)

Coordinated by

Cor Merks
(ARCADIS Nederland BV)

In cooperation with

IWA Water Loss Specialist Group
Institutions of EU member states

Main Report

Case Study Report

ILI as decisive real loss PI

BULGARIAN WATER LOSS GUIDELINE (2015)

IWA Water Balance
Set of Performance Indicators for
- real loss, NRW, failure rates
ILI as decisive PI
- Low/Middle Income Country ILI range = 2 x High Income Country

<table>
<thead>
<tr>
<th>ILI range</th>
<th>Leakage Performance Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3</td>
<td>A1</td>
</tr>
<tr>
<td>3 to &lt; 4</td>
<td>A2</td>
</tr>
<tr>
<td>4 to &lt; 6</td>
<td>B1</td>
</tr>
<tr>
<td>6 to &lt; 8</td>
<td>B2</td>
</tr>
<tr>
<td>8 to &lt; 12</td>
<td>C1</td>
</tr>
<tr>
<td>12 to &lt; 16</td>
<td>C2</td>
</tr>
<tr>
<td>16 to &lt; 24</td>
<td>D1</td>
</tr>
<tr>
<td>24 and more</td>
<td>D2</td>
</tr>
</tbody>
</table>
IWA Water Balance

Real Losses

- ILI is preferred KPI
- \(m^3/km/h\) traditional

ILI classification scheme in W 400-3, shows ALC interval for ILI and \(q_{VR}\)

### Water loss according W 392 (A)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Failure rate (mains)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td>low</td>
<td>every 6 years</td>
</tr>
<tr>
<td>moderate</td>
<td>every 2 years</td>
</tr>
<tr>
<td>high</td>
<td>annually</td>
</tr>
<tr>
<td>high</td>
<td>comprehensive measures</td>
</tr>
</tbody>
</table>

ILI ≤ 2

ILI > 4
All good?
LEARNINGS FROM AUSTRIA - ILI

Still **limited** acceptance of ILI

Classification scheme for ILI works well for systems with >3000 connections

But smaller systems (<3000 service connections) can be in Band A with ILI << 1.0 at average pressure of 50 metres

~ 90% of Austrian Utilities have < 3000 connections
> 80% of these systems have < 1000 connections

Review of Austrian/UK collaboration on understanding why this occurs since 2007, and recent developments
SIZE MATTERS: 
DATA FROM OVGW BENCHMARKING STUDIES

2007 and 2011 data, excluding 18 ILIs > 2.0

2007 and 2011 data

REASONS FOR LOW ILI IN SMALL SYSTEMS

Errors when calculating UARL – lack of systematic approach to infrastructure parameters and pressure

Influence of pressure:leak flow relationships for mostly flexible pipes if pressure less than around 40 metres

Small systems (< 3000 service connections):

» new unreported leaks quickly and easily identified from night flows, leads to shorter run times

» wider confidence limits for calculated CARL

» New research shows that for very small systems, low UARL leak frequency distributions need to be included
A POISSON DISTRIBUTION USED FOR FOOTBALL STATISTICS

Used to predict probability of occurrence of small numbers of isolated events, when only average number over several periods of time is known.

Example: goals per game in Premier League 2017-18

Poisson distribution has now been applied to study of low annual numbers of UARL bursts in small systems (WLR&A Ltd, 2019)

Graph shows how normal ‘bell-shaped’ distribution becomes more skewed as system size reduces
STEPS 1, 2: REVIEW AND IMPROVE BURST FREQUENCY ASSUMPTIONS

Step 1: Modify UARL average burst frequencies at 50m pressure for actual pressure
   › using international (2012) preferred practical approach to pressure:burst frequency relationships

Step 2: Interpret low numbers of UARL bursts in small systems using the median values of the 3 Poisson probability distributions
   ➢ degree of skewness increases as system size falls
   ➢ example is for UARL bursts, mains to property line, for 500 service connections
STEPS 3 AND 4

Step 3: FAVAD: Fixed and Variable Area Discharges assumptions

› N1 = 0.5 for rigid pipes
› N1 = 1.5 for flexible pipes and unavoidable background leakage
› Assess %s of rigid and flexible pipes on mains, on services from main to property line, and on services from property line to meter

Step 4: Derive customised System Correction Factor SCF to customise standard linear UARL equation, using UARL with SCF software

\[
\text{UARL (litres/day)} = \textbf{SCF} \times (18 \times L_m + 0.8 \times N_s + 25 \times L_p) \times P
\]

SCF varies with influence of pressure on 6 interacting zone-specific factors

› Presented as graphs of SCF vs average pressure, and customised UARL in m$^3$/day vs average pressure, for any individual Zone or system, of any size
### CALCULATION OF UARL in North American Units with System Correction Factor SCF

<table>
<thead>
<tr>
<th>Standard Linear Equations for UARL</th>
<th>US Units</th>
<th>Metric</th>
<th>US gal/day</th>
<th>m³/day</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UARL (USgal/day)</strong> = SCF x (5.4 x Lm + 0.15 x Nc + 7.5 x Lc) x AZP</td>
<td><strong>UARL (m³/day)</strong> = SCF x (18 x Lm + 0.8 x Ns + 25 x Lp) x AZP/1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lm and Lc in miles, AZP in psi</td>
<td>Lm and Lp in km, AZP in metres</td>
</tr>
</tbody>
</table>

#### Service Connection Help

<table>
<thead>
<tr>
<th>Calculation by</th>
<th>A. Lambert</th>
<th>5th Aug 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid/Flexible Pipes Help</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### System Data for Anytown Utility

- ** Reported Bursts: 75% **
- ** Number: 3,000 **
- ** Unreported Bursts: 25% **
- ** ft/conn: 50.0 **
- ** m/conn: 15.2 **
- ** miles: 28.41 **
- ** km: 45.7 **
- ** miles: 36.00 **
- ** km: 57.9 **
- ** Density of Connections DC per length of mains: 83.3 per mile / 51.8 per km **
- ** Average Zone Pressure AZP: 40.0 psi / 28.1 metres **
- ** Unavoidable Annual Real Losses UARL with SCF applied: 34299 USgalpd / 129 m³/day **

### System Data for Anyzone

<table>
<thead>
<tr>
<th>Reported Bursts: 75%</th>
<th>% Rigid, N1 = 0.5</th>
<th>% Flexible, N1 = 1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

### Note: small differences in UARL and are due to rounding errors when the Metric UARL equation is converted to US Units
EXAMPLE OF HOW SCF AND BURSTS REDUCE WITH SYSTEM SIZE
3000 SERVICES, 50% RIGID PIPES
1000 SERVICES, 50% RIGID PIPES
LEARNINGS – WATER BALANCE, PI

More and more countries are implementing the **IWA water balance** and **ILI** as decisive PI in national guidelines.

Unfortunately “%” are still widely used as technical indicator.

Using ILI bears risk that higher losses “hidden” in high pressure systems:
- Calculate and always quote average system pressure
- Identify potentials for pressure reduction
- Cross-checks with other performance indicators

Use ILI for the purpose it was developed for:
- Assessment and comparisons of Technical Performance in managing Real Losses between different systems with different characteristics
- Monitoring and target setting: **only** when pressure management completed

Use m³/km/h and l/conn/d for the traditional purpose of:
- Utility internal monitoring of individual systems/sub-systems
- Utility internal target setting of individual systems/sub-systems
- but not for comparisons between systems/sub-systems
LEARNINGS – SMALL SYSTEMS

Logical reasons for ILIs less than 1 in some very small systems

• New classification for small systems <3000 conn. to be developed?

UARL with SCF software with Poisson and pressure:bursts can:

• calculate a customised median UARL for any individual small system (and PMZ, DMA)
• be used for research into generalised SCF vs system size relationships
Thank you for your interest!

Copies of this presentation can be downloaded from:

www.bluenetworks.at

https://www.leakssuitelibrary.com/pros-abandon-percents-of-siv/

For further information on UARL with SCF software,

visit https://www.wlranda.com/software or contact info@wlranda.com
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