water NEW ZEALAND
The New Zealand Water & Wastes Association Wāiora Aotearoa

WATER LOSS GUIDELINES

SECOND EDITION

Overview

August 2023

MANAGING WATER LOSSES IN NEW ZEALAND - OVERVIEW

Introduction: Navigating this overview document and the New Zealand Water Loss Guidelines

This overview of managing water losses in New Zealand is intended to provide a quick insight into the key factors, to help water supply managers and others understand how their 'status quo' measures up. This includes what an achievable target level of water loss should be for the networks they manage.

It is a supporting resource to the *New Zealand Water Loss Guidelines 2023 (Water Loss Guidelines)* which provides detailed guidance, tools, and supporting information for measuring, monitoring, and managing real water losses from public water supply networks.

Water suppliers around New Zealand are all at various stages in the journey of managing real losses.

The table in Appendix A of this document provides descriptions of various levels of maturity for a range of aspects of water loss management. This is intended to give water network operators some insight into where they sit in terms of their current practices, and what an improved situation might look like.

The *Water Loss Guidelines* document provides significantly more detail.

The content map on the facing page provides an overview of the contents and where to find more detail in this document and the *Water Loss Guidelines*.

This supporting resource document has been produced by Water New Zealand as part of the project to update the *Water Loss Guidelines*.

You can find the full guidelines online in the Technical Documents section of the Water New Zealand Resource Hub at https://www.waternz.org.nz/resourcehub.

Content map

What	This is an overview of the *New Zealand Water Loss Guidelines*, aimed to support drinking water network operators to measure and understand water losses and how to improve network management to reduce losses. *The colours and italics cross-reference to the relevant sections of this Overview and the Guidelines*		
Why	Understand how measuring and reducing losses will help give effect to Te Mana o te Wai and find out about Taumata Arowai requirements and other drivers for action *(Overview section A, Guidelines section 2)*		
Where to start	Understand how your 'status quo' measures up to best practice for various size networks, and what an improved situation might look like (*Overview section B, H and I, Guidelines section 4*)		
What does best practice look like	**Measure** Find out how leaky the network currently is: • Calculate an annual water balance; that is, the current level of water losses with or without customer water meters. *(Overview sections C and D, Guidelines section 3)*	**Monitor** Find out where the leaks are: • Weekly monitoring of minimum night flows in network sectors or segments. • Monitor pressure and any backlog of leak repairs. *(Overview section D, Guidelines section 5)*	**Manage** Work out where to focus activities: • Active leakage control (ongoing leak location and repair) • Speed and quality of repairs • Asset management (materials, installation, maintenance, renewal) • Pressure management *(Overview section D and E; Guidelines sections 6, 7, 8 and technical guidance notes*
Evaluate	Benchmark against performance indicators, identify achievable target. *(Overview section C, Guidelines section 4)*	Compare to NZ averages. Identify priority areas for active leakage control. *(Guidelines section 5)*	Use information from measuring and monitoring to identify opportunities to reduce losses *(Guidelines section 6)*
Gap analysis	Where are there areas for improvement? What are the priorities? *Overview section G,H,I and Appendix A, Guidelines technical guidance note 1*		
Strategy/ long-term plan	Set targets, timeframe, budget/indicative costs and priority actions *(Overview section F and Guidelines 2.5.4 and 6.1)*		

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A. Why reducing water loss matters

The importance of water loss cannot be overstated.

Water is essential for life, and communities the length and breadth of New Zealand expect a safe and adequate supply of water to their homes and workplaces. Taumata Arowai, as the new water services regulator in New Zealand, is also taking a keen interest in this topic, and one of its key functions is to monitor the environmental performance of water networks.

Water is a taonga (treasure) and a precious resource, and real loss represents a waste of that resource. There are many drivers for characterising, measuring, and reducing real losses, including:

- Giving effect to Te Mana o te Wai.
- Reporting on the Taumata Arowai environmental performance measures for drinking water networks.
- Addressing water scarcity by improving the headroom between water supply and demand (water resources planning).
- Improving the efficiency of water use to meet consent conditions and support consenting.
- Demonstrating stewardship and contributing to the water supplier's social licence to operate.
- Adapting to climate change and improving resilience to drought.
- Mitigating greenhouse gas emissions and reducing energy use.
- Achieving a sustainable level of leakage including cost considerations.
- Demonstrating the integrity and condition of drinking water networks for the supply of safe potable water to customers.

The relevance of the drivers will change across different water supply networks, depending on the local circumstances.

All drinking water network operators are required to report annually to Taumata Arowai on the level of water losses in their networks from 2022/23.

A principle of the Water Services Act 2021 is that a drinking water supplier in carrying out their duties must give effect to Te Mana o te Wai.

Te Mana o te Wai in the context of the National Policy Statement for Freshwater Management 2020 relates to the essential value of water as a precious resource. This concept highlights the importance of sustaining the integrity and health of the water before providing it for human use, through the following three-tiered hierarchy of obligations:

1. First, protecting the health and mauri of freshwater
2. Second, essential human health such as drinking water.
3. Third, other uses that provide for the social, economic, and cultural well-being of people and communities.

Water loss reduction enables drinking water suppliers and network operators to give effect to Te Mana o te Wai. Consenting water abstraction

volumes is becoming more difficult due to pressure on our freshwater resources and the need to restore and preserve the balance between water, the environment, and people. Managing water loss is essential to demonstrate the efficient use of water when applying for consents and complying with consent conditions.

Managing water demand, which includes managing the level of real water losses, can help to make sure that there is an adequate supply of water to meet our needs while also protecting the health and mauri of freshwater. This is particularly important in the context of high population growth in our urban centres combined with water scarcity which is only likely to get worse in the future under climate change.

Furthermore, water loss is a very good indicator of both the general condition of water supply networks and numerous other important aspects of water network management outlined in this document. Leakage typically occurs from aging and faulty water main pipes and fittings, and high leakage is also often associated with networks laid in porous and/or corrosive soil types. High and fluctuating supply pressures (including pressure transients) exacerbate such leakage. If no attention is given to monitoring, locating, and repairing unreported leaks then levels of water loss can rise significantly over time. Geothermal and seismic considerations may also be contributing factors.

Typically, water supply networks with low levels of water loss are being managed well, and/or are relatively new comprising largely of modern materials such as polyethylene (PE) and polyvinyl chloride (PVC). Water supply networks with a high level of leakage have a greater risk of contamination from an external source if there is an event that causes negative pressures to occur. Maintaining a well-managed network with low levels of leakage can therefore result in an improved risk profile for customers.

The concept of measuring, monitoring, and managing is not new but applies well to this area of water network management. An overview of this concept is provided within this document and expanded in more detail in the *Water Loss Guidelines*.

B. Understanding water balance and definition of real water losses

Calculating a water balance is generally accepted as the best way to 'measure' the level of water loss in a water supply network. This section describes the key elements. Detailed guidance on how to calculate a water balance, even when a significant proportion of water connections/customers are not metered, is contained in the Water Loss Guidelines Section 5.

The key elements are shown in Figure 1 below, a simplified International Water Association (IWA) standard water balance.

Water enters as system input volume and becomes either authorised consumption or water losses. Authorised consumption can be billed or unbilled. The unbilled portion becomes part of non-revenue water (NRW). Water losses form the remainder of NRW and are either:

- Apparent losses- water used but not paid for (theft, customer meter under-registration)
- Real losses - leaks, bursts, and overflows from the systems of water suppliers.

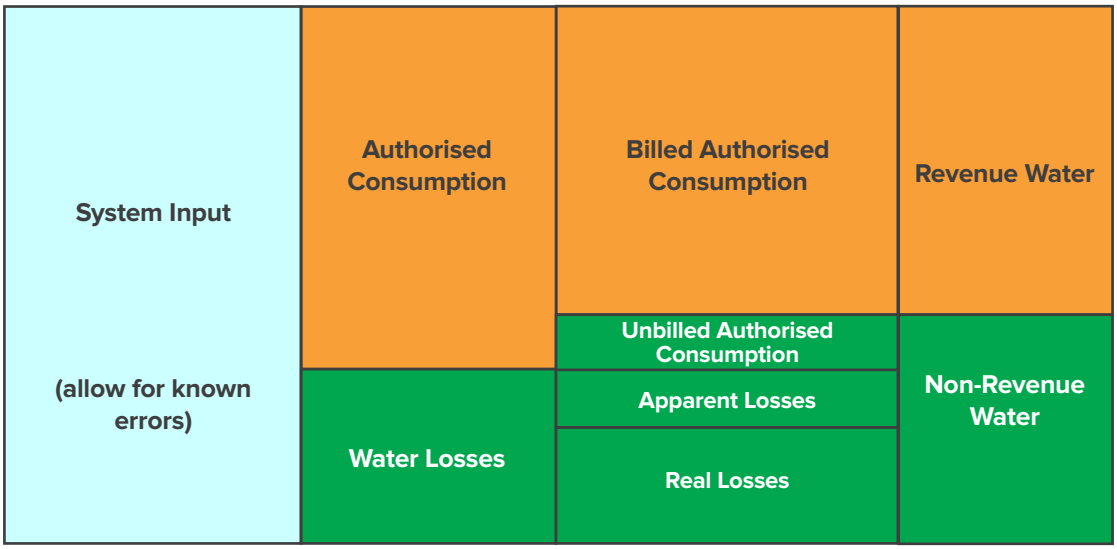

Figure 1: A simplified IWA standard water balance

This diagram is not drawn to any scale, and the composition of NRW in New Zealand is generally dominated by real losses.

The full IWA standard water balance diagram and definitions of each of the components of the water balance are given in the manual for the Benchloss NZ software, available free on the Water New Zealand website.

A water balance is generally calculated for a water supply network using volumes calculated over 12 months. The start and end dates for a water balance period are typically determined by the dates on which customer water meters are read.

Points to note

- The term unaccounted for water (UFW) is no longer recommended as the definition of UFW varies widely both within and between countries.
- Customers paying a uniform annual charge for water are effectively paying for the water use occurring on their property (as billed unmetered consumption). This consumption includes any private leakage occurring on the property (from the point of supply which is the property boundary).
- Default values for several components may be used in the absence of more robust information. Default values adopted for use in Australasia are:
  - Unbilled authorised consumption is assessed at 0.5% of water supplied;
  - Unauthorised consumption is assessed at 0.1% of water supplied;
  - Customer metering under-registration is assessed at 2% of billed metered consumption.

C. Performance indicators for real water losses

Real water losses performance indicators are expressed as:

- litres/connection/day (for urban systems with connection density > 20 conns/km main);
- m^3/km main/day (for rural systems with low connection density < 20 conns/km main); and
- Infrastructure Leakage Index (ILI). This is the ratio of actual water losses (current annual real losses or CARL) to the unavoidable annual real losses (UARL) (see below).

The ILI is best suited for comparing performance between water supply networks. It is not recommended for benchmarking of progress towards reaching a target for reductions in real losses for a specific water supplier. This is because the ILI reflects how well the network is performing at the current pressure, and reducing supply pressure will not reduce the ILI.

The performance indicators for real losses listed above are included in Taumata Arowai's environmental performance measures and replace the Department of Internal Affairs (DIA) mandatory 'non-financial' performance indicators (water loss as a percentage of supply).

NRW is generally expressed as a percentage of water supplied, based on volumes for each water balance component, and is considered a financial performance indicator.

Reporting real water losses as percentages is not recommended by the international water loss fraternity, because this relates water losses to water consumption. This is problematic because:

- First, a water supplier will be 'penalised' for reducing customer water consumption (such as being successful with water demand reduction initiatives) because the percentage of real water losses to water use will increase while actual real water losses remain the same.
- Second, comparisons between suppliers are unfair, as consumption varies with the presence of large water users, climatic conditions, soil types, occupancy of houses, etc.

D. Measure, monitor and manage water losses

Managing water demand includes managing the level of real water losses to ensure there is an adequate supply of water to meet current and future needs while also protecting the health and mauri of freshwater.

Managing water losses is no different from managing other products and services where the best results are achieved with the cyclic process of measurement, monitoring, and managing to achieve better outcomes as shown in Figure 2. Detailed information relating to each of these three activities is provided in the respective sections of the New Zealand Water Loss Guidelines document.

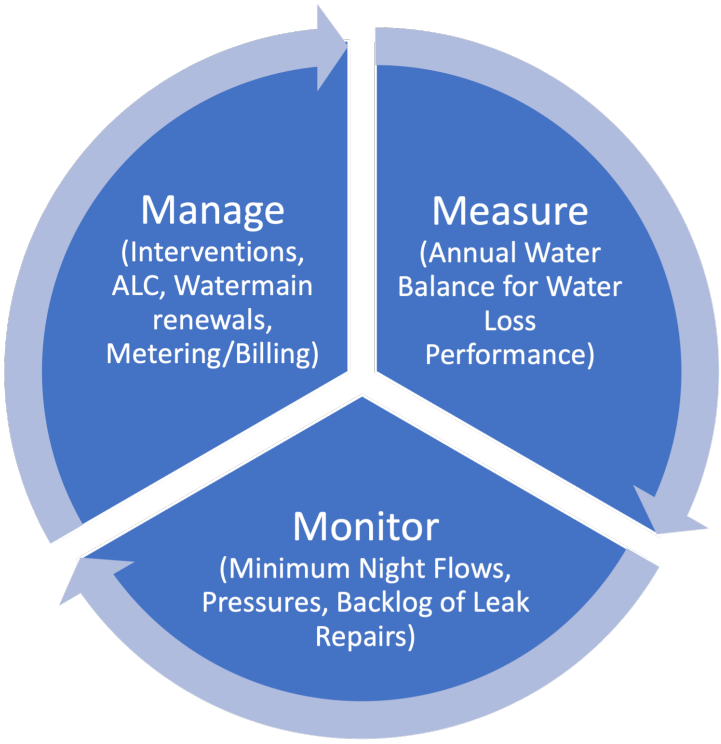

Figure 2: Water loss management overview

- **Measure:** The annual water balance is the recognised way of calculating the level of water losses in a network. This is a 12-month volumetric calculation where the volume of each component of the water balance is determined with varying levels of confidence. A 12-month calculation provides the big-picture of where every m3 of water leaving the water treatment plant is used. The current annual volume of real water loss (CARL) is therefore established, and water loss performance indicators as outlined above can be calculated for the network. Satisfactory metering of system input volume is essential for calculating a water balance.
- **Monitor:** Obtaining annual results for the level of water loss is unsatisfactory when it comes to maintaining or reducing the level of real water losses. The latter is best achieved by monitoring data at least weekly which reflects the current levels of water loss in segmented parts of the network. Network sectorisation and the monitoring of minimum night flows (MNFs) (or monitoring daily volumes where MNFs are not meaningful) is a proven method and a key aspect of managing real water losses. Monitoring supply pressures, pressure transients and any backlog of leak repairs are also important.
- **Manage:** The information gained from the annual water balance and weekly network monitoring provides the opportunity to manage real water losses. One option is to take no action in which case water losses will invariably rise. The latter is commonly referred to as the natural rate of rise of leakage and is particularly evident in networks with infrastructure in poor condition.

E. Four main components of managing water loss

The four main components of managing water loss from (public) water supply networks, recognised internationally, are shown in Figure 3.

The yellow rectangle represents the current level of annual real losses (CARL). The blue rectangle is the theoretical level of unavoidable annual real losses (UARL) for the system, which is a theoretical calculation of what water losses levels can be achieved (at the current pressure) with advanced water loss management. The ratio CARL/UARL is called the Infrastructure Leakage Index (or ILI) and is a good performance indicator for comparing real losses between water suppliers both nationally and internationally.

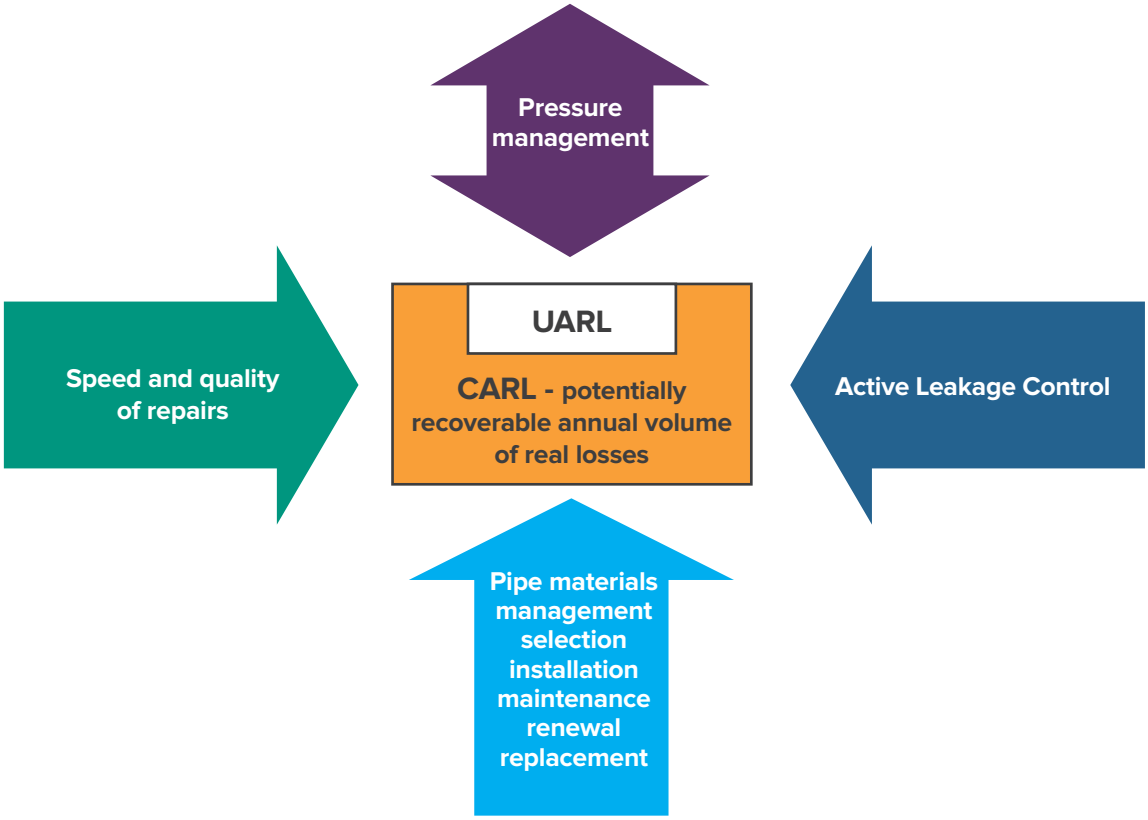

Figure 2: The four complementary leakage management activities

All four components are important and should all be considered as concurrent means of reducing the volume of real losses from a network. Ignoring any one of these components can lead to very poor outcomes.

Detailed information on the concepts and theory behind these four components can be found in *Water Loss Guidelines Technical Guidance Note 2*. Brief explanations of each component follow.

Speed and quality of repairs

The speed and quality of leak repairs impact the level of real water losses. All leaks must be repaired promptly and effectively. Leaks left to run result in larger volumes of water loss. Poor workmanship can also result in repeat failures and additional water loss, so ensuring quality materials and good workmanship is important. Where resources for leak repairs are constrained, leaks should be evaluated, and repairs prioritised to minimise the overall volume of water lost.

Pipe management

A holistic approach to renewals planning and network design is needed, to manage network pressure, improve the reliability of pipes and joint systems, and improve the installation techniques for pipes to enable these assets to perform throughout their asset life.

A renewals programme that includes condition and performance as criteria will ensure old pipes and materials that are more susceptible to leaks will be prioritised for replacement. Asset management provides a pivotal role in managing real water losses over the longer term to target areas of the network with high levels of background leakage and to ensure:

- Asset performance data is captured, such as break history, cause, etc.
- Design and standards are appropriate i.e., the use of high-quality materials and fittings.
- Quality standards are met during the construction phase.

Active Leakage Control (ALC)

Leaks in the public water supply systems need to be located and repaired on an ongoing basis, as leaks continually develop over time. Failure to do this will result in increasing real water losses. Larger leaks are generally noticed by members of the public and reported to the council for repair. Small and large leaks also occur which are not noticed or reported by the public, these are known as unreported leaks. It is the cumulative effect of unreported leaks that contributes mostly to overall real losses from the water network.

A proven method of cost-effectively and promptly identifying areas with high leakage, and thereby managing real losses to acceptable levels long term, is to monitor minimum night flows (MNFs) in water supply zones and district metered areas (DMAs). ALC can then be employed efficiently in specific areas where the leakage is known to be high based on the monitoring. Sectorisation of the network into zones of between 500 and 1,500 connections is an efficient means of monitoring and thereby managing real water losses in a water supply network.

There are also new technologies available for monitoring leaks and pipe breaks/water loss. This includes the use of acoustic loggers permanently or temporarily employed, which is now considered common practice, and the use of virtual DMAs with metered boundaries.

Pressure management

The double-headed ‘pressure management’ arrow in Figure 3 indicates that real water losses will both increase or decrease depending on whether supply pressure is increased or decreased.

There is a direct correlation between supply pressure and leakage rates from water supply networks, and therefore pressure management is a valuable tool for reducing water losses where there is the excess water pressure in the network. Pressure reducing valves (PRVs) with varying levels of control and automation can be used to reduce supply pressures from existing levels, and thereby reduce levels of leakage across the network with beneficial results. Pressure management may impact fire protection systems and affect hydrant fire flows hence any reduction in supply pressures needs to be carefully considered and managed. Water suppliers are however only required to provide agreed levels of service for flow and pressure, and can take steps to address anomalies associated with specific properties.

Pressure transients are sometimes present in networks and may damage the network causing increased leakage. Monitoring and managing pressure transients is also important.

F. Water loss strategy

Ideally, a water loss strategy is developed which encompasses all four main components of managing real losses, with associated budgets and funding requirements, and with a long-term target in mind. This strategy can then be linked to water resource and demand management plans.

Proactive options include the use of threshold or trigger levels based on MNFs for individual zones or DMAs; action (in the form of ALC) is only taken if an MNF exceeds the trigger level set for the DMA or zone. Additional measures such as targeted water main renewals within specific DMAs or zones may also be called for. Implementing network sectorisation (to create DMAs) requires a budget as does the ongoing monitoring, ALC, and leak repair works, and so an ongoing adequate budget is required to manage real losses in this way to achieve long-term goals.

Overall sustainable economic levels of leakage (ELL) for a network can be considered.

The need to reduce water losses will vary between networks depending on Te Mana o te Wai considerations, and the drivers and business case to reduce overall water demand.

Other important aspects of managing water loss include specifications and performance measures for leak response and repair, ensuring the overall condition of the water network is maintained or improved (achieved by ensuring an adequate and appropriate water main renewals programme), managing customer water metering (inventory and meter reading/billing cycles), and ensuring network monitoring meters and pressure control equipment is maintained properly.

Ensuring there are adequate resources and budgets assigned to water loss management is also a management task.

A recommended initial approach for those starting on this journey is to follow the steps shown in Figure 4. After an assessment of the current level of real losses has been made, a review of the status of all facets of water loss management, including an assessment of risks, is undertaken which then informs a water loss strategy.

Figure 4: Recommended initial approach

G. What does a well-managed network look like?

This is a good question and the answer will likely depend on numerous factors such as raw water supply availability, supply risk, network capacity, network risk, environmental factors, the size/scale of the network/supply, resource consenting factors, economic factors, political influences, and so on.

One essential factor will be that real water losses will be at a reasonable level. As one water authority's CEO said: 'If you manage water losses well, you manage the water network well'.

Managing water losses well requires the following:

1. Good asset management practices – ensuring the network is in good condition
2. Good maintenance practices – water main faults are repaired promptly and properly
3. Good customer metering and billing systems.
4. Good monitoring and management of water use/ demand.

It is possible to assess what a reasonable level of water loss for a network might be in the New Zealand context. Table 1, showing World Bank Institute (WBI) Bands based on ILI ranges, gives some guidance on this matter. This is relevant for large urban networks. However, this is a very generalised approach, and depending on the value of water, a water supplier may need to further reduce the level of water loss to give effect to Te Mana o te Wai, even if the current ILI is less than 2.0.

Developed Countries ILI range	BAND	Calculated ILI for this System	General description of Real Loss Management Performance Categories for Developed and Developing Countries
Less than 2	A		Further Loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost-effective improvement
2 to < 4	B	2.3	Potential for marked improvements; consider pressure management, better active leakage control practices, and better network maintenance
4 to < 8	C		Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensity leakage reduction efforts
8 or more	D		Very inefficient use of resources; leakage reduction programs imperative and high priority

Table 1: General description of meaning of World Bank Institute Bands A to D (Source: CheckCalcsNZ 2008)

The size of the network tends to be a factor in managing real water losses as larger urban centres generally have higher connection density, scale, and resources and manage real losses down to lower levels than smaller towns.

In a small town reducing real losses down to low levels does not result in significant volumes of water saved. For example, 5,000 connections x (200-140) litres/conn/day = 300m3/day or 3.5 litres/sec, and the cost to achieve and maintain the lower leakage level may be uneconomic. However, where consent limits and/or availability of water are significant issues, then lower long-term target levels will likely be appropriate.

Appropriate long term targets for New Zealand

As a guide, the ILI set out in the following table for various networks can be considered appropriate long-term targets or acceptable levels of water loss for water networks in New Zealand.

Table 3: Showing appropriate long-term targets/acceptable levels of real water losses in New Zealand

Size of Network	Fully Metered System	Partly Metered System (residential properties unmetered)	ILI
Small town	Up to 180 litres/conn/day	Up to 200 litres/conn/day	Up to 3.0
Medium town/city	Up to 160 litres/conn/day	Up to 180 litres/conn/day	Up to 2.5
Large city	Up to 140 litres/conn/day	Up to 160 litres/conn/day	Up to 2.2
Major city	Up to 120 litres/conn/day	Up to 140 litres/conn/day	Less than 2.0

Note: For this table, the serviced population figures are: small - less than 5,000; medium - 5,000 to 40,000; large - 40,000 to 100,000; major - over 100,000.

These targets need to be set within the context of the existing system, the current nature of the network, and the rate of renewals. Setting interim targets over a timescale is recommended for networks that require significant investment, to enable improvement to be tracked over years. In setting interim targets, it would be valuable to refer to the leakage journeys of other comparable towns and cities. Data on current network performance can be found in the relevant Water New Zealand National Performance Review dataset.

The slightly higher figures for partly metered systems reflect the greater difficulty in purposing real losses in partly metered systems. This raises the important and potentially significant matter of understanding the level of private leakage, or customer-side leakage occurring on unmetered properties. The international data indicates average underground service pipe (UGSP) leakage for unmetered properties is around 35 litres/connection/day, and this data is used to currently assess UGSP leakage in New Zealand. Actual levels of UGSP leakage in older towns and cities may be significantly higher, and further work and data are required to better understand this component of private consumption.

The *Water Loss Guidelines Section 3* provides greater context in terms of developing an appropriate target level of water loss for a particular water supply network.

H. Levels of maturity for various aspects of water loss management

The water loss management maturity guidance is intended to assist water network operators to identify where they 'sit' in terms of their current practices, and what an improved situation might look like or require.

A high level description of what constitutes basic/core, intermediate and advanced practices is set out in Appendix A. A much more detailed table is provided in the *Water Loss Guidelines Technical Guidance Note 1*.

I. What are the priorities for managing real water losses

Starting from a basic position, the following are considered to be the starting points and initial priorities for managing real water losses.

Water balance

The priority is being able to calculate a water balance for the network with an acceptable level of uncertainty.

Essential:

1. A water meter (or meters) records the flow of treated water into the water supply network. Having the meter connected to SCADA (Supervisory Control And Data Acquisition system) is not essential if weekly or monthly meter readings are being taken.
2. Customers with high water use are metered, and meter readings are taken at least annually near the start/end of the financial year.

Preferred:

1. Daily water use data is available (ex SCADA) for the system input meter(s).
2. The system input meters are appropriately sized and provide an accurate measure of system input volume.
3. All non-residential customers are metered and meters are read and billed for at least four-monthly.
4. Accurate GIS data (length of water mains), number of connections, and average system pressure for calculating water loss performance indicators.

Leak detection and repair

The second priority (assuming real water losses are high) is to arrange for leak detection across the network, and for all leaks identified to be repaired promptly. There may be some long-standing large leaks that can be located and repaired, resulting in a significant reduction in water use. A system to record, dispatch, monitor, and track leak repairs through to completion is required.

Network conditon

The third priority is ensuring that the water network is in good and improving condition. Old corroded water mains will continue to leak and leak at higher rates in the future. The only solution to reduce leakage significantly where they are assets in poor condition i.e. have a high burst frequency is to renew these water mains.

Essential:

1. Commence replacement (or relining) of old corroded and leak-prone water mains (such as cast iron mains with poor joints, galvanized steel watermains pre-1980, alkathene watermains pre-1990, early PVC watermains (pre-1975) etc., and continue until they represent a very small proportion of the network.
2. Ensure that the watermain renewal programme is at an appropriate level in the decades ahead and that sufficient priority is being given to replacing water mains with high leakage risk based on age, material, condition assessments, and performance, etc.

Monitor

The fourth priority is being able to monitor MNF for the network so that basic water loss management can be carried out continually e.g. 'week-to-week' across a DMA / network.

Essential:

1. A water meter (or meters) recording accurately the flows of water into the water supply network from reservoirs (or direct pumping into a closed network), and 15 min data (or more frequent) being available for monitoring using the SCADA system or dataloggers. These flows must show the 24-hour flow profile i.e. pumped flows into a reservoir are not satisfactory.
2. The flow profile of water use for customers with high water is also required, so the night flows from these high users can be deducted from the network MNF to provide a net flow MNF for the network.

Preferred:

1. Larger networks are sectorised so that residential areas are monitored separately from non-residential areas. This allows more precise monitoring. It is also preferable if monitored DMAs have fewer than 1,500 connections; ideally fewer than 1,000.

Active leakage control

The fifth priority is ensuring that there is a budget and resources to carry out ALC and effect leak repairs so that leakage is being brought under control.

The challenge from this point on is to grow in levels of maturity in all of the areas of water loss management as outlined in Appendix A and provided in much more detail in the *Water Loss Guidelines*.

J. Technical Resources

The following resources are available to support water network operators in all aspects of water loss management. Key resources, along with a brief description, are listed below. The guidelines and associated software can be found in the Technical Documents section of the Water New Zealand Resource Hub at www.waternz.org.nz/resourcehub.

1. **Benchloss NZ Manual and Software** This manual outlines the standard terminology and components associated with the IWA Standard Water Balance, and details the recommended performance indicators which should be used to best represent the level of real water losses from a water supply network.

   The software allows the user to input values and 95% confidence limits for the known components of the water balance, and the software then calculates the volume of real water losses along with the resulting level of uncertainty (95% confidence limits). The recommended performance indicators are also calculated for the water network, and there are graphs that provide a comparison of the water loss from the subject water network with others in New Zealand.

   New software tools (spreadsheets) for assisting with water balance calculations (Snapshot ILI MNF Calculations and Winter Water Use Analysis) are now provided alongside the Benchloss software. The Section "Assess Billed Unmetered Consumption" of the guide outlines the available tools in further detail.

   The CheckCalcs software, also available from the Water New Zealand Technical Library provides a more streamlined version of the Water Balance and PI calculations.

2. **New Zealand Water Loss Guidelines.** These guidelines are a toolbox of information, processes, information, guidelines, etc. to assist water network operators to calculate and manage the level of real water losses in their network(s). The main sections of the Guidelines are as follows:
   - Levels of water loss maturity, and how to navigate these guidelines
   - Building the business case for reducing real losses – the drivers
   - MEASURE – calculating a water balance – practical guide
   - Uncertainties with the water balance calculations (and how to reduce these)
   - Current water loss performance in New Zealand
   - MONITOR – network and water loss monitoring
   - MANAGE – water loss management
   - Smart metering guidance and practical suggestions
   - Additional resources
   - Further work/Initiatives identified

3. **IWA Standard Definitions for Water Losses.** David Pearson (Nov 2019) is available from IWA Publishing.

K. Acknowledgments

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APPENDIX A – BASIC DESCRIPTION OF WATER LOSS MATURITY

	Description	Basic/Core	Intermediate	Advanced	Water loss guidelines section
FOR WATER BALANCE CALCULATIONS	Ability to carry out robust water balance calculations	System input volume is unavailable or unreliable due to the absence of, or inaccurate meter(s)	System input volume is reliable but no SCADA Data is available	System input volume is reliable and SCADA data is available	3.2.1
	Billed metered consumption (over the 12-month water balance period)	Infrequent customer meter readings (i.e., annual or six-monthly) and using manual (hard copy) meter reading sheets.	Six-monthly meter reading and billing, plus monthly accounts for high water users.	All meters are read and billed either two-monthly or monthly using digital handheld devices for meter reading and/or smart meters.	3.2.2 7.9
	Customer water meters	Customer meters are very unreliable and likely to be inaccurate.	Customer meters are quite unreliable and may be inaccurate.	Customer meters are mostly accurate and well-maintained.	3.2.2 7.9
FOR WATER LOSS PIs	System parameters (i.e., length of mains, number of connections, average system pressure)	GIS is not up-to-date and does not show all water mains and connections. Uncertain data.	GIS is up-to-date and accurate, showing all water mains and connections.	GIS is up-to-date and accurate, showing all water mains and connections.	3.3.2
FOUR MAIN COMPONENTS OF MANAGING REAL LOSSES	Speed and quality of repairs	Leaks are not repaired promptly (often takes days or weeks to repair).	Leaks are repaired in a timely manner (generally within 12-24 hours).	Leaks are fixed in a very timely manner (generally within 4-6 hours).	6.4 TGN 2 (a)
	Network composition and condition – general	The network is in a poor condition with predominantly old water mains likely to be leaking.	The network is in an 'average' condition with numerous old water mains likely to be leaking.	The network is in very good condition with a low percentage of old water mains likely to be leaking.	6.5 TGN 2 (b)
	ALC - network monitoring	No regular monitoring of water use.	Infrequent monitoring of water use.	Regular (at least weekly) monitoring of water use and flow rates.	3.3.3, 6.1-6.4, 6.7 TGN 2 (c) TGN 3
	ALC – Leak detection and repair	No ALC is undertaken except in an emergency.	Occasional use of ALC on an 'ad-hoc' basis.	Frequent and effective use of ALC (and as part of a demand management strategy)	5.1 - 5.4, 7 TGN 2 (c) TGN 8
	Pressure management – general	High operating pressures (>65m average supply pressure). No attempt has been made to manage supply pressures.	The average supply pressure is less than 60m, with some pressure management in place.	The average supply pressure is less than 50m, with appropriate pressure management in place.	6.8 TGN 2 (d)