ONTARIO CENTRE FOR MUNICIPAL BEST PRACTICES

200 University Ave., Suite 801, Toronto, Ontario, M5H 3C6

BEST PRACTICE SUMMARY REPORT

February, 2008

Water and Sewer

GENERAL WATER LOSS MANAGEMENT

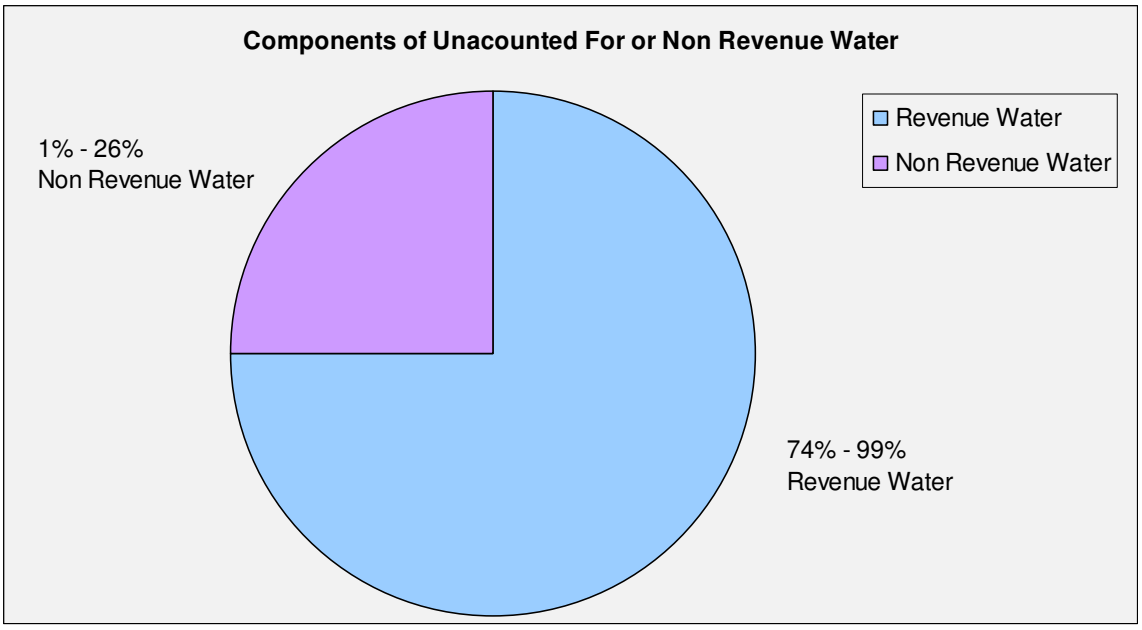
The 2007 OMBI business question sought to answer the following questions pertaining to water loss management:

- Can OMBI Municipalities estimate and quantify actual non-revenue water use in the categories referenced in the IWA Water Loss Management documents such as, watermain breaks, hydrant flushing, public works operations, fire fighting, meter errors, un-metered water and leakage?
- What are the estimated annual operating costs associated with water loss due to leakage for water distribution systems and water treatment systems?
- Is the adoption of the IWA Water Loss Management Performance Measure which expresses estimated water losses due to leakage in Litres per Connection per Day appropriate for adoption by the OMBI Water & Wastewater Expert Panel?

Currently the Ontario Municipal CAO's Benchmarking Initiative (OMBI) has a core framework measure for "Percentage of Water Unaccounted For" which is derived as follows:

- **% of Water Unaccounted For = [(Megalitres Water Treated – Megalitres Water Billed) / (Megalitres Water Treated)] * 100%**

As indicated in the figure below, the performance measure % of water unaccounted for simply compares revenue and non-revenue water.



Utilizing the above performance measure records, unaccounted for (or non revenue) water estimates range from 1.3% to 25.5% based on 2006 data for OMBI municipalities. The OMBI Water and Wastewater Expert Panel recognize that the use of percentages as an indicator of water loss within a system is misleading as a performance indicator. While it is intuitively understandable to express the amount of water lost within a system as a percentage of the total water input, it does not allow for sensible comparison between systems with different demands varying supply pressure and infrastructure, and is not suitable for use as a performance target.

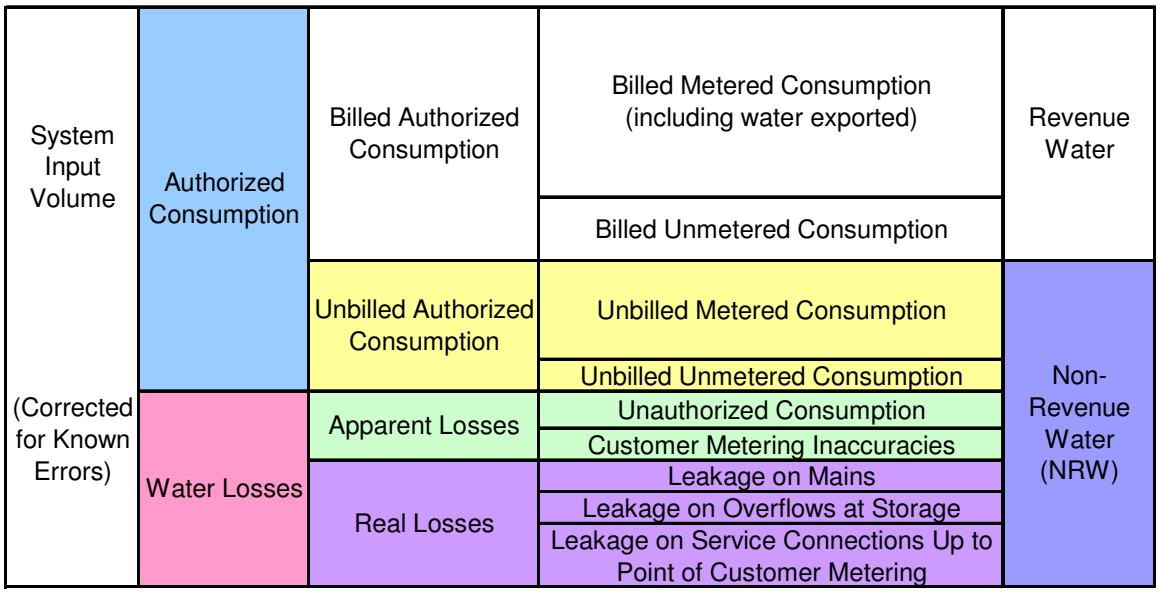
The more water a municipality sells the less unaccounted for water they will report; percentages don't represent the significance of the volume of water lost. When percentages are used for comparison between municipalities, there is another discrepancy in the fact that consumption can vary with climatic conditions or water use patterns. The percentage values depend on consumption and therefore a change in consumption can decrease the percent of lost water although the amount of water lost may have not changed. Consequently, using a percentage of input measure gives a false impression of true performance when a comparison is made with a system with a lower demand. It should also be considered that when using percentages, targets set to reduce the amount of water loss cannot be achieved with certainty.

International Water Association Water Loss Methodology

The International Water Association (IWA) has produced a 'best practice' standard approach for water balance calculations and the estimation of water losses. This approach is also advocated by the American Waterworks Association (AWWA) through both their Water Loss Control Committee and Manual M36 "Water Audits and Leak Detection". It is also advocated by InfraGuide in their best practice document "Water Use and Loss in Water Distribution Systems." As such, the OMBI Water and

Wastewater Expert Panel investigated this approach through their business question for the appropriateness of employing the Water Loss methodology in their annual performance measurements.

The IWA 'best practice' standard water balance is presented in the figure below:



IWA 'Best Practice' Standard Water Balance

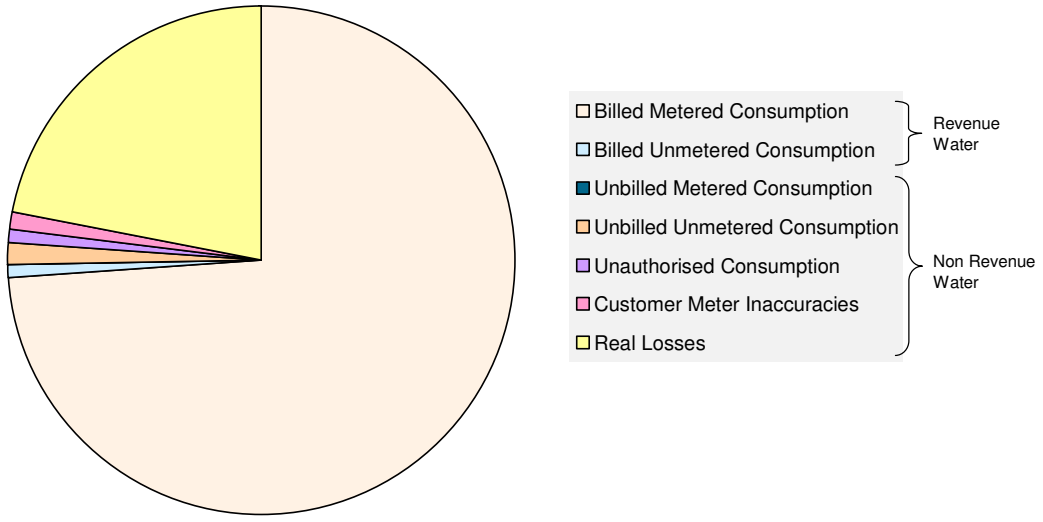
A table of definitions for the water balance components is presented below;

Billed authorized consumption (metered & unmetered)	Sum of Volume delivered to residential customers and Volume delivered to ICI customers. It represents the sum of all billed consumption from both metered and unmetered sources. The billed metered consumption includes all groups of customers such as domestic, commercial, industrial or institutional. The billed unmetered consumption includes all billed consumption which is calculated based on estimates or norms but is not metered.
Total non-revenue water volume	Quantity of water that does not provide any revenue to the utility. NRW= Total volume delivered from the treatment plants – Billed authorized consumption.
Unbilled metered volume	Metered Consumption which is for any reason unbilled. This might for example include metered consumption of the utility itself or water provided to institutions free of charge.
Unbilled unmetered volume	Any kind of Authorized Consumption which is neither billed nor metered. This component typically includes items such as fire fighting, flushing of mains and sewers, street cleaning, frost protection, etc. In a well run utility it is a small component which is very often substantially overestimated.

Apparent losses volume	= unauthorized consumption + meter under-registration + data handling errors Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal use). NOTE: Over-registration of customer meters, leads to under-estimation of Real Losses. Under-registration of customer meters, leads to over-estimation of Real
Real losses volume	Physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer consumption. In metered systems this is the customer meter, in unmetered situations this is the first point of consumption (stop tap/tap) within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows. May also be called leakage.

As shown in the figure below, the IWA Water Balance breaks out the component of water consumption and loss further than the performance measure "Unaccounted for Water."

Components of IWA Water Balance



Best Practice Performance Measurement

One common approach to unitize the amount of water lost in a system is to divide it by the length of mains in the system, or by the number of service connections served by the system. The performance indicator "L/service connection/day" is considered the most reliable of the traditional performance indicators for all systems with service connection densities of >20/km. If the system has a service connection density <20/km, the preferred performance indicator is m^3/km/day.

The international best practice performance measure advocated by the IWA (and the AWWA) is the Infrastructure Leakage Index (ILI). The Infrastructure Leakage Index is the ratio of current annual real losses (CARL) to the unavoidable annual real losses (UARL), and measures how well the system is being managed for control of real losses.

- **Current Annual Real Losses (CARL)** - Physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer consumption.
- **Unavoidable Annual Real Losses (UARL)** - The UARL is a theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. It is a key variable in the calculation of the Infrastructure Leakage Index (ILI). It is not necessary that water utilities set this level as the target level of leakage, unless water is unusually expensive, scarce or both.
- **Infrastructure Leakage Index (ILI)** - The ratio of the Current Annual Real Losses (Real Losses) to the Unavoidable Annual Real Losses (UARL). The ILI is a highly effective performance indicator for comparing the performance of utilities in operational management of real losses.

Four technical performance categories have been proposed for ILI values from developed countries by the IWA Water Loss Task Force1 as described below:

- ILI 1 to 2; Excellent – Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost effective improvement.
- ILI 2 to 4: Good – Potential for marked improvements; consider pressure management; better active leakage control practices and better network maintenance.
- ILI 4 to 8: Poor – Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensify leakage reduction efforts.
- ILI > 8: Very Bad – Very inefficient use of resources; leakage reduction programs imperative and high priority

[1] Liemberger,R. and McKenzie, R. "Accuracy Limitations

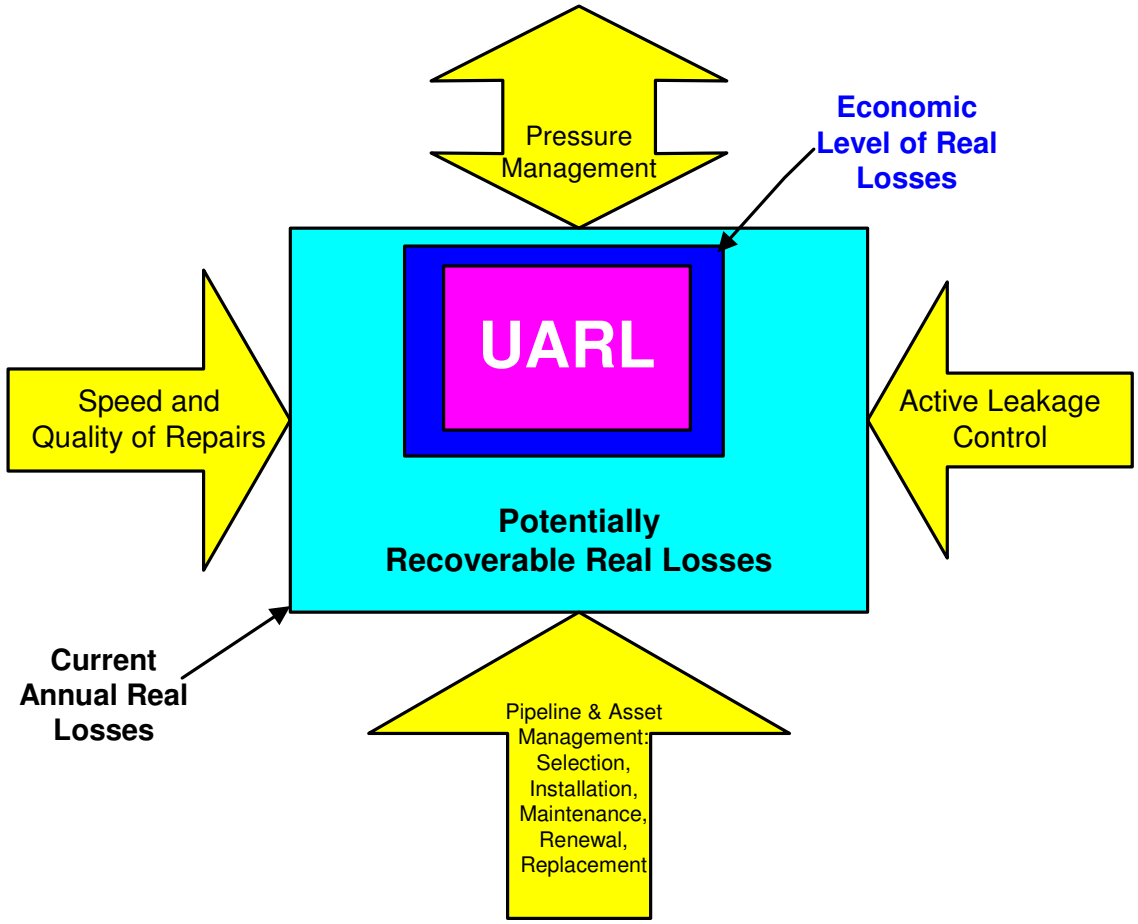
The ILI is a highly effective performance measure because it is:

- Based on a calculation that has been tested globally;
- Unit-less & based on real water loss;
- System specific – takes into account operating pressure, service connection length, pipe condition & meter location; and
- A measure that can be compared to an international data set

The ILI performance measure is recommended for systems with more than 5,000 service connections; 25m pressure and service connection densities greater than 20 connections/km. For system with a service connection density less than 20 connections/km, a more appropriate performance measure is real losses in m3/km mains/day.

Managing Real Losses

In the figure below, the components of determining ILI are demonstrated. As previously outlined, the ILI is the ratio of the current annual real losses (the large light blue square) to the unavoidable annual real losses (the small pink square) and is a measure of how well the four water loss reduction methods – repairs, asset management, pressure management and active leakage control – are being implemented.



The Four Basic Methods of Managing Real Losses[2]

An Infrastructure Leakage Index close to 1.0 may demonstrate that all aspects of a successful leakage management policy are being implemented by a water utility or that the distribution system is in excellent condition with very little water loss. Typically it will only be economical to achieve an ILI close to 1.0 if water is very expensive, scarce or both. Economic values of ILI typically lie in the range of 1.5 to 2.5 for most systems.

OMBI Municipalities Completion of Water Balances

Nine OMBI municipalities completed water balances as a component of the 2007 Business Question stage one questionnaire. While some municipalities have been completing water balances for a number of years, for some the IWA water balance methodology was a fairly new practice for accounting their water loss.

For all municipalities, the completion of the water balance clearly illustrates not only how much water is being lost in the system but also what information and data must be tracked to achieve an accurate understanding of water lost in the system.

[2] Fanner, P. "Assessing Real Water Losses: A Practical Approach" Water 21 Magazine, April 2004

The exercise of completing a water balance forces a review of,

- water production data;
- billing data; and
- data pertaining to authorized metered and unmetered consumption, such as hydrant flushing, fire fighting, and hydrant permit programs.

The water balance also requires a review of,

- apparent losses;
- meter inaccuracies; and
- the level of un-authorized consumption that could exist in the system.

The ultimate result is a much greater understanding of how much water is non-revenue water, how much is being lost, and an indication of how much effort is required to reduce water loss / leakage levels.

The Economic Level of Leakage (ELL) should also be considered by each municipality. This is the "sweet spot" that municipalities are aiming for, where water losses are reduced to the level where the cost of leak detection and reduction is no higher than the value of water saved. The ELL is different for each municipality and will depend on the cost of water to the distribution system and the balance of supply versus demand.

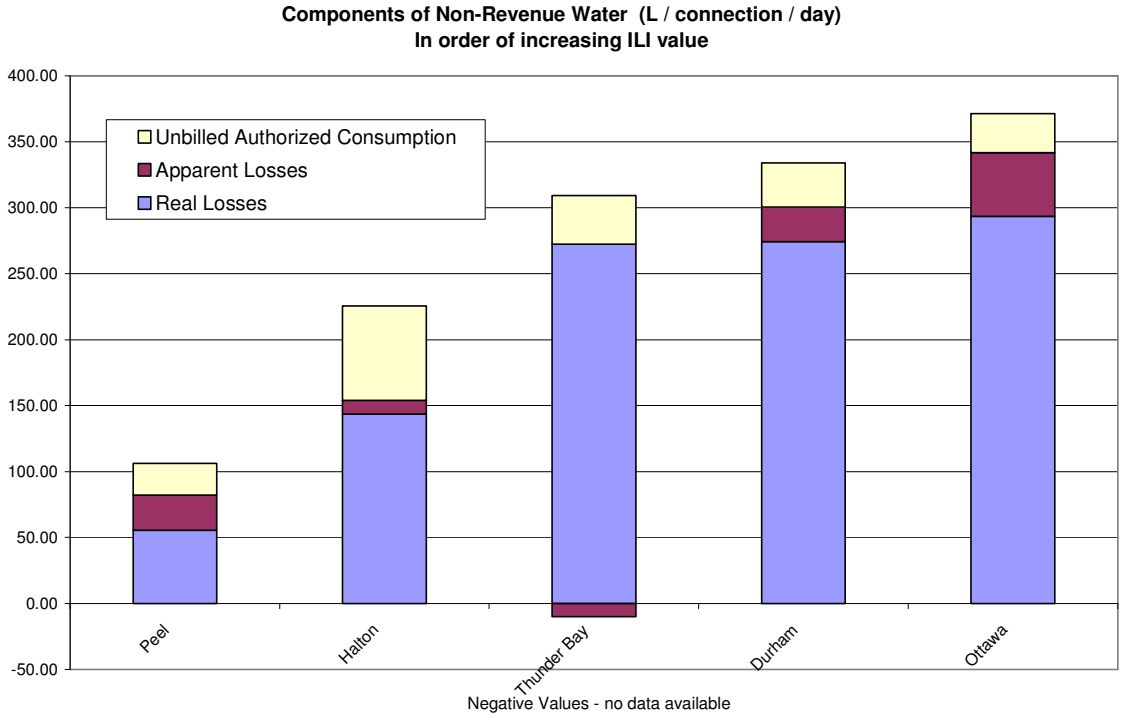
The unaccounted for water values reported by OMBI municipalities, based on 2006 data for the unaccounted for water performance measure, (range of 1.3% to 25.5%) can be translated into a volume of non-revenue water. The volume of non-revenue water ranges from as little as 448 ML to 43,017 ML per year. As an example, at a marginal cost of treatment of $\$0.07/m^3$, the 448 to 43,017 ML of non-revenue water can cost a municipality $31,360 to $3,011,190 per year to treat.

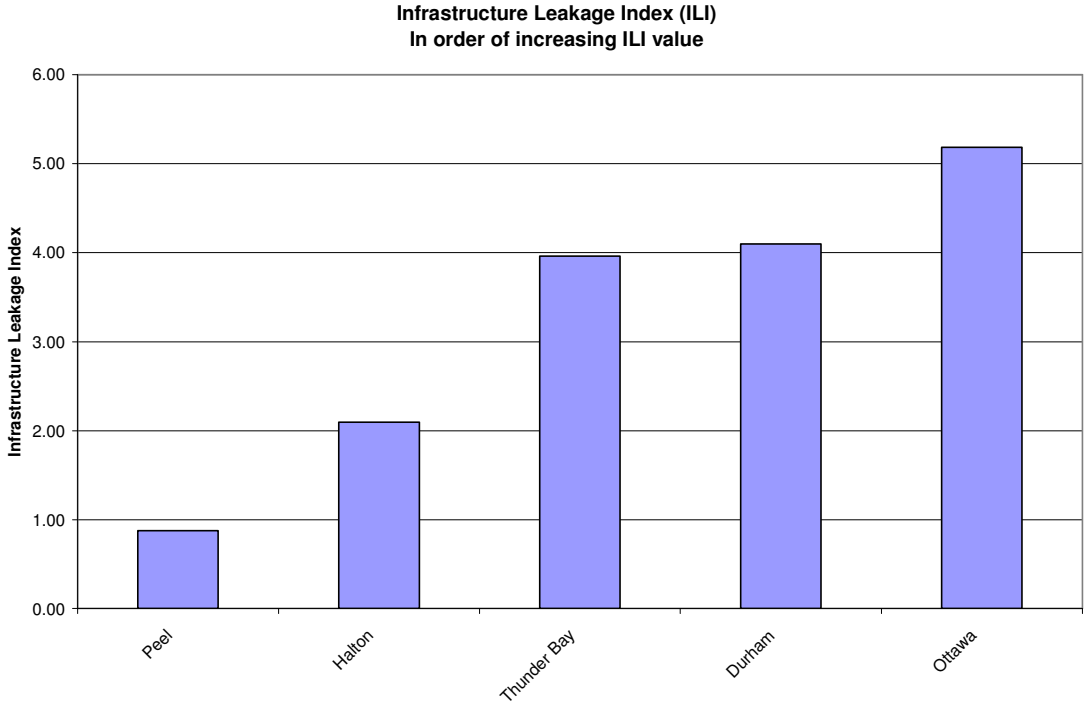
As stated above, the decision on the level of effort that should be applied to reduce water losses and non-revenue water will depend on each municipality's marginal cost of treatment (cost of chemical and pumping which represent the incremental unit cost of treating water). Water loss management can defer or eliminate the need for costly capital expenditures (reducing water loss should reduce the capacity constraints imposed on water mains and treatment plants). In addition, if significant portions of non-revenue water are resulting from customer meters under registering, this can greatly impact a municipality's water revenues.

While it is too early to accurately report the water loss performance measures for all participating OMBI members (ILI, water loss in L/Connection/Day or m^3/km/Day), the exercise was extremely valuable to all municipalities and sparked many discussions to help all municipalities move forward on tracking water losses and strategies to reduce water loss.

Water Loss performance measures for five OMBI municipalities (Regions of Peel, Halton, and Durham, and Cities of Thunder Bay and Ottawa) that have undertaken formal

water balances in addition to the water balance conducted for the 2007 business question are presented below.





The performance categories for the above ILI values can be found on Page 5.

Water Loss Management Case Studies and Best Practices

Although not all water loss management practices were selected for Case Studies and Best Practice Reports, many of the programs and practices discussed by the OMBI Water and Wastewater municipalities are examples of good day-to-day management practices that contribute to water loss management. The OMBI Water and Wastewater Expert Panel felt that it would be beneficial to report on all measures and practices that contribute to water loss management and that can be emulated by other municipalities.

The general purpose of these practices is to ensure that systems are maintained in good condition, and that measures are taken to reduce water losses in the system. This can be achieved either through operation and maintenance activities or other initiatives. Summarized below are some of the practices noted by the thirteen municipalities that participated in stage one surveys and/or stage two interviews.

Water distribution system maintenance and operation activities

- Cathodic protection program
- Maintaining an inventory of water distribution system and its deficiencies
- Identification and prioritization of replacements and repairs
- Addressing distribution system deficiencies through spot repairs, complete replacement, relining and hydrant repairs/replacement
- Preventative maintenance on distribution system components such as hydrants and valve assemblies
- Meter replacement programs
- Speed and quality water main break repairs
- Polybutylene service replacement program

Water distribution water loss investigations

- Acoustic leak detection
- Step testing
- Correlation studies to pinpoint localized leaks during main breaks
- Pressure analysis
- Hydraulic modeling
- Determination of the Infrastructure Leakage Index and corresponding volume of real losses
- Night flow monitoring using SCADA data and/or district metered areas

Municipal policies and procedures to control water loss

- Bulk water dispensing program and/or hydrant meter permit programs
- Municipal design standards/criteria such as requiring ferrous components of distribution system on new construction to be cathodically protected
- Water conservation program, promoting conservation through rebates for ultra low flow toilets, efficient washing machines, waterless urinals, rain barrels and water conservation kits.
- Decrease the unmetered use of water through metering
- Compare water billing accounts to see that they closely match other City databases

Continued Information and Data Collection and Performance Measurement

Information and data collection continues to be a key component of completing a water balance and identifying the levels and sources of water loss. For any initiative, it is necessary for improvement identification, supporting the need, and implementing improvement initiatives.

Moving forward, the OMBI Water and Wastewater Expert Panel has recognized and advocates the IWA and AWWA 'best practice' approach to water balance calculations and the estimation of water losses. The panel will develop and present a revised performance measure to stakeholders to replace the existing ("unacounted for water") performance measure.

For further comparisons, and perhaps more accurate comparisons, the following performance measures have been proposed:

- Real Losses (L/connection/day or m^3/km/day)
- Apparent Losses (L/connection/day or m^3/km/day)
- Unbilled Authorized Consumption (L/connection/day or m^3/km/day)
- Non-Revenue Water (L/connection/day or m^3/km/day)
- Infrastructure Leakage Index (ILI)

It is understood that these measures will require municipalities to undergo formal water balances and water consumption data each year, however, this information allows municipalities to benchmark their own performance over time in addition to performing comparisons with other municipalities both here in Canada and worldwide.