Special Council Meeting
AGENDA

Tuesday, May 28, 2019, 5:30 pm
Tecumseh Town Hall
www.tecumseh.ca

Pages

1. **Call to Order**

2. **Roll Call**

3. **Disclosure of Pecuniary Interest**

4. **Delegations**

   a. Phil Bartnik, Director Public Works and Environmental Services and Kingsley Blease, Consultant — 2

      Re: 2018 Water Audit and Water Balance

5. **Communications**

6. **Reports**

   a. PWES-2018-30 2018 Water Audit and Water Balance — 20

7. **Adjournment**

TOWN OF Tecumseh
ONTARIO · CANADA

2018 Water Audit and Water Balance

Presentation to Council
May 28, 2019

Background

- Water Audit & Water Balance approved as part of the 2019-2023 PWES Capital Works Plan
- Kingsley Blease Consulting and Watermark Solutions was retained
- Kingsley Blease professional engineer – 40 years experience, and has completed over 40 water audits
- IWA/AWWA Water Audit Best Practice Methodology (Water audit is for a full year's water use)
- Completed by April 2019, with full year 2018 data

Previous Water Audit in 2012

- Water system well managed with no excessive water loss issues
- Infrastructure Leakage Index (ILI) is Real Water Losses / Unavoidable Water Losses
- ILI in 2012 was 1.73
- Kingsley Ontario audits last 10 years averaged 3.7
- Non-Revenue Water (NRW – water loss and customer meter revenue loss) was 17.5%
- 40% of this NRW was auto flushers – needed to maintain water quality

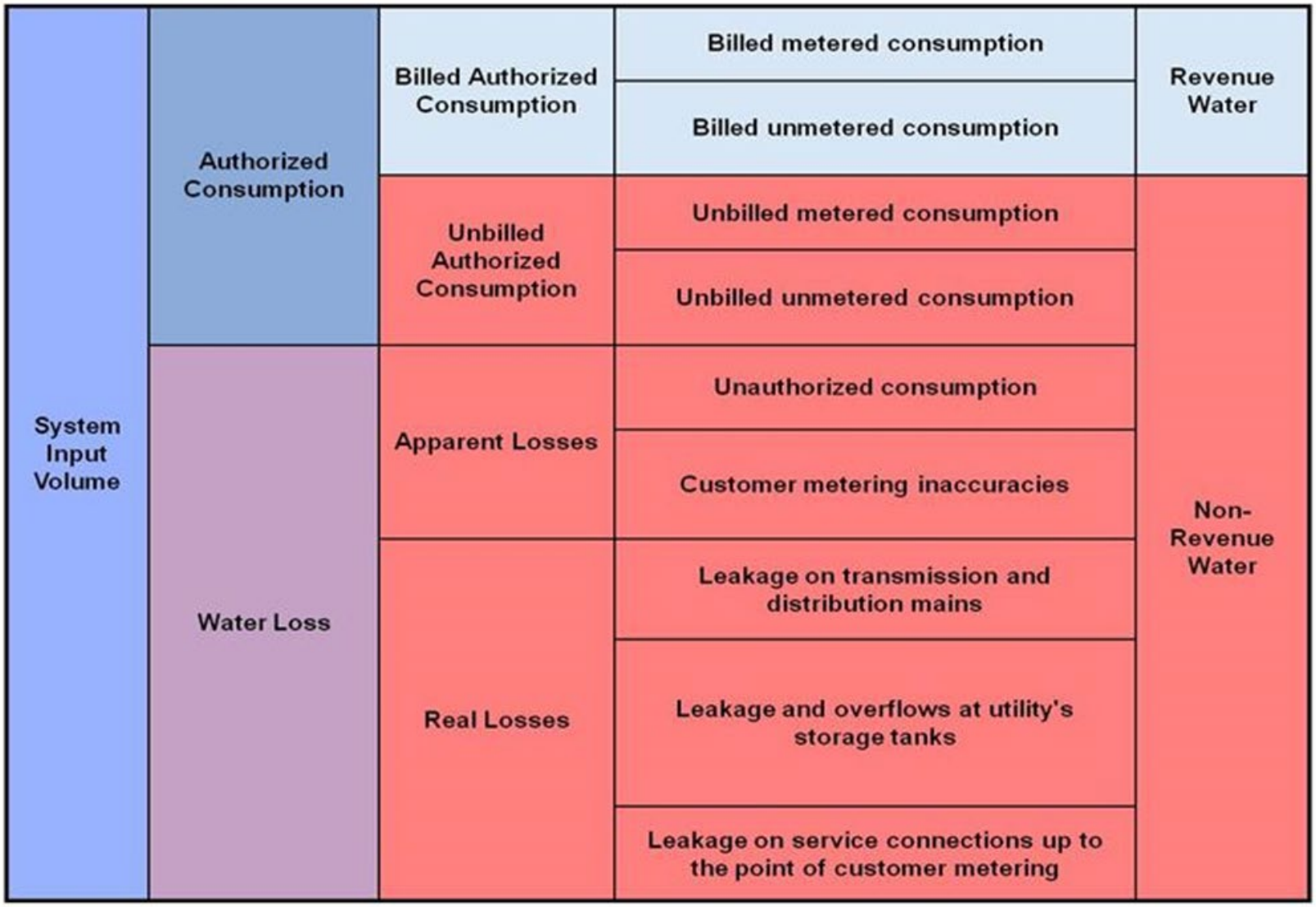
Improvements Completed since 2012

- Annual verification testing of boundary meters from Windsor
- Annual accuracy testing of small and large customer meters
- Final stages (95%) multi-year customer water meter replacement program
- Old customer meters under-register, causes loss in revenue (Apparent Losses)
- 2015 and 2018 sacrificial anode program for cast and ductile iron mains

Improvements since 2012 ….continued

- Reduced number of watermain breaks
- 41 breaks in 2014, down to 16 breaks in 2018
- Ongoing watermain replacement program
- 42.2 km of cast and ductile iron (19.6% of total 215 km)
- Last 6 years 7.5 km replaced – 17.8% of cast and ductile iron pipe

IWA / AWWA Water Audit



Water Audit in 2018 – AWWA Software

- Grading system for quality of data entered
- Score of 1 to 10 for each item of data (total 100)
- Overall score 61 out of 100
- Typical Ontario audits in 70 to 75 range
- Main recommendations are to increase quality of data for next year's audit

AWWA Software Results - NRW

	Volume (m3)	
Total Water Supplied	3,544,170	
Total Billed Metered Consumption	3,105,757	
Non-Revenue Water	439,413	12.4%
NRW Results Ontario range 11% to 34% Average 23%		

NRW Breakdown

	Volume (m3)	NRW %	Cost of NRW	Cost per m3
Unbilled Authorised	180,847	5.1%	$65,709	$0.40
Apparent Losses	31,846	0.9%	$75,290	$2.36
Real Losses	226,720	6.4%	$90,665	$0.40

Infrastructure Leakage Index (ILI)

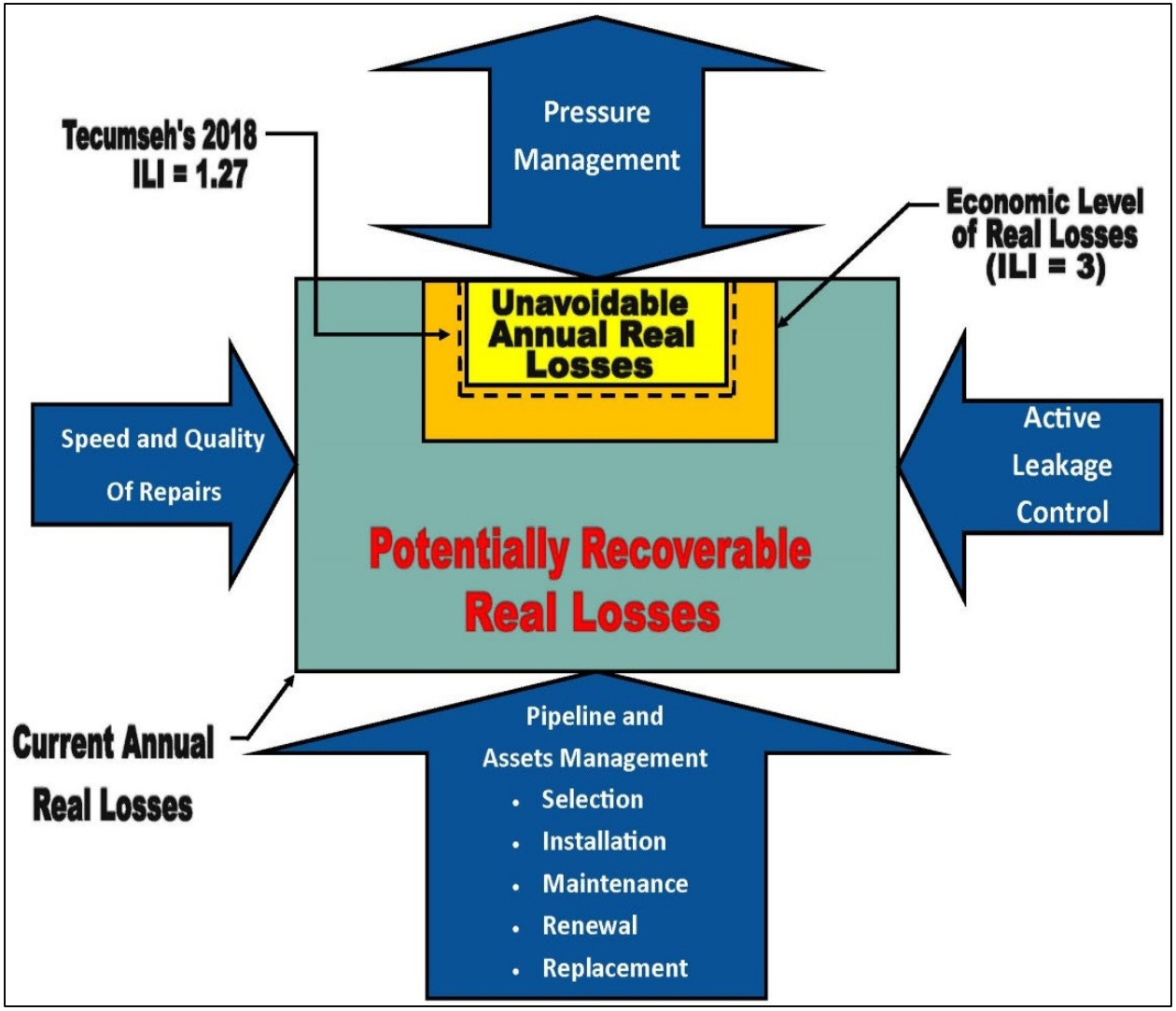
- Current Annual Real Losses (CARL)
- Unavoidable Annual Real Losses (UARL)
- Infrastructure Leakage Index (ILI)
- Tecumseh ILI = 1.27
- Ontario results ILI average 3.7 (range from 1.8 to 5.8)
- All performance indicators – low grading score (61/100); low NRW (12.4%); and low ILI (1.27)
- Indicates data needs to improve – main recommendations

Real Losses

- Unavoidable Annual Real Losses (UARL)
  - Represents the lowest loss technically achievable
  - In any water system there will be a volume of leakage that includes small leaks and weeps that are undetectable or not economic to find/repair.

Real Losses	Volume (m3)	NRW %	Rate ($/m3)	Costs
UARL	179,000	5.05%	$0.40	$71,582
Large Leaks & Breaks	47,720	1.35%	$0.40	$19,083
TOTAL	226,720	6.40%	---	$90,665

Four Pillars of Real Losses Reduction



2018 Audit Recommendations - 1

Windsor Utilities Commission Import Meters (mag meters)

- Currently verification test – transmitter test only, not the flow element. Standard Ontario practice
- Phased approach
- Review flow patterns – range meter operates
- Complete site accuracy testing
- If required, change flowmeter
- Town working to completing the testing in the Fall of 2019

2018 Audit Recommendations - 2

Town of Lakeshore Export Meters

- Three of four meters are mechanical (not mag)
- Mechanical meters do not record lower flows, accuracy deteriorates over time, do not record reverse flows
- Recommend change to electromagnetic (mag) meters
- Met with Town of Lakeshore who own and maintain meters – to be completed in the Summer of 2019.

2018 Audit Recommendations - 3

Union Water System Connections

- Two connections to Union Water System – for emergency use
- Increase information – data log water pressures for 7 days, both sides of closed valves
- Operate valves and flush water either side of valves on a regular basis
- Town staff will co-ordinate with Union staff in late 2019
- If connections part of new South system, consider regular / automatic flushing

2018 Audit Recommendations - 4

Customer Meter Testing

- Majority of customer meters changed in last 6 years
- Meters likely still very accurate
- When meters reach 10 years old, test a sample for accuracy, and any under-registration
- Repeat every 5 years, to track performance
- Also test larger meters on a regular basis, based on consumption
- Town exploring implementing these measures

2018 Audit Recommendations - 5

Number of Customer Billed Accounts, and Number of Customer Services

- Large difference between number of customer accounts from analysis of billing data (9,006)
- Compared to number of water services from Town's GIS mapping (7,928)
- Recommended find source of this discrepancy
- Town to schedule meeting with Essex Power Services to co-ordinate a review of the information
- To be completed by Summer/ Fall of 2019

2018 Audit Recommendations - 6

Unbilled, Unmetered Consumption

- Authorized use by the Town, traditionally not metered
- Includes hydrant flushing, auto-flushers, firefighting, etc.
- Town's Water Services, and Fire and Rescue, have already began developing recording sheets and Best Practices to measure this water
- Put in place now –improved data for the 2019 water audit

The Corporation of the
Town of Tecumseh

Public Works & Environmental Services

To: Mayor and Members of Council

From: Phil Bartnik, Director Public Works & Environmental Services

Date to Council: May 28, 2019

Report Number: PWES-2019-30

Subject: 2018 Water Audit and Water Balance

Recommendations

It is recommended:

That the Public Works & Environmental Services Report PWES-2019-30 2018 Water Audit and Water Balance **be received.**

Background

At the December 11, 2018 Regular Meeting of Council, Council approved the recommendations (Motion RCM-361/18) of PWES Report No. 2018-08 2019-2023 Public Works & Environmental Services Five Year Capital Works Plan that authorized Administration to proceed with the 2019 capital works projects, including the completion of a Water Audit and Water Balance on the 2018 water distribution system data.

The Town retained the services of Kingsley Blease Consulting and Watermark Solutions to complete the 2018 Water Audit and Water Balance, which followed the International Water Association / American Water Works Association (IWA/AWWA) Water Audit Best Practice Methodology.

Kingsley Blease is a professional engineer with over 40 years of experience in water and wastewater projects in both Canada and the United Kingdom. Mr. Blease has considerable experience over the last 35 years with water loss management. He has also completed over 40 IWA/AWWA Water Audit and Water Balances, and has been involved in active leak detection programs for utilities and municipalities of varying sizes. Mr. Blease was a member of the Ontario Water Works Association Water Efficiency Committee for 19 years, and was one of the founding members and first chair.

2012 Water Audit and Water Balance

The Town completed a Water Audit and Water Balance in 2012, which was received by Council at the November 25, 2014 Regular Meeting of Council (Motion RCM-452/14). The final report outlined the methodology, observations, results and conclusions of the 2012 Audit. The key conclusions consisted of:

- Based on the results of the 2012 IWA/AWWA Water Audit performed by Veritec, it can be concluded that the Town of Tecumseh water system is well managed and does not suffer from excessive water loss issues.

- Based on the AWWA table, the Tecumseh Infrastructure Leakage Index (ILI) benchmark of 1.73 for 2012 is well within the top tier representing a high level of excellence with respect to the management of real losses and indicating low leakage levels.

- Since the ILI has been calculated at 1.73 from the 2012 Water Audit, there is no economic justification to initiate a detailed leakage reduction program at this time.

- Although the level of Non-Revenue Water (NRW) may appear high at 17.5%, nearly 40% of the NRW volume is related to unbilled authorized consumption mainly related to auto-flushers which are required to maintain water quality.

Improvements Completed Since 2012

The Town of Tecumseh has completed a number of system improvements since 2012 and continues to strive for further enhancements. These water system improvements consist of:

- The Town currently retains Flow Metrix to provide annual detailed water meter verification for all boundary meters from Windsor, as well as other larger meters within the distribution system (i.e. Bonduelle meter, and Lakeshore boundary meters).

- The Water Services Division has developed an annual testing/calibration random sampling procedure for small and large water meters in 2015. This procedure tests random residential meter and larger water meters (i.e. bulk water filling stations) annually.

- The Town is in the final stages of a multi-year customer water meter replacement program with approximately 95% of the meters being replaced to date. It is well-documented that older meters often underreport water volumes and thereby contribute to the Apparent Losses calculation.

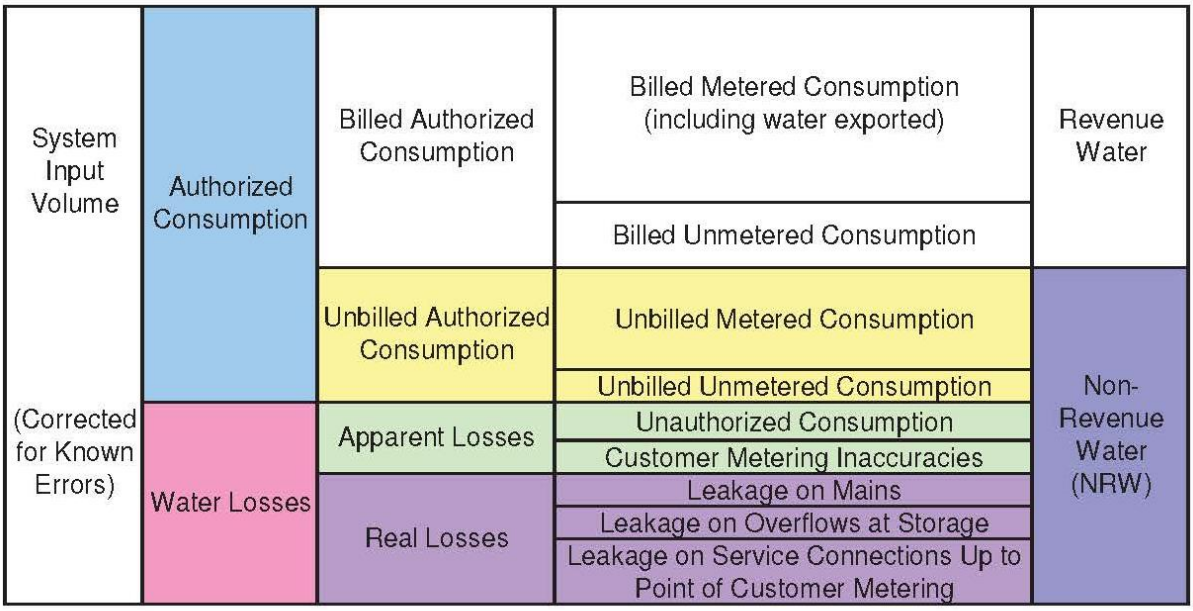
- The Town has installed sacrificial anodes on cast iron and ductile iron watermains as part of the 2015 & 2018 Anode Protection Programs. This has significantly reduced the number of watermain breaks since its inception in 2015:
    - **2014 – 41 watermain breaks (Prior to Anode Protection Program)**
    - 2015 – 23 watermain breaks, a 44% reduction from 2014
    - 2016 – 18 watermain breaks, a 56% reduction from 2014
    - 2017 – 11 watermain breaks, a 73% reduction from 2014
    - 2018 – 16 watermain breaks, a 61% reduction from 2014

- The Town continues with an ongoing watermain replacement program of cast iron and ductile iron watermains with new PVC watermains to reduce the risk of leaks and breaks within the system. Over the last 6 years, approximately **7.5 km** of varying sizes of watermains (100mm – 300mm dia.) have been replaced.
    - Ductile Iron and Cast Iron made up **42.2 km (19.6%)** of the total **215 km** watermains within the Town's system.
    - The **7.5 km** of Ductile Iron and Cast Iron replaced in the last six years represents **3.5%** of the total **215 km** watermains, and **17.8%** of the total **42.2 km** of Ductile Iron and Cast Iron watermains.
    - Currently, Ductile Iron and Cast Iron make up **34.7 km (16.1%)** of the total **215 km** watermains within the Town's distribution system.

Comments

The IWA/AWWA Water Audit is a tool available to North American water utilities for assessing the level of Non-Revenue Water (previously known as Unaccounted-for Water) and developing true performance indicators for international comparison and benchmarking with respect to Apparent Losses (metering) and Real Losses (leakage).

Completion of an IWA/AWWA Water Audit and Water Balance is an integral part of the water loss management methodology and is recognized as a best management practice under the **AWWA Manual of Practice** "**M36 Water Audits and Loss Control Programs**", which was originally published in 1991, with revisions occurring in 1999, 2009 and 2016. An IWA/AWWA Water Audit and Water Balance is recommended annually in order to assess water losses and gauge the performance of ongoing water loss reduction measures. The IWA 'best practice' standard water balance is presented in the figure below:



IWA 'Best Practice' Standard Water Balance

Understanding the Components to Non-Revenue Water (NRW)

NRW is the difference between Water Supplied (production volume) and Billed Authorized Consumption (metered and unmetered volumes). Calculating NRW is therefore relatively simple, however understanding the components that account for the volume of water determined as being NRW is often misinterpreted. There is a range of different types of NRW and Water Loss components that are common to all municipal water distribution systems, and have been summarized in the following three categories by the IWA/AWWA water audit methodology. Additional details can also be found in Attachment No. 2.

1) Unbilled Authorized Consumption – Metered or Unmetered
    a. Firefighting and training
    b. Flushing of mains and sewers, new construction
    c. Auto-flushers or blow-offs
    d. Street cleaning
    e. Parks irrigation

2) Apparent Losses
    a. Unauthorized consumption (i.e. theft)
        i. Illegal connections or water meter by-pass
    b. Customer metering inaccuracies – under/over registration of customers
        i. Older water meters tend to under-register with age
        ii. ICI meters are often oversized and under-register consumption at lower flows
    c. Systematic data handling errors
        i. Not opening a new account when required
        ii. Active accounts tagged as inactive, and not being billed
        iii. Identify inactive accounts with usage (occupied or vacant with leakage)
        iv. Misread meters
        v. Computer programming or billing software errors
        vi. Improper calculations or multiplier in billing software

3) Real Losses
    a. Leakage on distribution and transmission mains, including breaks
    b. Leakage and overflows at storage tanks
    c. Leakage on service connections up to the point of customer metering

2018 Water Audit and Water Balance – Results

The American Water Works Association (AWWA), Water Loss Control Committee (WLCC), in conjunction with the IWA, developed water audit software for use by Utilities across North America. The first version was produced in 2006, and the current version (version 5.0), was released in 2014 which was used for the Tecumseh 2018 Water Audit. The performance indicators produced by the software, coupled by the understanding of the operation of the water distribution system were used to develop recommendations and next steps for the Town to undertake.

The Audit identifies Revenue and Non-Revenue Water, the quantities of each, in terms of volumes of water, and costs (both operational costs to purchase water from Windsor Utilities

Commission), plus potential revenue losses from the customer metering and billing systems. In summary the NRW for the 2018 Audit is:

2018 Water Audit and Water Balance - Summary		
	(m^3)	
Total Water Imported from WUC	3,559,635	
Total Water Exported to Lakeshore	15,465	
Total Water Supplied	3,544,170	
Total Billed Metered Consumption	3,104,757	
Total Non-Revenue Water (NRW)	**439,413**	**12.40%**

In comparison, the NRW results of IWA/AWWA Audits completed by Kingsley Blease over the last 10 years in Ontario where the quality of data was good (in the IWA/AWWA software grading range of 75 to 80 out of a maximum score of 100), ranged from 11% to 34%, with an average of 23%.

The following discusses the components of the NRW for the 2018 Audit in greater detail.

1) Unbilled Authorized Consumption – Metered or Unmetered:

   For Canadian water utilities the volumes of Unmetered, Unbilled Consumption are usually of significant size, and frequently comprise of water used by the utility from fire hydrants, or bleeders / auto flushers from the water distribution system. This was found to be the case for the Town of Tecumseh, where the spring hydrant flushing program and auto flushers were estimated to be large volumes of water. The 2018 unbilled and unmetered water for the Town consisted of:

   - Firefighting and training
   - Hydrant flushing program
   - Flushing of mains and sewers
   - New watermain construction/commissioning of watermains and testing
   - Watermain repairs
   - Auto-flushers or blow-offs
   - Street cleaning
   - Water tower cleaning
   - Sampling stations

   The quantity and value of the water used is typically viewed as a necessity to maintain the water distribution system and to ensure adherence to the safe drinking water legislation. The following table details the associated NRW percentage and associated wholesale costs for water purchased for Unbilled Authorized Consumption.

Unbilled Authorized Consumption	Volume		Costs - Water	
	Volume (m^3)	NRW %	Rate [3] ($/m^3$)	Costs ($)
i) North Bulk Water Filling Sta.[1]	16,534	0.47%	$0.40	N/A
ii) New Watermains	618	0.02%	$0.40	$247.14
iii) Firefighting	1,743	0.05%	$0.40	$697.03
iv) Hydrant Flushing	86,817	2.45%	$0.40	$34,718.12
v) Auto-Flusher	65,617	1.85%	$0.40	$26,240.24
vi) Miscellaneous [2]	9,518	0.27%	$0.40	$3,806.25
Total	**180,847**	**5.10%**	**---**	**$65,708.77**

1) Revenue from the Filling Sta. used to offset the operating costs of PW bldg.
2) Water tower cleaning, street cleaning, sample stations, etc.
3) Wholesale Water Rate of $0.3999/$m^3$

2) Apparent Losses

There are three main sub-categories that make up Apparent Losses which consist of (i) Unauthorized Consumption, (ii) Customer Metering Inaccuracies, and (iii) Customer Meter Data Handling Errors.

(i) Unauthorized Consumption: The default estimate of unauthorized consumption (illegal connections or by-pass, i.e. theft) recommended in the IWA/AWWA Standard Water Balance is equal to 0.25% of water supplied which was utilized as part of the 2018 Audit.

(ii) Customer Metering Inaccuracies: Customer metering inaccuracies typically represent the largest component of Apparent Losses. In general, meter under-registration increases with meter age and/or the volume of water registered (i.e. mileage of the meter). For the 2018 Audit the auditor assumed the customer meters were under registering by 0.50% due to the age of the meters ranging being between 0-6 years.

(iii) Systematic Data Handling Errors: Although hard to determine the actual quantity, the auditor used the AWWA software default value of 0.25% of the billed volume.

The following table details the associated NRW percentage and associated lost water and wastewater revenues for Apparent Losses.

Apparent Losses	Volume		Costs - W&WW Revenues	
	Volume (m^3)	NRW %	Rate [1] ($/m^3$)	Costs ($)
i) Unauthorized Consumption	8,860	0.25%	$2.36	$20,946.81
ii) Customer Meter Inaccuracies	15,224	0.43%	$2.36	$35,992.58
iii) Systematic Data Handling Errors	7,762	0.22%	$2.36	$18,350.92
Total	**31,846**	**0.90%**	**---**	**$75,290.31**

1) A combined Water and Wastewater Rate of $2.3642/$m^3$

3) Real Losses

Current Annual Real Losses (CARL) is the physical water losses from the pressurized distribution system up to the point of customer consumption. CARL is calculated by subtracting the Authorized Consumption and Apparent Losses from the total non-revenue water.

- **CARL = Total NRW – Unbilled Authorized Consumption – Apparent Losses**

A component of CARL is the **Unavoidable Annual Real Losses (UARL)**, which represents the lowest loss technically achievable in a water utility based on its key characteristics. In any water system there will be a volume of leakage that includes small leaks and weeps that are either undetectable in practice or not economic to find and repair.

The IWA/AWWA software uses physical characteristics of water distribution system (length of watermains and services, number of connections, average pressure, etc.) to make an estimate of UARL. The UARL calculation is based on leakage data gathered from well-maintained and well managed systems worldwide, and was developed and tested by the International Water Association's Water Loss Task Force and published in 2000.

- **UARL (litres/day) = (18.0Lm + 0.8Nc + 25.0Lc) x P**
  - Lm = length of mains (miles or km)
  - Nc = number of customer service connections
  - Lp = the average distance of customer service connection piping (ft or m)
  - Lc = total length of customer service connection piping (miles or km)
    - Lc = Nc x Lp (miles or km)
  - P = Pressure (psi or metres)

The Infrastructure Leakage Index (ILI) is the ratio of CARL to UARL (**ILI = CARL/UARL**). The AWWA Manual M36 (Water Audits and Loss Control Programs), provides the definition of ILI as:

> "ILI is a performance indicator quantifying how well a water distribution system is managed (maintained, repaired, rehabilitated) for control of real losses (leakage) at the current operating pressure. Mathematically, it is the ratio of current annual real losses (CARL) to unavoidable annual real losses (UARL), or ILI = CARL/UARL. A low ILI value indicates that the water utility has managed its leakage down towards the UARL, or the theoretical low limit of leakage technically available."

The “Best Practice Summary Report: General Water Loss Management” completed for the Ontario Centre for Municipal Best Practices identifies that four (4) technical performance categories have been proposed for ILI values from developed countries by the IWA Water Loss Task Force as[1]:

- 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.

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

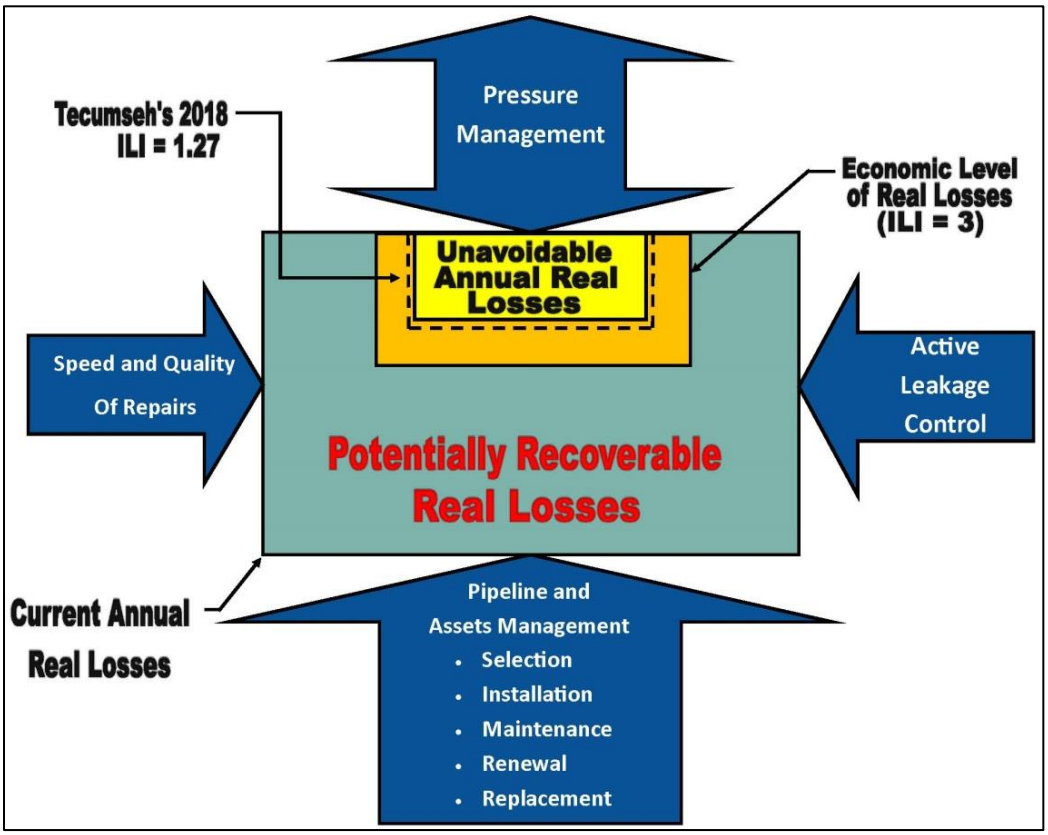
- Based on a calculation that has been tested globally;
- Unit-less and based on real water loss;
- System specific – takes into account operating pressure, service connections length, pipe condition and meter location; and
- A measure that can be compared to an international data set.

The Town’s ILI for the 2018 Audit is 1.27. In comparison, the ILI results of IWA/AWWA Audits completed by Kingsley Blease over the last 10 years in Ontario where the quality of data was good (in the IWA/AWWA software grading range of 75 to 80 out of a maximum score of 100), ranged from 1.8 to 5.8, with an average of 3.7.

An ILI close to 1.0 may demonstrate that all aspects of a successful leakage management policy are being implemented by a water utility or the distribution system is in excellent condition with very little water loss.

The figure below depicts the ‘Four Basic Methods of Managing Real Losses’, and identifies the CARL, UARL, and the Economic Level of Real Losses.

[1] Ontario Centre for Municipal Best Practices: Best Practices Summary Report, General Water Loss Management, February 2008 (which is now known as the Ontario Municipal Knowledge Network, launched in 2009 in partnership with Ministry of Municipal Affairs and Housing and the Association of Municipalities of Ontario)



The following table details the associated NRW percentage and associated lost wholesale water costs for Water Losses.

Real Losses	Volume		Costs - Water	
	Volume (m^3)	NRW %	Rate [1] ($/m^3$)	Costs ($)
i) UARL	179,000	5.05%	$0.40	$71,582.10
iii) Large Leaks & Breaks	47,720	1.35%	$0.40	$19,083.23
Total	**226,720**	**6.40%**	**---**	**$90,665.33**

1) Wholesale Water Rate of $0.3999/$m^3$

To put the data in the above table into perspective, the value of Real Losses that the Town would be able to detect and improve upon ($19,083.23) is **0.38%** of the Total 2018 Water Revenues ($5.06M).

2018 Water Audit and Water Balance – Recommendations

The purpose of the AWWA/IWA water audit is to identify and quantify areas of Non-Revenue Water (NWR), and then with that information in hand, make recommendations to reduce that NRW. However, the quality of data gathered during the audit very much provides confidence in the audit results, and recommendations to follow. Fortunately, the later versions of the AWWA/IWA software (now version 5.0) have a grading system for each item that is entered into the software, with an aggregate total out of 100, as a result of the audit.

A lower grading indicates that better data is needed before there can be sufficient confidence in the results of the audit, and measures identified to reduce NRW. As described in the 2018 Audit, the quality of data is not high (a software score of 61 out of 100) and consequently the main recommendations of the 2018 Audit will be a number of measures to increase the accuracy of data, ready to be used for the 2019 IWA/AWWA Water Audit and Water Balance. Therefore, at this time, no recommendations will be made for any measures to identify and reduce NRW. However the following operational recommendations are made in an effort to obtain better quality data.

1) Windsor Utilities Commission Import Meters: Additional testing and calibrating of the eleven (11) WUC Import Meters to obtain a better understanding of each meter's accuracy. This can be accomplished by means of a phased approach consisting of a review of the flow patterns through the meters; completion of a site accuracy test; and (if required) a potential change-out of the meter based on the results obtained.

    - The Town's Water Services Division is actively working towards completing this recommendation by the fall of 2019 as part of the 2019 Operational budget. This will ensure a higher level of confidence in the data obtained for the future 2019 Water Audit and Water Balance.

2) Town of Lakeshore Export Meters: Three of the Four Lakeshore export meters are mechanical meters, which do not record flows as low as an electromagnetic flowmeter, and their accuracy can deteriorate over time. In addition any reverse flows are unlikely to be recorded by the mechanical meter, which may introduce additional errors. It is recommended that the mechanical meters are replaced with electromagnetic flowmeters, which will record low flows and flows in both forward and reverse directions.

    - Administration will be scheduling a meeting with Lakeshore to discuss the recommendations of the 2018 Water Audit and Water Balance. The Lakeshore Export Meters are owned and maintained by Lakeshore, and their replacement would have to be coordinated. It is anticipated that their replacement could take place in the summer of 2019, and would be subject to Lakeshore's annual capital and operational budgets.

3) Union Water System Connections: There are two connections to the Union Water System (along County Road 19) that are closed and are available in the event of an emergency between the Town and the Union Water System. It is recommended that pressures be data logged for a 7-day period on either side of the closed valves to establish the pressure profiles on each water system. It is also recommended that the valves be operated and the sections of watermain on either side of the valve be flushed on a regular basis.

    - The Town's Water Services Division will coordinate this work with Union Water in late 2019.

4) Customer Meter Testing: The majority of the customer meters have been changed in the last six years, so it is likely that they are still accurately recording water use by the Town's customers. However, in order to establish future under-registration of these meters, it is recommended that a statistically valid number of meters be tested when they reach the age of 10 years, and this testing be repeated every five years. It is also

recommended that larger customer meters be tested on a regular basis, based on volume of consumption.

- The Town's Water Services Division will explore implementing the recommended testing program.

5) Investigation of number of billed accounts and customer services: During the 2018 Audit it was identified that there was a large difference between the number of customer accounts found during the analysis of the billing data and the number of water services extracted from the Town's GIS Mapping. It is recommended to determine the cause(s) of the discrepancy.

    - The Town's Water Services Division and Information and Communication Services Department will schedule a meeting with Essex Power Services to coordinate a review of the information. This should be completed by summer/fall 2019.

6) Unbilled, Unmetered Consumption: Unbilled, unmetered consumption is authorized uses of water that in Tecumseh, and as in most municipalities, has traditionally not been metered. As this could represent a significant volume of water, many municipalities are starting to measure this volume by various methods.

    - The Town's Water Services Division and Tecumseh Fire & Rescue Services have already begun to develop recording sheets and best practices to measure all of the unmetered water (hydrant flushing, auto-flushers, firefighting, etc.). With this practice being put in place now, the data for the future 2019 Water Audit and Water Balance will be improved.

Consultations

Financial Services
Kingsley Blease Consulting and Watermark Solutions

Financial Implications

There are no financial implications associated with this report.

Link to Strategic Priorities

Applicable	2017-18 Strategic Priorities
☐	Make the Town of Tecumseh an even better place to live, work and invest through a shared vision for our residents and newcomers.
☒	Ensure that the Town of Tecumseh's current and future growth is built upon the principles of sustainability and strategic decision-making.
☐	Integrate the principles of health and wellness into all of the Town of Tecumseh's plans and priorities.
☒	Steward the Town's "continuous improvement" approach to municipal service delivery to residents and businesses.
☐	Demonstrate the Town's leadership role in the community by promoting good governance and community engagement, by bringing together organizations serving the Town and the region to pursue common goals.

Communications

Not applicable ☒

Website ☐ Social Media ☐ News Release ☐ Local Newspaper ☐

This report has been reviewed by Senior Administration as indicated below and recommended for submission by the Chief Administrative Officer.

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Attachment Number	**Attachment Name**
1	Town of Tecumseh, American Water Works Association/International Water Association Water Audit, Prepared by Kingsley Blease Consulting and Watermark Solutions, April 25, 2019
2	Understanding the Components of Non-Revenue Water
3	Summary of 2012 and 2018 Water Audits

Town of Tecumseh

American Water Works Association / International Water Association Water Audit

Prepared by
Kingsley Blease Consulting
and
Watermark Solutions

Final Report

April 25, 2019

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1.0 Introduction

The Town of Tecumseh is aware of the importance of identifying and reducing Non-Revenue Water (NRW) in its distribution system. This is particularly important, as the water has to be purchased from Windsor Utilities Commission (WUC), and any water that does not reach customers because of leakage, or is not billed, becomes a cost for the Town. In addition water is exported from the Tecumseh water distribution system to the Town of Lakeshore. Furthermore, customer metered billing is performed by a third party, Essex Power.

In order to understand the levels of NRW better, in 2012, the Town completed an American Water Works Association (AWWA) / International Water Association (IWA) Water Audit. As it has been a few years since the audit was performed, the Town decided to complete the audit for the year of 2018, and this report provides the results of that audit.

The AWWA Manual M36 (Water Audits and Loss Control Programs) recommends completing an AWWA / IWA Water Audit for water systems, and that it be performed annually. The AWWA / IWA Water Audit is considered to be North American Best Management Practice (BMP). The audit identifies Revenue and Non-Revenue Water, and quantifies each, in terms of volumes of water, and costs (both operational costs to purchase water from WUC, plus potential revenue losses from the customer metering and billing systems).

There are eleven metering stations (boundary meters), that record the volumes of water supplied by WUC, and the volumes of water recorded at these stations is used to bill the Town. The eleven WUC flowmeters are the electromagnetic type, manufactured by Khrone, and vary in size from 150 mm to 500 mm in diameter. They were all, except one, installed between 2006 and 2008. One was installed in 2014.

Water is exported to the Town of Lakeshore at four locations, although currently one of the locations, Amy Croft, is closed, as Lakeshore has determined that it is not required at this time. There are also two connections to the Union Water System, which are left closed, and are available for emergency use.

During the process of the audit, the project team worked closely with Town staff, so as well as obtaining data for the audit, the team gained a real understanding of the operation of the Town's bulk water purchase, distribution and customer revenue systems. This knowledge gained enabled recommendations to be made in all areas of operation included in the audit. In addition, with Town staff being involved in detail, throughout the audit, it has enabled them to become familiar with the process and methodology. Next year, and in future years, Town staff will be able to complete the audit themselves.

2.0 AWWA/ IWA Water Audit and Water Balance Methodology

The AWWA / IWA Water Audit identifies categories of Revenue and Non-Revenue water from the water supplied to a system. There is a whole range of types of Non-Revenue Water (NRW) that may or may not be significant, for each individual supplier of water. They have been conveniently summarized in the following three categories by the IWA methodology:

2.1 Unbilled Authorized Consumption

Unbilled metered and Unbilled unmetered

The following is unbilled, and can be metered or unmetered, according to local practice:

- Flushing of mains and sewers
- Hydrant flow tests
- Hydrant flushing
- Water taken from hydrants for other uses
- Distribution system bleeders / auto flushers
- Water used on building sites
- Filling new watermains and abandoning others
- Cleaning storage tanks
- Filling water tankers
- Fire fighting
- Street cleaning
- Parks irrigation
- Public fountains
- Frost protection

2.2 Apparent Losses

Unauthorized consumption

- Theft
  - Not opening an account
  - Self connecting / disconnecting meter
  - Tampering with meter or remote
  - Use of false names
  - Illegal connections and by passes
  - Unauthorized use of fire hydrants

Metering and Billing inaccuracies

- System boundary meters from WUC, and to the Town of Lakeshore
  - Type of meters, and calibration history
- Under / over registration of customer meters
  - Age and type of commercial or residential meters, accuracy testing results

- Accounting procedure errors
  - Difference between dates of source meter readings and customer readings
  - Adjustments, units conversions, in billing systems

2.3 Real Losses

Leakage on distribution and transmission mains

- Holes and cracks in mains
- Joints
- Drain valves left open, leaking

Leakage on service connections up to the point of customer metering

- Holes in service pipes
- Joints

Leakage and overflows at storage tanks

- Buried reservoirs structures
- Drain valves left open, leaking
- Overflows

2.4 Definitions

It is the Real Losses that the leak detection techniques target, referred to as ***CARL*** (Current Annual Real Losses). Within these Real Losses there is a volume of water that is unavoidable, even with the most comprehensive leak detection program – this is called ***UARL*** (Unavoidable Annual Real Losses). So the difference between ***CARL*** and ***UARL***, is the Real Losses that is targeted for reduction. This ratio of ***CARL*** to ***UARL*** is referred to as the ***ILI*** (Infrastructure Leakage Index).

For the management of these Real Losses, there are four areas to look at. They are as follows:

- Active leak detection, to find leaks that are not surfacing
- Speed and quality of repairs
- Pressure management
- Pipeline and asset management / renewal

3.0 Water Audit Process

The water audit process involved the Town gathering information of all areas of water use across the distribution system. In order to facilitate this process, a questionnaire, which describes all areas of water use required for the AWWA / IWA audit, was sent to the Town ahead of the start up meeting. This questionnaire has been developed by Kingsley Blease over the last twelve years, during the completion of over 40 water audits.

Obtaining data was a series of tasks – as data was received it was recorded in the questionnaire. The updated questionnaire was sent back to the Town, with the areas noted where data was still needed. This stage of the audit was repeated four times, until all the data was received, and a copy of the final questionnaire is included as **Appendix A**. The process went very well, as Town staff supplied information very quickly, and answered any resulting questions without delay.

The American Water Works Association (AWWA), Water Loss Control Committee (WLCC), in conjunction with the IWA, developed water audit software for use by Utilities across North America. The first version was produced in 2006, and the current version, 5.0, was released in 2014 – this current version was used for the Tecumseh water audit.

As data was received from the Town, it was entered into a series of spreadsheets, which corresponded to the AWWA / IWA water audit software data entry items. These spreadsheets, which are provided as **Appendix B**, included all the raw data gathered data, assumptions made, and calculations completed. The final aggregate values from the data gathering spreadsheets were then entered into the AWWA / IWA software, which is attached as **Appendix C**.

The data gathering spreadsheets, and AWWA / IWA software run, have been included with this report, so that the Town can use them in future years to complete the audit - they can be updated with current data. In addition, the updated questionnaire, which is also included with this report, can help guide Town staff in future audits.

The performance indicators produce by the software, coupled by the understanding of the operation of the water system, were used to develop recommendations of the next steps.

4.0 Water Imports and Exports

A key component of the IWA audit is to verify the accuracy of the bulk water meters that measure water into and out of the Town of Tecumseh water distribution system. A summary of these import and export meters is described below.

4.1 Windsor Utilities Commission Import Meters

Water is supplied to Tecumseh by WUC from 11 metering stations, which consist of Krohne electromagnetic (mag) flowmeters, as shown in the table below. Chamber No. MCT05 has not been put into operation yet. The Krohne mag meters record both forward (from WUC to Tecumseh), and reverse flow (from Tecumseh to WUC), and the pattern of flow is as follows:

- 7 meters generally record mostly forward flow, but there are times when reverse flow takes place
- 1 meter generally records reverse flow back to Windsor, but at times recorded flow into Tecumseh
- 2 meters generally record significant volumes of forward and reverse flow
- 1 meter recorded just forward flow

Chamber No	Location	Dia of Existing Watermains		Flow Direction		Meter Size	Meter Manufacturer	Comments	Meter Install Date
		IN	OUT	Forward	Reverse				
		mm	mm			mm			
TECUMSEH NORTH - WATER FROM WUC									
MCT01	Dillon Drive/Kenny Court	500	400	Yes	Yes	300	Krohne	Mostly forward flow	2006
MCT02	McNorton Drive	300	300	Yes	Yes	200	Krohne	Mostly forward flow	2006
MCT03	Tecumseh Road	400	400	Yes	Yes	350	Krohne	Mostly forward flow	2006
MCT04	Mulberry Dr/Arpino Av(CR22)	600	600	Yes	Yes	500	Krohne	Mostly forward flow	2006
MCT05	Intersection Road	600	200			450		Not in operation	2006
MCT06	County Road 42	200 / 600	600 / 200	Yes	Yes	150	Krohne	Mostly reverse flow	2006
MCT07	Baseline Road	200	200	Yes	Yes	150	Krohne	Forward and reverse flow	2006
TECUMSEH SOUTH - WATER FROM WUC									
MCT08	8th Concession Road	200	200	Yes	Yes	150	Krohne	Mostly forward flow	2008
MCT09	County Road 46 (Provincial Rc	600	600	Yes	Yes	200	Krohne	Mostly forward flow	2007
MCT10	Walker Road	300	300	Yes	Yes	200	Krohne	Mostly forward flow	2008
MCT11	North Talbot Road	300	300	Yes	Yes	200	Krohne	Forward and reverse flow	2008
MCT12	Howard Avenue	150	150	Yes	No	150	Krohne	All forward flow	2014

In order to get a sense of the range of operation of the Krohne mag flowmeters, and how that compares to the manufacturers operation range, flow rates were reviewed. The results are shown in the following table. It can be seen, that generally the Krohne meters operate in the lower end of the manufacturers flow range for each meter.

Chamber No	Location	Flow Range		
		Meter Range	Nov-17 Actual	Max Flow as Percentage of Meter Full Range
		l/s		
TECUMSEH NORTH - WATER FROM WUC		zero to	Max	
MCT01	Dillon Drive/Kenny Court	200	40	20%
MCT02	McNorton Drive	150	25	17%
MCT03	Tecumseh Road	300	52	17%
MCT04	Mulberry Dr/Arpino Av(CR22)	300	78	26%
MCT05	Intersection Road			
MCT06	County Road 42	150	7.7	5%
MCT07	Baseline Road	100	12	12%
TECUMSEH SOUTH - WATER FROM WUC				
MCT08	8th Concession Road	100	12.3	12%
MCT09	County Road 46 (Provincial Rd)	100	21.5	22%
MCT10	Walker Road	150	48.8	33%
MCT11	North Talbot Road	150	67.1	45%
MCT12	Howard Avenue	100	0.1	0.1%

All of these Krohne mag meters are tested every year, and the work is completed by Summa Engineering. The tests were performed in October, 2018, and are a verification test.

The test involves disconnecting the primary flow element (electromagnetic sensor pipe, with water flowing through it) from the converter / transmitter. A simulator is then connected to the converter / transmitter, and different outputs are made by the simulator – these outputs are compared to the converter / transmitter. Although this is a common practice method of testing mag flowmeters, it is more of a validation, than true calibration of the accuracy of the flowmeter.

4.2 Town of Lakeshore Export Meters

There are four flowmeters that measure the water exported to the Town of Lakeshore. Meter No L1, at Amy Croft Drive was closed during 2018, as it was determined by the Town of Lakeshore that it was not required.

When tested in February 2019, the Elster Aquamaster mag meter, L3, at Manning Road and County Road 42 was reading in error, and under-registering by about 3%.

A summary table of these four meters is shown in the table below:

Chamber No	Location	Dia of Existing Watermains		Flow Direction		Meter Size	Meter Manufacturer	Comments	Meter Install Date
		IN	OUT	Forward	Reverse				
		mm	mm			mm			
L1	Amy Croft Drive	200	300	Yes	No	150	Neptune	Closed	2000
L2	Little Baseline Road	150	150	Yes	No	100	Compound?		1988
L3	Manning / CR42	200	200	Yes	No	100	Elster	Aquamaster Mag Meter	2003
L4	Manning / 10th Concession	150	150	Yes	No	150	?		1998

The Elster meter at L3, Manning and County Road 42 did have a check valve installed to prevent reversal of flows from the Town of Lakeshore to the Town of Tecumseh. However, there did not appear to be check valves on the other three flowmeters. Check valves ensure that flow only takes place in one direction - the meter at L3 does have a check valve, so that flow can only flow from the Town of Tecumseh to the Town of Lakeshore.

4.3 Union Water System Connections

There are two connections to the Union Water System, that are closed, and available for emergency use between the Town of Tecumseh and the Union Water System. The closed valves are located on Manning Road, between S Talbot Road and County Road 8.

5.0 Customer Meters and Billed Volumes

It is understood that the majority of customer meters have all been changed out over the last 6 years, and have an Itron Ert radio read module, so that the meters can be read remotely from a vehicle driving by. There are about 120 accounts that still require the meter changing. It is likely that customer meters are recording accurately, based on age, and as a group, should not be under-registering. Also, it is also understood that the Town tests the larger customer meters at the Bonduelle facility on a regular basis.

Raw data was provided by the Town which they obtained from Essex Power, who currently provide billing services. The data was analysed to obtain the volume of water supplied to the Town's customers for the full year of 2018. During the analysis, information on meter size and what were the units of measure was identified.

From the analysis, the volume of water billed to customers was 3,104,757 m^3 in 2018.

There were 9,006 meter accounts in the data base provided by Essex Power. It was found that 418 of these accounts were meters that had a register reading in gallons. The remainder of customer meters were reading in m^3 .

The table below summarises the numbers of meters in each size:

Meter Size	Number
5/8" and ¾"	8,765
1"	119
1 ¼" and 1 ½"	28
2"	82
3"	3
4"	4
6"	5
Total	9,006

It should be noted that the number of services provided by the Town during the data gathering exercise was 7,928. This large difference between the number of customer accounts and the number of services should be investigated, to establish the reason for such a large discrepancy.

6.0 Unbilled, Unmetered Consumption

For Canadian water utilities the volumes of Unmetered, Unbilled Consumption are usually of significant size, and frequently comprise of water used by the utility from fire hydrants, or bleeders / auto flushers from the water distribution system. This was found to be the case for the Town of Tecumseh, where the Spring Flushing Program, and Auto Flushers were estimated to be large volumes of water. The following table summarises all the unbilled, unmetered water, for the Town.

Description	2018 Annual Volume – m^3
Spring Flushing	85,705
Water Tower Cleaning	3,783
Street Cleaning	409
Building Water for New Construction	3,000
Auto Flushers	65,617
7014, 9th Concession Hydrant Flushing	927
50 Sampling Stations	655
Fires – Structure	109
Fires - Vehicle	18
Fires – Rubbish (small)	61
Fire Hall Training	1,555
Watermain Repairs and Flushing	1,669
Commissioning New Watermain Testing	588
Capital Projects New Watermains Filling	30
Flushing for MTO at Herb Grey Parkway	185
Totals	**164,313**

7.0 Summary of Gathered Data

The gathered data for the 2018 water balance was entered into a series of spreadsheets which are included as **Appendix B**. The spreadsheets were developed to match the AWWA / IWA software data entry pages, and the following table summarises the data gathered:

No	IWA Balance Totals	2018 Values
1	Water from Own Sources	0
2	Import, Export Meter Inaccuracies	0
3	Water Imported from WUC	3,559,635 m3
4	Water Exported to Lakeshore	15,465 m3
5	Billed Metered Consumption	3,104,757 m3
6	Billed Unmetered Consumption	0
7	Unbilled Metered Consumption	16,534 m3
8	Unbilled Unmetered Consumption	164,313 m3
9	Unauthorised Consumption	8,860 m3
10	Customer Meter Inaccuracies (under registering)	15,524 m3
11	Data Handling Errors	7,762 m3
12	Length of mains	226.62 km
13	Number of Services	7,928
14	Avg. Length of Services (Curb Stop - property)	12 m
15	Average Operating Pressure	38.35 m
16	Total Annual Cost of Operating	$3,351,620
17	Customer Water and Wastewater Rate	$2.3642 per m3
18	Variable Water Production Cost	$399.90 per ML

8.0 AWWA / IWA Software Analysis

The gathered data for 2018 was entered into the AWWA – WLCC (American Water Works Association – Water Loss Control Committee) software program (version 5.0), which is included as **Appendix C**. All volumes for this program are entered as Megalitres (ML) - one thousand cubic metres, and the audit is for a full year.

Parameter	2018 Values
Current Annual Real Losses (CARL)	227 ML
Unavoidable Annual Real Losses (UARL)	179 ML
Infrastructure Leakage Index (ILI)	1.27
Water Imported from WUC	3,559 ML
Water Exported to Town of Lakeshore	15.47 ML
Revenue Water	3,105 ML
Non-Revenue Water	439 ML
Non-Revenue Water as a percentage of water purchased from WUC	12.4 %

9.0 AWWA / IWA Software Analysis Commentary

In any water system there will be a volume of leakage that includes small leaks and weeps that is either undetectable in practice, or not economic to find and repair – this is the Unavoidable Annual Real Losses (UARL). The AWWA / IWA software uses the physical characteristics of the water distribution system (length of water mains and services, number of connections, average pressure) to make an estimate of UARL.

The Current Annual Real Losses (CARL) are also calculated by the software, by taking the water imported from WUC, and exported to the Town of Lakeshore, to give the volume supplied to the Town of Tecumseh's water distribution system. The calculated authorized consumption and apparent losses are then deducted from the volume supplied to the Tecumseh distribution system, to calculate CARL.

The Infrastructure Leakage Index (ILI) is the ratio of CARL to UARL. The AWWA Manual M36 (Water Audits and Loss Control Programs, provides the definition of ILI as:

"ILI is a performance indicator quantifying how well a water distribution system is managed (maintained, repaired, rehabilitated) for control of real losses (leakage) at the current operating pressure. Mathematically, it is the ratio of current annual real losses (CARL) to unavoidable

annual real losses (UARL), or ILI = CARL/UARL. A low ILI value indicates that the water utility has managed its leakage down towards the UARL, or the theoretical low limit of leakage technically available."

The AWWA / IWA software also provides a results of Non-Revenue Water (NRW), as a percentage of water supplied. Operators of water systems find this percentage a useful indicator, as well as the ILI

In order to understand the results for Tecumseh, a summary of the results of AWWA / IWA audits completed by Kingsley Blease of the last 10 years in Ontario, are provided in the following table. The results presented are audits where the quality of data was good, and was in the AWWA / IWA software grading range of 75 to 80, out of a maximum score of 100.

The following table summarizes the results of Ontario water audits:

Software Performance Indicator	Range of Values	Average Values
Infrastructure Leakage Index (ILI)	1.8 to 5.8	3.7
Non-Revenue Water as Percentage of Water Supplied	11% to 34%	23%

On inspection, the ILI of 1.27 is extremely low, outside of the range of Ontario municipalities, and well below the average. The Non-Revenue Water as a Percentage of Water Supplied at 12.4%, is at the bottom end of the Ontario ranges, and below the average.

These two results of the software analysis indicate, on initial examination, that leakage and NRW are extremely low in the Town of Tecumseh. However, there was a low level of confidence in the quality of data, and this was reflected in a software grading score of 61 out of 100. This grading was expected by the auditor, as there were a number of areas of low confidence in the quality of the data.

Having described the limitations of the Town of Tecumseh AWWA / IWA software runs, the following commentary of the financial analysis is still provided, although likely not correct, it will give an indication of the potential cost implications.

Two of the key values that have a financial effect on the operation of municipal water systems are the cost of Real Losses (leakage), and the loss in revenue from Apparent Losses (customer meter under-registration, unauthorized consumption, billing etc.). For the town, the values from the AWWA / IWA software analysis are shown in the following two tables:

Real Losses (Leakage)		
Purchase Cost of Water	Real Losses Volume	**Annual Cost of Real Losses**
from WUC (per ML)	ML	
$399.90	226.700	**$90,657**

Apparent Losses (Estimated Customer Meter Inaccuracy, Unauthorised Consumption, Data Handling Errors)		
Water and Wastewater	Apparent Losses Volume	**Annual Cost of Apparent Losses**
Rate per m3	ML	
$2.3642	31.800	**$75,182**

10.0 Recommendations

The purpose of the AWWA / IWA water audit is to identify and quantify areas of Non-Revenue Water (NWR), and then with that information in hand, make recommendations to reduce that NRW. However, the quality of data gathered during the audit, very much provides confidence in the audit results, and recommendations to follow. Fortunately, the later versions of the AWWA / IWA software (now version 5.0) have a grading system for each item that is entered into the software, with an aggregate total out of 100, as a result of the audit.

A lower grading indicates that better data is needed before there can be sufficient confidence in the results of the audit, and measures identified to reduce NRW. As described in section 9.0, the quality of data is not high, and consequently the main recommendations of the 2018 audit will be a number of measures to increase the accuracy of data, ready to be used for the 2019 annual AWWA / IWA water audit. Therefore, at this time, no recommendations will be made for any measures to identify and reduce NRW.

The recommendations are as follows:

10.1 Windsor Utilities Commission Import Meters

The eleven meters that are used to measure the volumes of water supplied to the Town by Windsor Utilities Commission (WUC) are all electromagnetic (mag) flowmeters, manufactured by Krohne. They were installed between 2006 and 2008, and one in 2014. Inspection of the "as built" drawings has verified that they have all been installed with sufficient diameters of pipework upstream and downstream of the meter.

An annual test is completed for the flowmeters. The test involves disconnecting the primary flow element (electromagnetic sensor pipe, with water flowing through it) from the converter / transmitter. A simulator is then connected to the converter / transmitter, and different outputs are made by the simulator – these outputs are compared to the converter / transmitter. Although this is a common practice method of testing mag flowmeters, it is more of a validation, than true calibration of the accuracy of the flowmeter.

The manufacturers flow ranges for each size of mag meter were obtained, and also a representative hourly print out was provide by Town staff, from the Scada system. On inspection of the two sets of data, it showed that the meters operated in the lower end of the meter's operating range – generally in the 10% to 30% area of maximum flow. In addition, the annual testing procedure used, covered a much larger range of flows, many of which may not be attained during normal working conditions.

It is therefore recommended that additional testing be performed, in order to obtain a better understanding of each mag meter's accuracy. A phased approach is suggested, as follows:

Firstly – Review Each Flowmeters Flow Patterns

- Obtain Scada data at the shortest interval available – likely to be every 5 minutes, or less
- Establish the maximum, minimum and average flow rates
- Inspect where the flow direction reverses, and observe times of zero flow rate

This exercise will provide, for all Khrone flowmeters, information on how the flow rates are varying. It will also show where, on the manufacturers flow range, each one is operating.

With this information in hand, site accuracy testing can be designed, and the testing targeted to the ranges of flow that each individual meter is operated at.

Secondly - Complete Site Accuracy Testing

Site accuracy testing of mag flowmeters is designed to check the accuracy of the whole instrument – the converter, or transmitter and the primary flow element. There are a number of ways to do this.

One method of site testing, is to pass the whole flow through another, calibrated, full bore flowmeter – a volumetric comparison, or "Master Meter" test. This method should provide the greatest accuracy, compared to the other tests, and is the preferred option. Town staff have recognized this, and are in the process of investigating the practicalities and costs of this method of field testing.

Two other methods involve finding a section of pipework close to the existing meter, and installing a second meter to record the flow. The most common devices are a "clamp on ultrasonic" flowmeter, installed on the outside pipe wall, or an "insertion" flowmeter, installed through a tapping on the pipework. These techniques, in theory, are less accurate than the full bore mag meter they are testing. However, they can provide accuracy in the order of 2% to 5%, depending in site conditions, and pipework conditions.

For all three methods, often the deciding factor is site conditions, and the practicality of each test. It is recommended that the Town complete site testing of all WUC Krohne magnetic flowmeters, once the flow patterns of each meter have been established.

Thirdly – Consider Potential flowmeter Changeout, Based on Results Obtained

All except one of the Krohne flowmeters are between 11 and 13 years old. Once the accuracy testing has been completed, a program of replacement can be established. It may be that none need to be replaced in the immediate future. Also, sometimes age is not a factor in accuracy and useable life of a flowmeter, so the testing recommended for these magnetic flowmeters is key to ensure that meters that are not accurate are changed, and meters that are accurate can remain.

10.2 Lakeshore Export Meters

Three of the four meters used to measure the flow from the Town of Tecumseh to the Town of Lakeshore are mechanical meters. Meter number L3, Manning and County Road 42 is an Elster Aquamaster electromagnetic meter, installed in 2003, and has a check valve installed. Of the other three meters, currently L1, Amy Croft Drive, is closed off. All three of these meters were installed between 1998 and 2000, so are 20 years old

It is recommended that it be established which locations, in the long term, are required to be supplied to Lakeshore. When this has been established, the mechanical meter locations should be changed to electromagnetic flowmeters. Mechanical meters do not record flows as low as electromagnetic meters, and their accuracy can deteriorate over time. In addition, any reverse flows are unlikely to be recorded by the mechanical meter, so introducing additional errors.

Electromagnetic flowmeters will record low flows, and also flows in both directions, forward and reverse.

10.3 Union System Connections

There are two connections to the Union Water System, that are closed, and available for emergency use between the Town of Tecumseh and the Union Water System. For these connections, it is recommended that pressures be data logged for a 7 day period either side of each closed valve, to establish the pressure profiles on each water system.

Because these closed valves are located in the South distribution system, which is currently being considered for significant operational changes, it should be established if they will still be required in the future.

In the interim, it is recommended that the valves be operated, and the sections of watermain either side of each closed valve be flushed on a regular basis. If the connections will be part of the future changes, then consideration should be made to regular flushing of water.

10.4 Customer Meter Testing

It is understood that the majority of the customer meters have been changed in the last six years, so it is likely that they are still accurately recording water use by the Town's customers. However, in order to establish future under-registration of these meters, it is recommended that a statistically valid number of meters be tested when they reach the age of 10 years, and this testing be repeated every five years.

Below is a table to give an indication of the number of meters that would require testing. As an example, if there were about a third of the meters 10 years or older, and an error of 10% in the results was acceptable, then 93 meters would need testing. If smaller margins of errors were desired, then the sample size could be increased, as indicated

Simple Random Sample											
With a 95% confidence level and 50% estimate of population proportion											
Population size – error margin	**Unlimited**	**1,000,000**	**500,000**	**250,000**	**100,000**	**10,000**	**5,000**	**3,500**	**1,000**	**500**	**100**
1%	9,604	9,513	9,423	9,249	8,762	4,899	3,288	2,565	906	475	99
2%	2,401	2,395	2,390	2,378	2,345	1,936	1,622	11,424	706	414	96
3%	1,067	1,066	1,065	1,063	1,056	964	879	818	516	340	91
4%	600	600	600	599	597	566	536	512	375	273	86
5%	384	384	384	384	383	370	357	346	278	217	79
6%	267	267	267	266	266	260	253	248	211	174	73
7%	196	196	196	196	196	192	189	186	164	141	66
8%	150	150	150	150	150	148	146	144	130	115	60
9%	119	119	119	119	118	117	116	115	106	96	54
10%	96	96	96	96	96	95	94	**93**	88	81	49
11%	79	79	79	79	79	79	78	78	74	68	44
12%	67	67	67	67	67	66	66	65	63	59	40

Reference: Chakrapani: C&K Deal, Market Research: Methods and Canadian Practice, 1992

In this manner, future under-registration of customer meters, and the associated revenue loss can be tracked. This will enable a business case to be established, in the future, for a meter changeout program.

It is also recommended that the larger customer meters be tested on a regular basis, based on volume of consumption. The Town currently test the meters at Bonduelle frequently, but other meters should be included in that program, if they are not already.

10.5 Investigation of Number of Billed Accounts and Customer Services

As has been described earlier in this report, there is a large difference between the number of customer accounts found during the analysis of the Essex Power billing data, and the number of water services. There were 9,006 customer accounts in the billing system, and 7,928 water services. An investigation should take place to establish the reason for such a large discrepancy.

For the billed accounts, an audit should be completed, to verify that each unique account number / meter number is located in the Town of Tecumseh.

For the customer services, an audit should be completed of the services, to verify the number of services with a single meter, and the number of services taken from the watermain, that supply multiple customer meters.

10.6 Unbilled, Unmetered Consumption

Unbilled, unmetered consumption is authorized uses of water that in Tecumseh, and as in most municipalities, has traditionally not been metered. Because this represents a significant volume of water, many municipalities are starting to measure this volume, by various methods. The Town of Tecumseh has recognized this, and is developing recording sheets, and best practices to measure all of this unmetered water (Spring flush, auto flushers, fire fighting etc.).

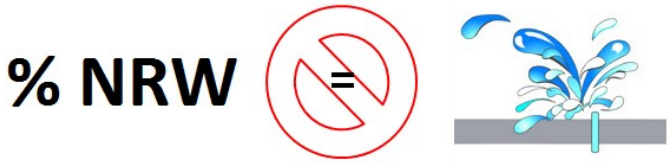
This is being put in place, so that data for the 2019 audit will be vastly improved – every m3 of water metered here, becomes a m3 less of leakage.

Report prepared by:
Kingsley Blease, P.Eng.
April 4, 2019

ATTACHMENT No. 2

Understanding the Components of Non-Revenue Water

Non-Revenue Water **(NRW)** is the difference between the Water Supplied (production volume) and Billed, Authorized Consumption (metered, and unmetered volumes). Calculating NRW is therefore relatively simple, however understanding the components that account for the volume of water determined as being NRW is often misinterpreted. Non-Revenue Water is neither “unaccounted- for” nor is it all equal to leakage.



There is a range of different types of Non-Revenue Water (NRW) and Water Loss components that may or may not be significant, and they have been summarized in the following three categories by the IWA/AWWA Water Audit methodology.

Unbilled Authorized Consumption – Metered or Unmetered

The following uses are unbilled and can be metered or unmetered, according to local practice:

- Firefighting & training,
- Flushing of mains and sewers, new construction and existing,
- Auto-flushers or blow offs,
- Cleaning water storage tanks & reservoirs,
- Filling water tankers,
- Water taken from hydrants (flow testing or routine annual maintenance activities),
- Street cleaning,
- Parks irrigation,
- Public fountains, pools & splash pads, and
- Building water for new construction and developments.

Apparent Losses

Apparent Losses (customer metering and/or accounting errors) can be further categorized into the following components:

Unauthorized consumption (a.k.a “Theft”)

- Self-connecting / disconnecting water meter,
- Tampering with water meter or remote reader,
- Illegal connections and/or water meter by-pass opening, and
- Unauthorized use of fire hydrants.

Metering inaccuracies- Under / over registration of customer meters

- Older water meters tend to under-register with age,
- ICI meters are often oversized and under-register consumption at lower flows,

- Compound meters under-register in the cross-over range of the flow profile,
- Improper water meter register programming or matching causing over / under registration,
- Stopped meters – particularly compound meters, and
- New water meter quality control issues causing waters to over / under register.

Systematic data handling errors

- Not opening a new account when required,
- Active accounts tagged as inactive accounts not being billed,
- Active accounts with no consumption for the last 6 months (meter issue),
- Identify inactive accounts with usage (occupied or vacant with leakage),
- Misread meters,
- Incorrect estimates,
- Adjustments to original meter readings,
- Unit conversions,
- Improper calculations or multiplier in billing software, and
- Computer programming or billing software errors.

Real Losses

Real Losses (a.k.a “Leakage”) can be further broken down into the following categories:

Leakage on distribution and transmission mains

- Holes and cracks in watermains,
- Joints or mechanical connections,
- Drain valves left open, leaking

Leakage and overflows at storage tanks

- Seepage from cracks to buried reservoir structures,
- Drain valves left open, leaking, and
- Overflows.

Leakage on service connections up to the point of customer metering

- Holes or splits in service pipes, and
- Joints and fittings, and
- Service saddle connections.

2012 Water Audit and Water Balance - Summary

	(m^3)	
Total Water Imported from WUC	3,810,294	
Total Water Exported to Lakeshore	67,758	
Total Water Supplied	3,742,536	
Total Billed Metered Consumption	3,087,718	
Total Non-Revenue Water (NRW)	**654,818**	**17.50%**

Non-Revenue Water (NRW) - Summary	Volume		Water Costs		Wastewater Costs	
	Volume (m^3)	% NRW	Rate ($/m^3$)	Costs ($)	Rate ($/m^3$)	Costs ($)
1) Unbilled Authorized Consumption						
i) New Watermains	12,825	0.34%	$0.32	$4,104.00		
ii) Firefighting	22,896	0.61%	$0.32	$7,326.72		
iii) Hydrant Flushing	27,270	0.73%	$0.32	$8,726.40		
iv) Auto-Flusher	171,185	4.57%	$0.32	$54,779.20		
v) Miscellaneous	-	0.00%	$0.32	$0.00		
Total	**234,176**	**6.26%**	**---**	**$74,936.32**	**---**	**$0.00**
2) Apparent Losses						
i) Unauthorized Consumption (Theft @ 0.25%)	9,356	0.25%	$1.22	$11,414.32	$0.83	$7,765.48
ii) Customer Meter Inaccuracies	63,015	1.68%	$1.22	$76,878.30	$0.83	$52,302.45
iii) Customer Meter Data Handling Errors [1]	-	0.00%	$1.22	$0.00	$0.83	$0.00
Total	**72,371**	**1.93%**	**---**	**$88,292.62**	**---**	**$60,067.93**
3) Real Losses						
i) Unavoidable Annual Real Losses	201,450	5.38%	$0.32	$64,464.00		
ii) Large Leaks & Breaks	146,821	3.92%	$0.32	$46,982.72		
Total	**348,271**	**9.31%**	**---**	**$111,446.72**	**---**	**$0.00**

1) Auditor assumed '0' due to the lack of available data

2012 Total Water Revenues: $ 5,159,467
2012 Total Wastewater Revenues: $ 3,332,763

Losses in Relation to Total Revenues
Real Losses: Large Leaks & Breaks 0.91%

2018 Water Audit and Water Balance - Summary

	(m^3)	
Total Water Imported from WUC	3,559,635	
Total Water Exported to Lakeshore	15,465	
Total Water Supplied	3,544,170	
Total Billed Metered Consumption	3,104,757	
Total Non-Revenue Water (NRW)	**439,413**	**12.40%**

Non-Revenue Water (NRW) - Summary	Volume		Water Costs		Wastewater Costs	
	Volume (m^3)	% NRW	Rate ($/m^3$)	Costs ($)	Rate ($/m^3$)	Costs ($)
1) Unbilled Authorized Consumption						
i) North Bulk Water Filling Station [1]	16,534	0.47%	$0.40	N/A		
ii) New Watermains	618	0.02%	$0.40	$247.14		
iii) Firefighting	1,743	0.05%	$0.40	$697.03		
iv) Hydrant Flushing	86,817	2.45%	$0.40	$34,718.12		
v) Auto-Flusher	65,617	1.85%	$0.40	$26,240.24		
vi) Miscellaneous	9,518	0.27%	$0.40	$3,806.25		
Total	**180,847**	**5.10%**	**---**	**$65,708.77**	**---**	**$0.00**
2) Apparent Losses						
i) Unauthorized Consumption (Theft @ 0.25%)	8,860	0.25%	$1.15	$10,230.64	$1.21	$10,716.17
ii) Customer Meter Inaccuracies	15,224	0.43%	$1.15	$17,579.15	$1.21	$18,413.43
iii) Customer Meter Data Handling Errors	7,762	0.22%	$1.15	$8,962.78	$1.21	$9,388.14
Total	**31,846**	**0.90%**	**---**	**$36,772.58**	**---**	**$38,517.74**
3) Real Losses						
i) Unavoidable Annual Real Losses	179,000	5.05%	$0.40	$71,582.10		
ii) Large Leaks & Breaks	47,720	1.35%	$0.40	$19,083.23		
Total	**226,720**	**6.40%**	**---**	**$90,665.33**	**---**	**$0.00**

1) Revenue from the Filling Station is used to offset the operating costs of the PW Lacasse Building

2018 Total Water Revenues: $ 5,060,318
2018 Total Wastewater Revenues: $ 4,428,917

Losses in Relation to Total Revenues
Real Losses: Large Leaks & Breaks 0.38%