

Water Loss Group: IWA Task Force

Best Practice Performance Indicators for Non-Revenue Water and Water Loss Components: A Practical Approach

In this eighth article in a special series for *Water21* by the IWA Water Loss Task Force, Dr. Ronnie McKenzie and Allan Lambert highlight practical developments over the last decade in this topic.

The scope of this series of articles 'A Practical Approach to Water Loss Reduction' was outlined in the May 2003 issue of *Water21*⁽¹⁾ by Ken Brothers, Chair of the Water Losses Task Force (WLTF). This article outlines the latest developments in WLTF thinking on Best Practice Performance Indicators (PIs) for Non-Revenue Water, Real Losses, Unbilled Authorised Consumption and Apparent Losses.

The Performance Indicators for Water Supply Services Best Practice Report⁽²⁾

A clearly defined water balance is the first essential step in the assessment of volumes of Non-revenue water and the management of water losses in potable water distribution systems. In July 2000, the IWA Task Forces on Performance Indicators and Water Losses published a standard international 'best practice' water balance as shown in **Figure 1**. This water balance has since been recognised and adopted as international 'best practice' by a steadily increasing number of countries and water utilities throughout the world.

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Water Exported	Revenue Water
			Billed Metered Consumption	
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	Non Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorised Consumption	
		Real Losses	Customer Meter Inaccuracies	
	Leakage on Transmission and Distribution Mains			
	Leakage and Overflows at Storage Tanks			
		Leakage on Service Connections up to point of Customer Meter		

Figure 1: the IWA 'best practice' standard water balance

In addition to the standardised water balance, the task force also proposed several key 'best practice' PIs for :

- Non-Revenue Water;
- Water Losses;
- Apparent Losses and;
- Real Losses.

Of particular significance is the use of the term ‘Non-Revenue Water’ in place of the widely used ‘Unaccounted-For Water’ due to the scope for misinterpretation and manipulation associated with the latter term. One only has to examine publications from around the world to see how the definitions and calculations of ‘Unaccounted-for Water’ vary from one country to another. The term ‘Non-revenue Water’ is clear and unambiguous, even to non-specialists.

While some healthy debate still continues around the world, the IWA approach of selecting different PIs for different purposes - namely: Financial, Operational, and Water Resources – is a clear step forward. In each case, PI’s have been recommended for both basic and detailed levels within each category. (Intermediate PIs have also been proposed in some cases, however, to avoid confusing the issue even further, this article will concentrate on only a few of the key and most useful PIs relating to water losses and non-revenue water)

Table 1: Details of Selected Key PI’s

Component	Type	Basic PI	Detailed PI
Non- Revenue Water	Financial	Volume of NRW as % of System Input Volume	Value of NRW as % of cost of running system
Real Losses	Water Resources	Volume of real losses as % of System Input Volume	
Real Losses (In each case, this PI is calculated per day ‘when the system is pressurised to allow for the effect of intermittent supply).	System Operational	litres/service connection/day for systems with 20 or more services/km mains (32 per mile) Use m ³ /km mains/day for systems with fewer than 20 services/km of mains	The Infrastructure Leakage Index: defined as the Ratio of the Current Annual Real Losses to the Unavoidable Annual Real Losses = CARL/UARL This indicator is fully explained by Lambert et. al. (5)
Apparent Losses	Operational		m ³ /service connection/year
Water Losses	Operational	m ³ /service connection/year	

Some discussion on each of the PIs listed in **Table 1** is provided below.

Non-Revenue Water: Financial PI

Although “% by volume” has traditionally been widely used as a PI for many components of the water balance (including Non-revenue Water), it can be very misleading as it is strongly influenced by:

- differences and changes in the volume of consumption,
- intermittent supply,
- the presence or absence of customer storage tanks (which usually result in significant under-recording of customer meters)⁴.

While “% by volume” is still recommended as a basic financial PI for Non-revenue Water, and a basic PI for Real Losses from a Water Resources viewpoint, it should definitely not be used for assessing any aspect of operational performance management of Water Losses; (other components of the water balance and where possible the recommended PI’s given in **Table 1** should be used).

The detailed financial PI for Non-revenue Water is based on the **% by value** of the water rather than the **% by volume**. A simple example of a typical calculation is provided in **Table 2** which highlights the differences between the two PI’s for Non-revenue Water.

Table 2: Comparison of basic and detailed NRW Financial PIs for a Canadian System

NRW Component	Volume as % of System Input Volume	Marginal Cost (\$/m ³)	Value as % of Annual System Running Cost
Unbilled Authorised Consumption	1.06	0.0440	0.08
Apparent Losses	1.25	0.2550	0.57
Real Losses	17.72	0.0447	1.41
Non-Revenue Water	20.03		2.06

Real Losses: Water Resources PI

The **basic** Water Resources PI recommended in Ref (3) is 'Real Losses by volume'

$$= \text{Volume of Real Losses as \% of System Input Volume}$$

No further work has been done on this PI by the Water Losses Task Force since 2000. As previously mentioned, %'s by volume are strongly influenced by differences and changes in consumption, and if improvements to this PI are to be considered, it would be useful to assess whether or not the 'Real Losses' become available for re-use.

Real Losses: Operational PI

The IWA Best Practice Report⁽²⁾ clearly states that “%’s by volume” are unsuitable for assessing the efficiency of operational management of Real Losses. This conclusion has been endorsed by many organisations throughout the world including; Ofwat in England/Wales, the national regulator in Malta, AWWA in N. America, WSAA in Australia, NZWWA in New Zealand and DWAF in South Africa.

As comparatively few systems have less than 20 service connections/km, '**litres/service connection/day**' is the preferred basic operational PI for most distribution systems. This basic PI is the best of the 'traditional' PIs but has certain limitations, as it does not allow for the following:

- density of connections (per km of mains);
- length of service pipe between the main and the customer meter, and;
- average pressure (leakage rates vary approximately linearly with pressure for systems with mixed pipe materials).

To address these deficiencies, a detailed operational PI for Real Losses was developed and is referred to as the Infrastructure Leakage Index (ILI). This relatively new PI is the ratio of the Current Annual Real Losses (CARL) to the Unavoidable (Technical Minimum) Annual Real Losses (UARL) and is discussed in detail by Lambert et al 1999⁽⁵⁾.

The ILI measures how effectively a Utility is managing Real Losses under the current operating pressure regime. However, it is important to note that this does not imply that the pressure management is optimal, and it is usually possible to reduce the volume of real losses (but not the ILI) by improved active pressure management. This 'twin track' approach to leakage management directly addresses comments that the ILI somehow favours water utilities that operate at high pressures and discriminates against those that implement strict pressure management measures. Once again, this is the subject of considerable debate, however, the speed at which water utilities throughout the world have adopted the ILI as their preferred PI for Real Losses is clear testament to its value in the water industry. The ILI has in fact been the subject of many workshops and is included in many water balance models including, BENCHLEAK⁽⁶⁾, BENCHLOSS⁽⁷⁾,

BENCHLOSSNZ⁽⁸⁾, AQUALIBRE⁽⁹⁾, FASTCALC⁽¹⁰⁾, as well as many other similar models developed and used throughout the world by various water utilities or water distribution specialists.

Since the ILI was first introduced in 1999, it has been calculated in an increasing number of countries as shown in **Figure 2**. Theory and experience both show that it can be used with confidence for comparisons at international, national, state and within-system levels for systems with:

- more than 5000 service connections;
- more than 25 metres pressure on average throughout the system, and have;
- more than 20 service connections per km of mains.

Apparent Losses: Operational PI

The operational PI for Water Losses (i.e. the sum of Real and Apparent Losses) and Apparent Losses in the 2000 PIs Report⁽²⁾ was m³/service connection/year (to provide consistency with the basic PI for Real Losses). However, numerous international applications of the Water Balance since 2000 have identified a need for more specifically focused practical operational PIs for Unbilled Authorised Consumption (UAC), and the components of Apparent Losses (AL). When auditing and comparing volumes attributed to UAC and AL, it's necessary to check that these components are not excessive.

A practical approach undergoing further testing by the Performance Indicators Team of the WLTF is to use '% of Water Supplied' as a PI for checking the Unbilled Authorised Consumption (metered and unmetered), and the Unauthorised Consumption. The most meaningful practical PI for the remaining component of Apparent Losses – mainly customer meter error – is likely to be '% (+/-) of registered metered consumption', as this is the usual basis for presenting results from systematic testing of randomly selected customer meters.

Other Ongoing Initiatives

Consideration is being given to possible revision of the definition of 'number of service connections' in complex situations, including aspects such as fire service connections and fire hydrants separated from the main by lateral connections. These and other aspects will be discussed as part of a WLTF Workshop planned for the IWA Marrakech Symposium in September 2004.

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10.	FASTCALC: Water Balance and Pis software with 95% confidence limits . Customised versions to date for Australia, Brazil, Canada, Italy, Morocco, UK and USA. For further details contact A0andJGLambert@aol.com

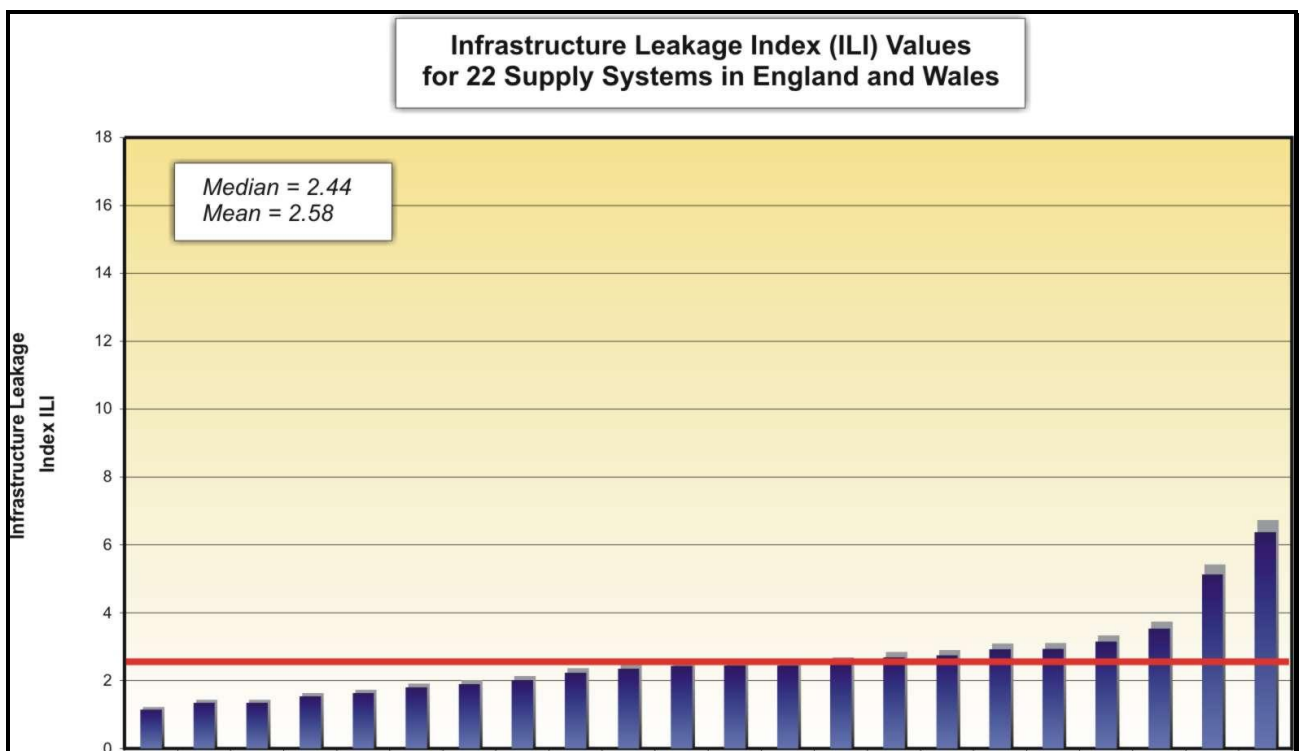


Figure 2a: ILI results for 20 systems from England and Wales
 (Source: February 2004 paper by David Howarth, Environment Agency)

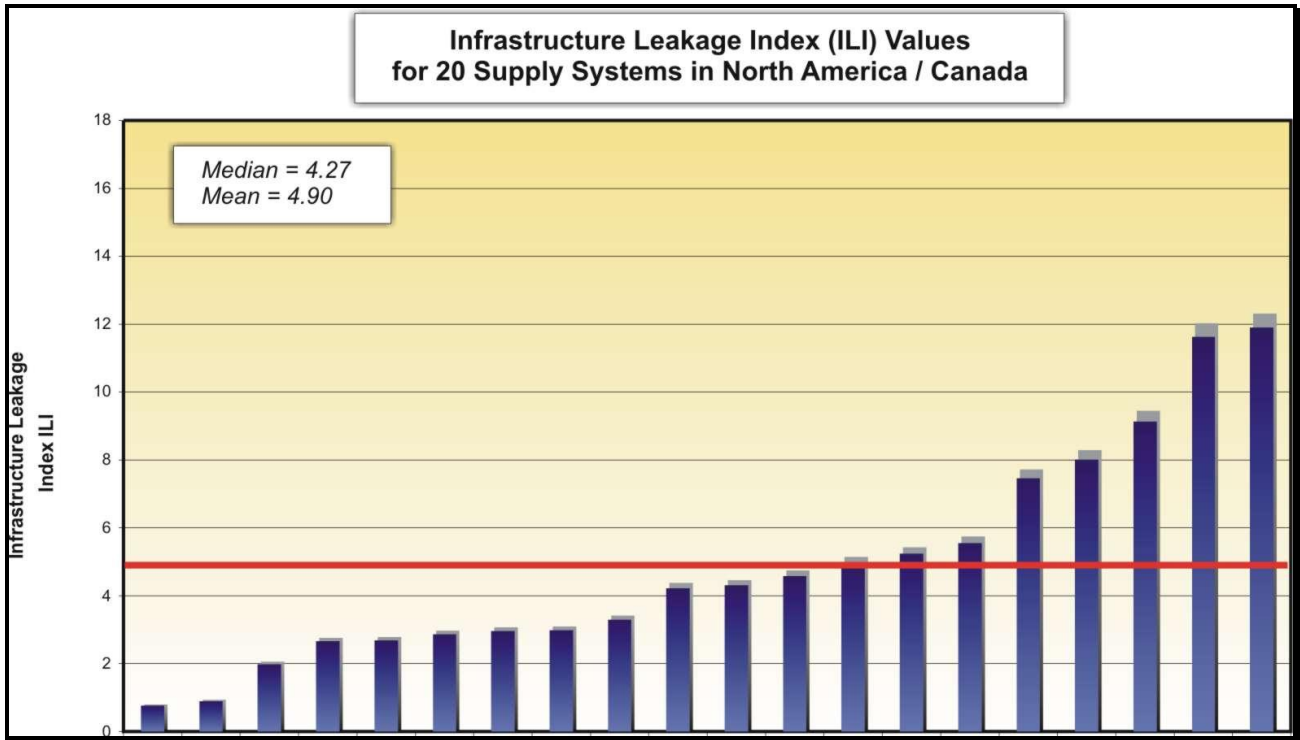


Figure 2b: ILI results for 20 systems from the USA and Canada
(Source: June 2004 presentation by Tim Waldron and Allan Lambert based on various data sources)

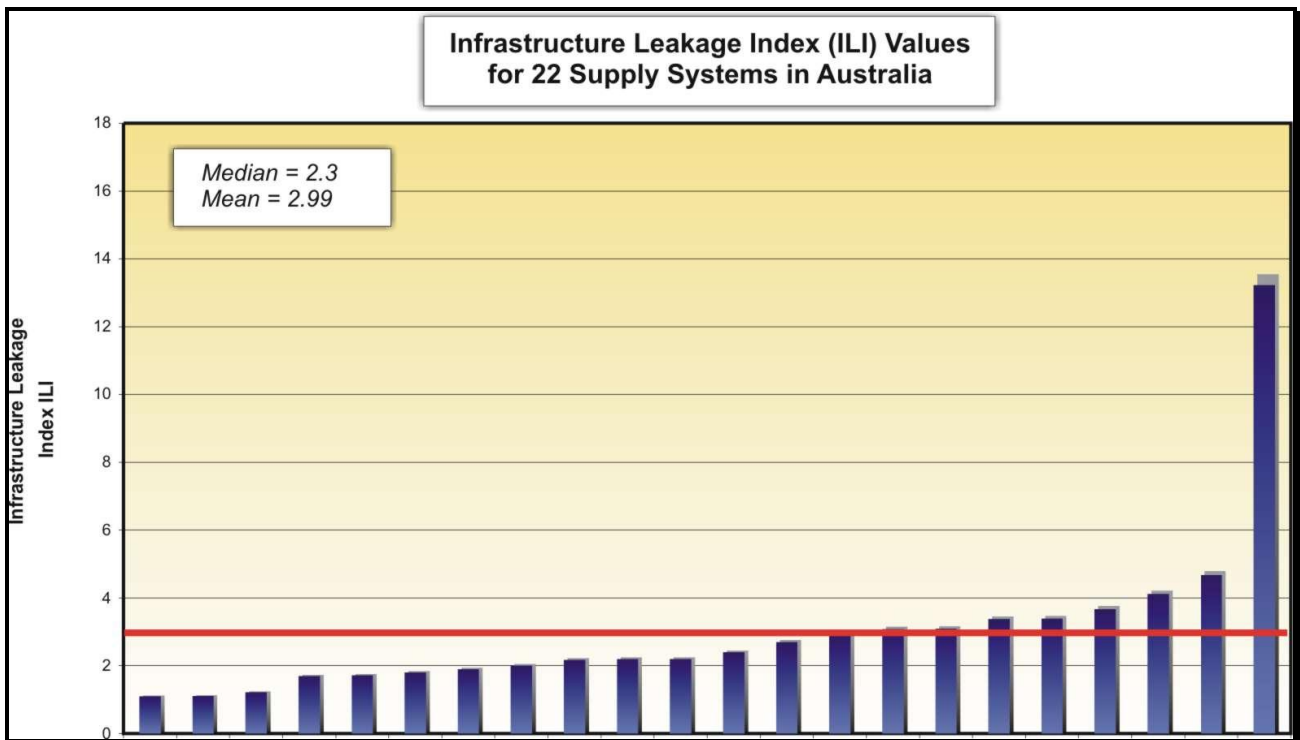


Figure 2c: ILI results for 20 systems from Australia
(Source: March 2004, Tim Waldron, Wide Bay Water)

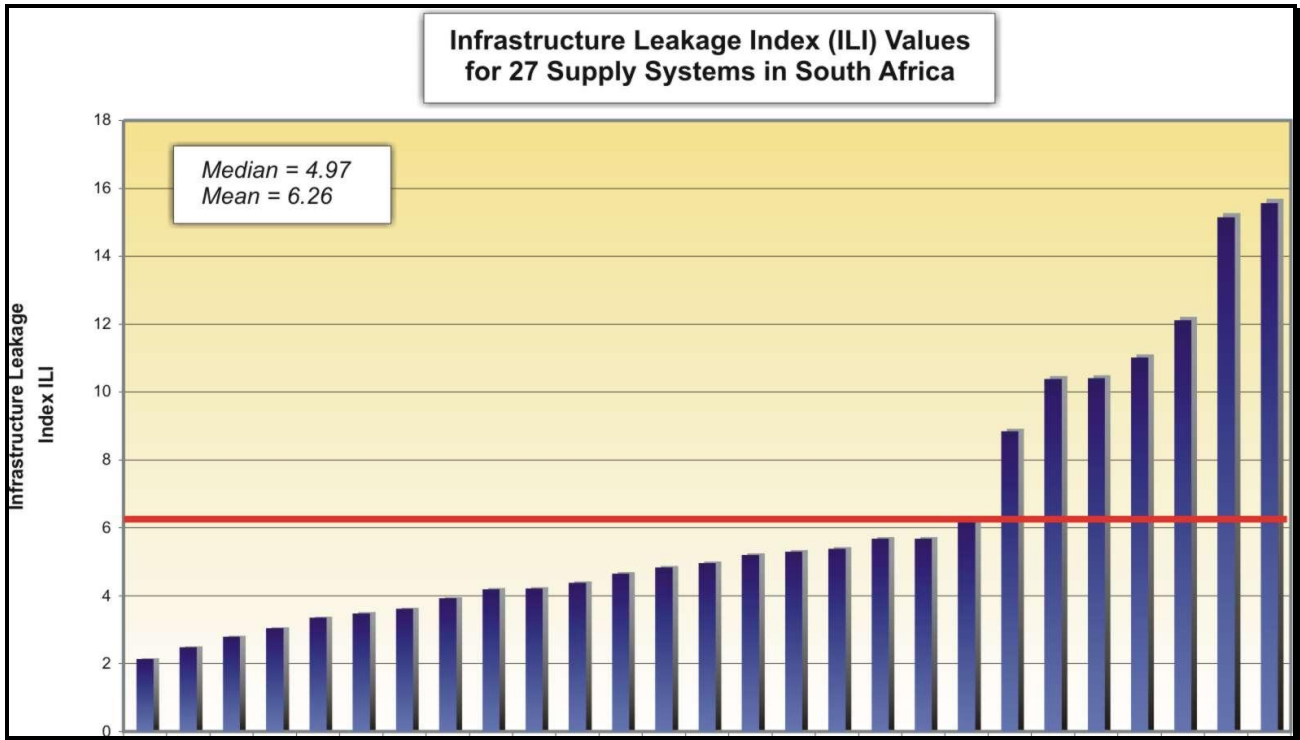


Figure 2d: ILI results for 27 systems from South Africa
(Figures courtesy the South African Water Research Commission)

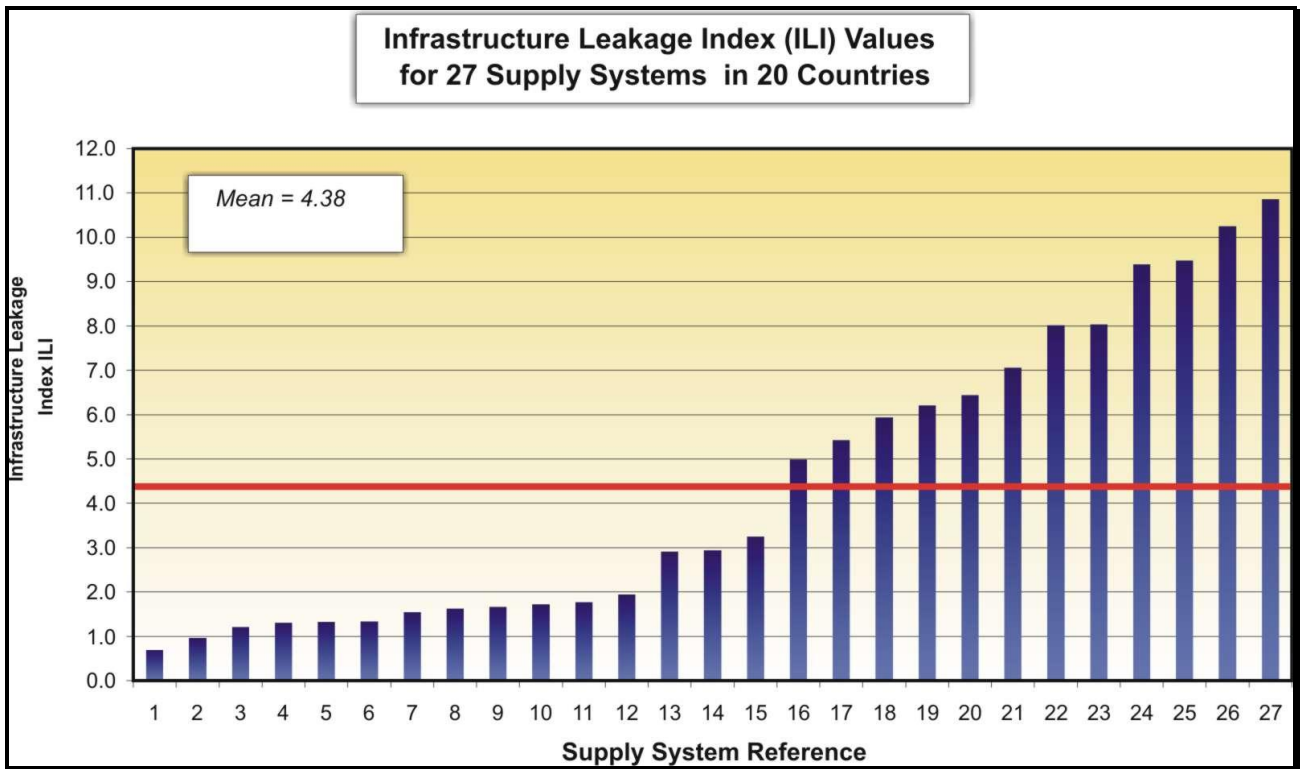


Figure 2e: ILI results for 27 systems from 20 countries
(Figures courtesy Allan Lambert and IWDC Ltd)