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Memo

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	City of Joliet		Engineering Enterprises, Inc.
File:	Non-Revenue Water Reduction Strategies	Date:	September 21, 2020
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Executive Summary

From 2016 through 2019, the City of Joliet has experienced Non-Revenue Water (NRW) percentages from 32.4% to 34.9% based on the American Water Works Association (AWWA) methodology found in AWWA Manual M36 – Water Audits and Loss Control and associated software. The City of Joliet has developed many strategies to reduce its NRW percentage, and currently is in the process of working through those strategies. This NRW Reduction Plan summarizes a number of the past strategies that had been put in place along with additional strategies the City has developed over time.

The main goal is to reduce NRW to below 10% by 2030 to meet the Lake Michigan Allocation permit requirements. Strategies have been developed to reduce both apparent and real losses to achieve that goal. While the City already has a robust water main replacement program that focuses on replacing 1% of the water main in the water works system per year, this plan commits the City to increase its water main replacement program to 3.2% per year. The 3.2% per year water main replacement program requires an investment of approximately $33.7M per year in water main replacement from 2022 to 2030. With this funding commitment to reduce the real losses through aging water mains, along with the City's commitment to reduce apparent losses through tactical analysis of its metering and accounting systems, the City has set a path to achieve a 9.7% NRW percentage by 2030, the year the City integrates Lake Michigan water into its system.

1.0   Introduction

In 2018, following the completion of the calendar year 2016 and water year 2017 water loss audits based on the AWWA M36 methodology in which the NRW percentages were 33.9% and 32.4%, respectively, the City of Joliet began to develop strategies to reduce its NRW levels. Over the last two years, City staff has been making strides in implementing the subsequent recommendations to reduce NRW including, but not limited to, the following:

- ♦ Appointed a Water Loss Champion

- ♦ Committed to complete a water audit based on the AWWA M36 methodology on an annual basis

- ♦ Established a Water Loss Task Force of a diverse group of City Department representatives that meet on a monthly basis

Non-Revenue Water Reduction Strategies

- Implemented an annual master meter testing program at distribution entry locations

- Refined the City staff's understanding of the status of the Exported Water Users and billing practices

- Implemented an annual meter testing program for the majority of the Exported Water Meters

- Performed larger customer inspections and meter testing

- Increased leak detection and repairs from every other year to annuallyImproved tracking on unbilled, unmetered water use

- Implemented new procedures internally to minimize unmetered construction water use on City of Joliet projects

- Passed and implemented a new ordinance and process to eliminate unmetered construction water use

- Continued to implement water main replacement up to the budgeted amount

- Developed a water main break analysis to prioritize water main replacement program projects

- Completed Sensus Analytics training and met with Sensus Analytics to begin the development of more accurate reports for billed water use during specific time periods

- Hired a consultant to conduct testing on residential water meters and then develop a residential water meter replacement program and record-keeping process for meter replacements

Until a solid foundation for data collection and verification is identified for the information in the water loss audit, a true understanding of the magnitude or quantity of Non-Revenue Water (NRW) cannot exist or be managed. As a result of City staff's efforts, the Data Validity Score improved from 53 in 2017 to 65 in 2019 which indicates confidence in the data has increased despite no decrease in reported NRW. The Data Validity Score ranges from 0 to 100. The closer the Data Validity Score is to 100, the higher level of accuracy/confidence exists in the data.

While City staff has made significant improvements, they have also recognized a NRW level of 34.9% in 2019 is undesirable. Therefore, a NRW Reduction Plan needs to be developed and implemented to reduce NRW to below 10% by 2030 to meet the Lake Michigan Allocation permit requirements. This memorandum summarizes the City's water loss audit results for 2016 through 2019 and the recommended next steps to reduce the NRW levels.

Non-Revenue Water Reduction Strategies

2.0 The AWWA M36 Terminology

Before discussing the NRW Reduction Plan, it is critical to understand some of the common terminology utilized in the AWWA M36 methodology. First, the M36 completely eliminates the term "unaccounted for water." This term is vague and holds a different definition depending on the various utilities. Two new terms are introduced in lieu of this traditional term: Water Loss and Non-Revenue Water.

Non-Revenue Water is the difference between system input volume (water produced) and billed authorized consumption. It consists of the following:

o   Unbilled Authorized Consumption (fire hydrant flushing, water treatment plant process water, municipal buildings whose water is not metered, etc.);

o   Apparent Losses (non-physical losses such as unauthorized consumption (water theft), meter inaccuracies, systematic data handling errors, etc.) and;

o   Real Losses (physical losses from the distribution system and storage tanks up to the point of connection to the customer meter).

Unbilled Authorized Consumption is the difference between Non-Revenue Water and Water Loss. The two equations below summarize how each is calculated:

o   Non-Revenue Water = Apparent Losses + Real Losses + Unbilled Authorized Consumption

o   Water Loss = Apparent Losses + Real Losses

Water loss in the system equates to lost revenue for the utility. It is critical to the success of any water utility to manage and minimize water loss. In response to the need for consistent water loss auditing and benchmarking, the AWWA released Version 5 of their audit software in August 2014. This tool is focused on identifying water distribution system losses, not water treatment losses. This smart Microsoft Excel based audit program offers water utilities a tool to accurately and consistently identify, record, trend and benchmark the apparent and real losses in their water system. The audit provides a roadmap to help utilities reduce water waste and better prioritize infrastructure investments by identifying water losses that are viable to eliminate and are economically recoverable. Another benefit of the audit is that it provides a measuring stick by which to compare against past performance of other similar sized utilities. By completing the audit, several operational efficiency and financial performance indicators are calculated which will be discussed in a later section of this report.

3.0   Water Loss Audit Results (2016-2019)

The M36-based water audit software provides an array of performance indicators that allow for comparison of the utility to themselves from year to year to determine if they are improving or falling behind. These performance indicators are outlined within this section.

Non-Revenue Water Reduction Strategies

3.1 Historical Water Usage

Per the AWWA Manual M36, a focus on the Data Validity Score is the first critical step to reducing water loss. In terms of data validity, the key entries are the treated water use and billed water use confidence. Gaining confidence in the data entered into the audit form is the first step in managing the City's Non-Revenue Water.   The closer the Data Validity Score is to 100, then the higher level of accuracy/confidence exists in the data.

3.2 Unavoidable Real Losses (UARL)

In every utility, a certain amount of real losses is inevitable. The software, based on the M36 Manual, provides a calculation of this "unavoidable" real loss based on the length of water main within the system, the number of services, and the average pressure in the system. The City of Joliet's UARL is estimated to be 364 million gallons (MG)/year.

3.3 Annual Cost of Apparent Losses

Apparent Losses are the non-physical losses such as unauthorized consumption (water theft), meter inaccuracies, systematic data handling errors, etc. Ultimately, these losses directly impact the amount of water that can be billed. Therefore, the cost of the apparent losses is calculated based on the retail unit cost for water (i.e. the cost per gallon to operate, maintain, and manage the system, including capital improvement projects).

3.4 Annual Cost of Real Losses

Real losses are the physical losses from the distribution system and storage tanks up to the point of connection to the customer meter. These types of losses do not correlate to less water use. To illustrate, if a water main break occurs, the water lost during the break and fixing the break is not water that otherwise would have been billed to a customer. Therefore, the only financial loss to the City for real losses are the operational costs. For utilities that supply and treat their own water, the operational costs are relatively low because they typically only include water supply and treatment labor, chemical, electrical, and possibly natural gas costs. However, if the City of Joliet moves to purchasing Lake Michigan water from the City of Chicago, the cost of the real losses will likely include higher operational costs such as the retail cost from the City of Chicago, in addition to any labor, chemical and electrical costs needed to distribute the water throughout the City of Joliet's system safely and sufficiently.

3.5 Non-Revenue Water and Water Loss as a Percent of Volume of Water Supplied

Joliet's Lake Michigan allocation will be subject to the State of Illinois' Level of Lake Michigan Act [615 ILCS 50] which then must meet the requirements of the 17 Illinois Administrative Code Ch. I Section 3730 Rules Allocation of Water From Lake Michigan which was updated in 2014. Under these requirements, Non-Revenue Water must be less than 10% of the Lake Michigan water used and the permittee must outline an action plan with timelines to reduce the Non-Revenue Water accordingly.

Non-Revenue Water Reduction Strategies

3.6   Infrastructure Leakage Index (ILI)

A common operational efficiency performance indicator that many utilities refer to is the Infrastructure Leakage Index (ILI). The ILI is a comparison benchmark that focuses on real losses. The ILI is calculated by dividing the current annual real losses (CARL) by the Unavoidable Real Losses (UARL). The ILI score ranges from 0 to 10 with a lower score representing a more robust and efficient distribution system.

In addition to the performance indicators specifically identified above, several other ones are calculated as well and are intuitive by name. These include the following:

- o   Non-Revenue Water as Percent of Operating System

- o   Apparent Losses Per Service Connection Per Day

- o   Real Losses Per Service Connection Per Day

- o   Real Losses Per Length of Main Per Day

- o   Real Losses Per Service Connection Per Day Per psi of Pressure

3.7   Water Audit Metric Comparison

Currently, there are no non-revenue water, or water loss, regulatory requirements or standards that apply to the City of Joliet. However, to establish a reasonable goal for non-revenue water, it is recommended that the benchmarking indicators of other utilities be reviewed for comparison. In 2011, as a result of a water audit data collection initiative, the AWWA Water Loss Control Committee created its first dataset of validated water audit data. The data has been posted for review by water utility stakeholders. AWWA has subsequently provided brief updates since that time. The document is titled Validated Water Audit Data for Reliable Utility Benchmarking. In 2017, seventeen (17) utilities provided their water audit data for review and careful validation by members of the Committee's Water Audit Software Subcommittee. Data from the entire group of utilities was assembled with results that document the 2017 North American benchmark performance indicators using the AWWA water audit methodology. This is a significant step toward improving the level of accountability and the robustness of water audit data within North America.

Table 1 presents a comparison of the City of Joliet's performance indicators alongside the North American Data set in 2017.

Non-Revenue Water Reduction Strategies

Table No. 1: Water Audit Summary and Comparison

Key Performance Indicators	FY2016	FY2017	FY2018	Federal FY 2019	North American Data Set (2017 Average)
System Attributes					
Apparent Losses (MG/Year)	612.4	602.8	613.0	596.3	NA
Real Losses (MG/Year)	1,395.6	1,224.0	1,489.1	1,377.3	NA
Total Water Loss (MG/Year)	2,007.9	1,826.8	2,102.1	1,973.6	NA
Unavoidable Real Losses (MG/Year)	323.8	323.8	363.5	364.4	NA
Financial Indicators					
Non-Revenue Water as Percent by Volume of Water Supplied:	33.9%	32.4%	34.9%	34.5%	NA
Non-Revenue Water as Percent by Cost of Operating System:	23.4%	25.8%	33.6%	28.3%	10.1%
Annual Cost of Apparent Losses:	$ 2,137,110	$ 2,326,911	$ 3,291,754	$ 3,184,575	N/A
Annual Cost of Real Losses:	$ 891,539	$ 824,117	$ 641,030	$ 695,018	N/A
Total Annual Cost of Water Loss:	$ 3,028,649	$ 3,151,028	$ 3,932,783	$ 3,879,593	N/A
Operational Efficiency Indicators					
Apparent Losses Per Service Connection Per Day (gallons/connection/day):	35.8	35.3	31.4	30.5	11.0
Real Losses Per Service Connection Per Day (gallons/connection/day):	81.7	71.6	76.3	70.5	67.0
From Above, Real Losses = Current Annual Real Losses (CARL) (million gallons/year):	1395.6	1224.0	1489.1	1377.3	NA
Infrastructure Leakage Index (ILI) [CARL/UARL]:	4.31	3.28	4.10	3.78	3.13
Validity Score	53	54	65	65	80

## 3.8   Non-Revenue Water Distribution

A common operational efficiency performance indicator that many utilities refer to is the Infrastructure Leakage Index (ILI). As discussed in Section 2, NRW is comprised of Apparent Losses, Real Losses, and Unbilled Authorized Consumption. Exhibit A provides the distribution of NRW volume amounts and percentages for the City of Joliet 2019 water loss audit.

Non-Revenue Water Reduction Strategies

Exhibit A: 2019 Non-Revenue Water – Components By Volume
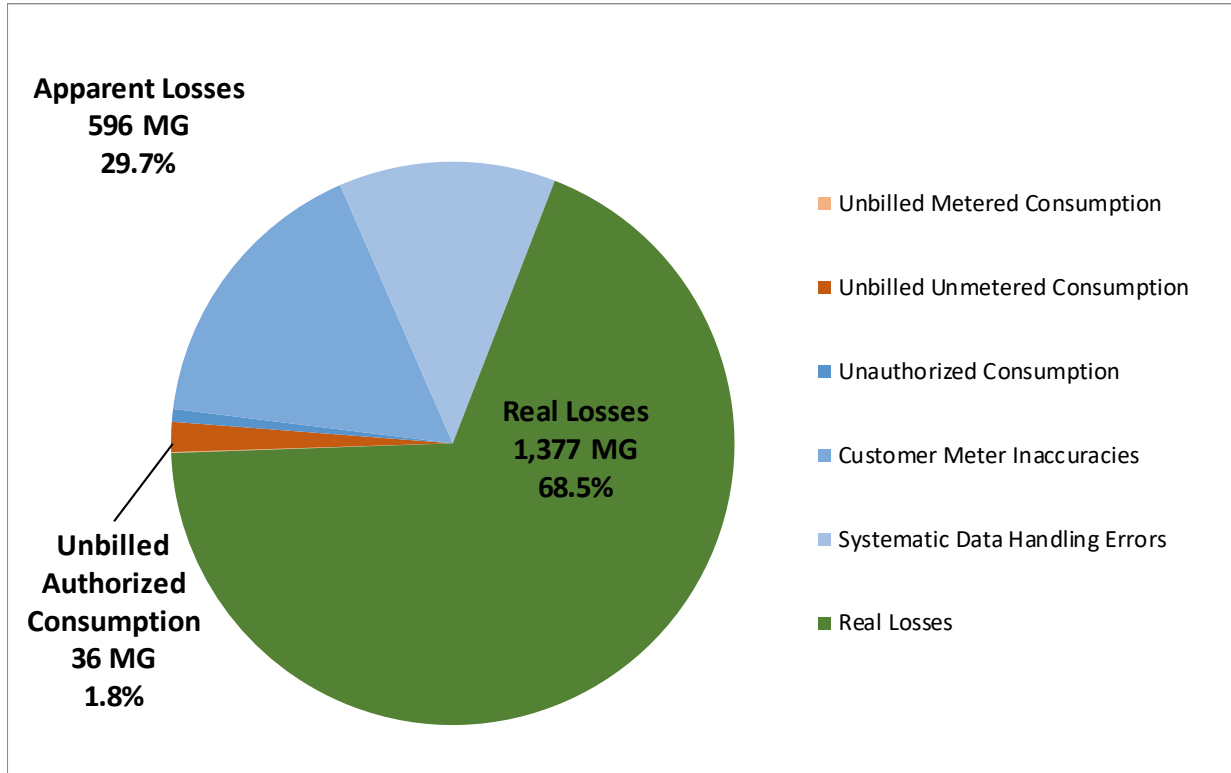
The blue pie shapes are associated with apparent losses, green aligns with real losses, and the orange aligns with the Unbilled Authorized Consumption. From a volume perspective, real losses clearly account for the majority of the NRW. However, when comparing the costs associated with losses, as is shown in Exhibit B, the value of the apparent losses becomes greater than the real losses due to the minimal operational costs associated with the current water distribution system that is based on well supply and treatment.

Exhibit B: 2019 Non-Revenue Water – Components By Cost
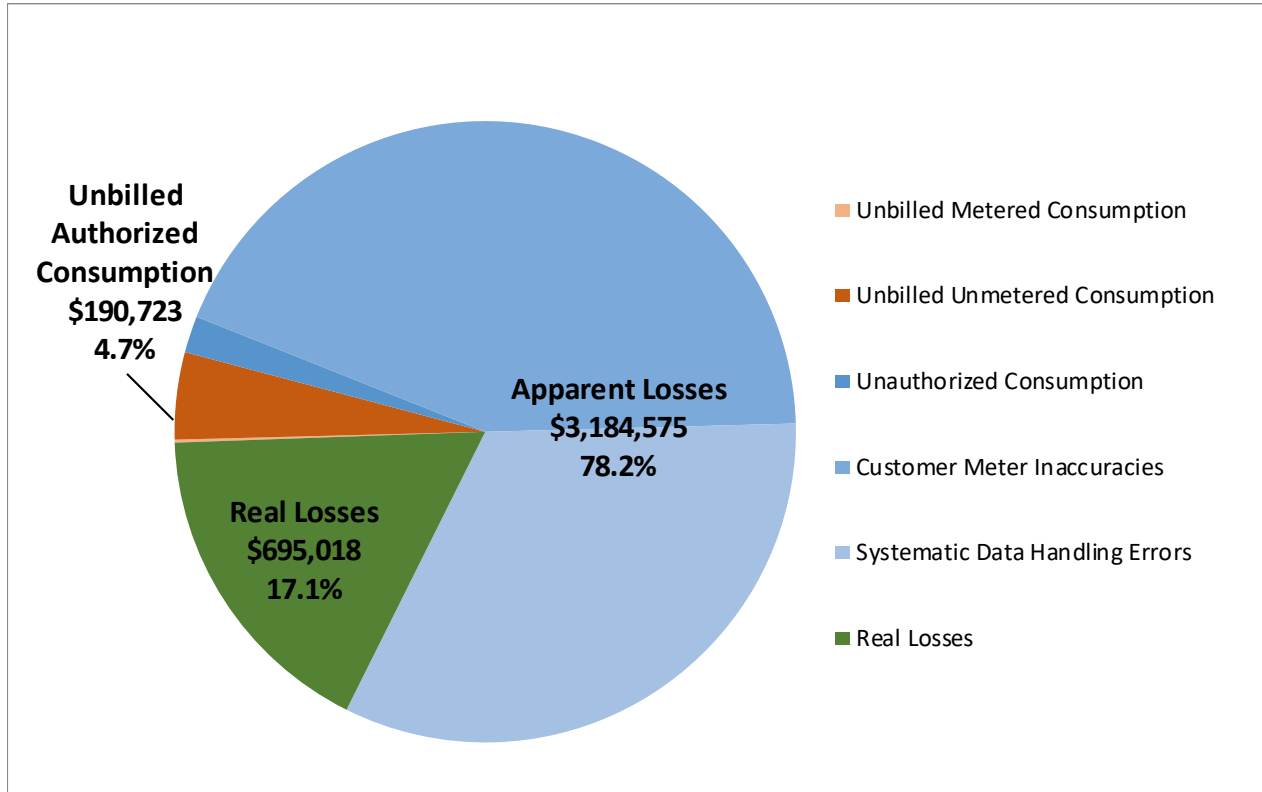
It is worth noting that the unavoidable water loss calculated by the M36-based software is approximately 6%. No distribution system is perfect, and unavoidable water loss is that which would typically be expected in the distribution system. This 6% of unavoidable real loss is less than the 10% maximum NRW requirements of a Lake Michigan supplied system.

Non-Revenue Water Reduction Strategies

4.0   Non-Revenue Water Reduction Motivation

Since a Lake Michigan allocation is sought, the Illinois Department of Natural Resources (IDNR) requires all permittees to submit an annual water audit form (LMO-2). The LMO-2 form details the amount of water used, sold and lost by a permittee in the past water year (October – September) and also utilizes the M36 methodology. This form is used to track individual users' compliance with the conditions of their allocation permits. By regulation, all permittees shall have a NRW percentage below 10%. If the permittee's NRW percentage is above 10%, the permittee is required to submit a Non-Revenue Water Reduction Plan to IDNR. The City of Joliet City Council has memorialized its commitment to achieve the 10% NRW requirement by passing Resolution No. 7613 on January 5, 2021 stating that goal.

5.0   Non-Revenue Water Reduction Strategy & Action

A robust NRW strategy addresses Apparent and Real Losses simultaneously. Table No. 2 summarizes the recommended actions and associated timeframes. The recommendations are divided into Apparent Losses and Real Losses as well as time periods (Short-Term, Mid-Term, Long-Term).

Non-Revenue Water Reduction Strategies

Table No. 2: Non-Revenue Water Reduction Strategies

Apparent Losses		
Short-Term		**Anticipated Deadline**
	Annual water loss audit completion	On-going
	Flowchart the customer billing process for various users (residential, commercial, exported)	2021
	Initiate an Education and Outreach Program to City Staff Regarding Water Efficiency and Water Loss Reduction Strategies for Operations	Complete
	Provide fire hydrant meters to all Public Works staff to better track water used by City Staff	2021
	Implement bulk water stations	2021
	Perform bench testing on customer meters for accuracy	2021
	Audit billing records and visit sites/customers to determine potential missed billings	On-going
	Implement new ordinance/procedures to meter all construction related water use	Complete
	Implement Sensus Analytics at Joint meeting(s) with Water Staff, Billing, and meter manufacturer	Complete
	Request the third-party contractor who performs customer meter testing to provide a summary spreadsheet in Excel of the meters, size, and meter accuracy	On-going
	Prepare and implement illegal water use policies/ordinances	On-going
	Exported Water Users Improvement	
	Install meter(s) for SEJSD	Complete
	Inventory Customer Meters and Develop a Customer Meter Change-out Program	2021
Long-Term		
	Implement improvements based on discovered AMR capabilities	TBD
	Consider simplifying rate structure to minimize potential billing errors	2025
	Conduct exported water meter replacement programs	TBD
Real Losses		
Short-Term		**Anticipated Deadline**
	Conduct water main break analysis	Complete, Continue to Monitor
	Hydraulic analysis to review pressures	Complete, Continue to Monitor
	Leak detection (Annual)	On-going
	Increase water main replacement program based on NRW desired goals	2022
	Investigate the Potential of implementing District Metered Areas (DMAs) or, at a minimum, areas that could potentially just be monitored to better narrow down the locations of water loss.	Complete
Mid-Term		
	If applicable (once DMAs are reviewed), construct the necessary valves, meters, and distribution improvements to implement smaller metered areas or DMAs to better narrow down the location of the water loss.	2023
Long-Term		
	Monitor water main replacement rate and water reduction to determine impact on NRW and adjust accordingly	On-going

5.1 Apparent Loss Reduction Strategy and Action Plan

Additional explanation of the short-term strategy and action plan for apparent loss reductions is as follows:

a. Annual Water Loss Audit Completion – The City began preparing detailed audits in 2016 and is intending to continue to complete them on an annual basis.

b. Flowchart the customer billing process for various users (residential, commercial, exported) - Develop a flowchart to track the customer meter reading and billing process as a starting point to reduce the apparent water losses. Identify any loopholes in the process where errors could occur.

c. Construct and implement three bulk water stations to replace current paper tracking system for sale of water to contractors

d. Meet with Water Staff, Billing, and meter manufacturer to identify the most accurate reporting tools for billed water use. Create standard reports that can be prepared routinely with minimal effort to obtain the following information on any time interval:

    I. Exported Water Use (The Exported Water Use should be audited by the Public Utilities Department every billing cycle and the water use trended.)

    II. Billed Metered Water Use

    III. Unbilled Metered Water Use

    Furthermore, the goal is to eventually be able to provide this metered water data from a specific date to another specific date (i.e. 10/1/20 through 9/30/21).

e. Exported Water Users Improvement – Install meters for Southeast Joliet Sanitary District (SEJSD) [Note: Completed in July 2020]

In addition to the items above, the City should continue with the initiatives that they began that were mentioned in the introductory part of this section (i.e. continue with annual master meter testing program at distribution entry locations, continue with the annual meter testing program for majority of the Exported Water Meters, etc.)

5.2 Real Loss Reduction Strategy and Action Plan

From a volume perspective, real losses comprise the bulk of the water losses. Additional explanation on short-term strategies to reduce real loss reductions are as follows:

a. Conduct water main break analysis – Over the last three years, the City has averaged approximately 250 water main breaks per year. The City of Joliet's Water System Master Plan Report, dated August 2019, provides concise priorities and recommendations for water main replacement. Although the water main break analysis was based on various criteria, one critical

item noted was that the majority of the on-going water main breaks occur in the old cast iron/ductile iron pipe installed from the 1940s through the 1960s. While the mains installed from the 1940s to 1960s only comprise 19% of mains in the system, 62% of the breaks analyzed occurred in the mains installed in that time period. Based on this simple analysis, it would seem the City should focus on replacing the mains from this era first along with the older mains that are also experiencing higher than the desirable break rate. Additional discussion and information regarding the recommended water main replacement program is provided later in this report.

Based on AWWA Partnership for Safe Water, 2011, a fully optimized system has a maximum of 15 breaks per 100 miles per year. Furthermore, per AwwaRF Report 91165, "Main Break Prediction, Prevention and Control," Neil S. Grigg, 2007, a maximum acceptable level of breaks for a distribution system is 25 to 27 breaks per 100 miles of water main per year. In a period of 7 years (2012-2018), 811 breaks occurred in approximately 121 miles of water main, which translates to an average of 96 breaks per 100 miles per year. At this level, the City of Joliet's water main break rate is nearly 4X the maximum acceptable rate and over 6X a fully optimized system.

Furthermore, in addition to the water main break analysis, it is recommended to evaluate the water main break repair process and determine if some breaks can be repaired in a shorter period of time. Track the time reported versus time repaired, the type of leak, the size of leak, etc.

b. Hydraulic analysis to review pressures - This was completed as part of the Water System Master Plan Report dated August 2019. The higher the pressure, then the higher the amount of real water loss that is produced in the system. Therefore, the City should confirm with the model, and through needs assessment calculations for supply and storage, determine whether it is viable to reduce pressure in certain sections of the City or across the whole distribution system. If feasible, without hindering domestic and fire flow service capabilities, the City should consider reducing pressure either across the system or in certain sections of the City to minimize the real losses.

c. Leak detection (Annual) - Continue annual leak detection efforts.

d. Review the potential of implementing District Metered Areas (DMA) or, at a minimum, areas that could potentially just be monitored to better narrow locations of water loss. DMA's would be challenging to create given the complex water main network and elevations across the City. However, it may be beneficial to place meters at certain locations to better verify potential locations of water loss.

e. Increase water main replacement program based on NRW desired goal – The Water System Master Plan recommends a water main replacement program of 1% per year (or replacement of water main every 100 years). For reference, the Utah State Water Main Break Study recommends planning to replace water main every 60 to 100 years (i.e. 1.6% to 1.0% of the total water main per year).

Every water distribution system is unique and has different NRW goals. For well sources, the primary motivation for water loss reduction is the combined need of being a good steward of a
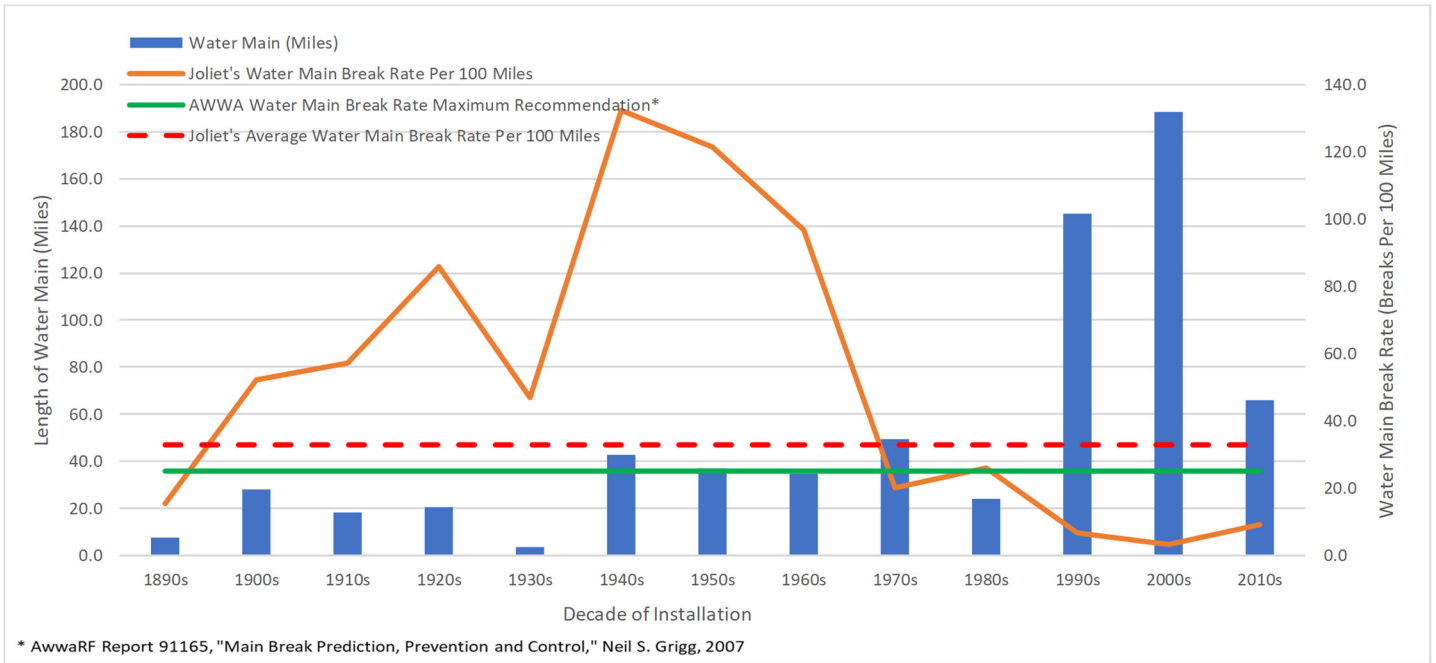
limited resource while balancing an appropriate financial investment into the program to minimize rate increases. However, for Lake Michigan water, the City will also have to contend with achieving the regulatory requirement of a maximum of 10% NRW. It is likely that the current anticipated annual expenditure level of $8M to $10M will not allow the City to meet this regulatory goal in a reasonable duration.

To reduce the real losses more aggressively to meet the Non-Revenue Water requirements set forth for Lake Michigan permittees, a more robust and targeted water main replacement program will be required. Therefore, a detailed water main study that included a water main inventory and water main break analysis was completed to determine the most problematic mains and to develop a water main replacement program. A historical analysis of water main breaks based on the age of the water main installation date was completed and is summarized in Table No. 3 and Exhibit C below:

Table No. 3: Water Main Length By Year of Install and Main Breaks

Decade of Installation	Length of WM (Miles)	Water Main Length (%)	Length of WM (Miles) (Aggregate)	Water Main Length (%) (Aggregate)	# of Main Breaks	Breaks Per 100 Miles
1890s	7.6	1.1%	7.6	1.1%	7	15.4
1900s	28.1	4.2%	35.7	5.4%	88	52.3
1910s	18.0	2.7%	53.7	8.1%	62	57.3
1920s	20.5	3.1%	74.3	11.2%	106	86.0
1930s	3.6	0.5%	77.8	11.7%	10	46.8
1940s	42.9	6.4%	120.7	18.1%	340	132.2
1950s	37.0	5.6%	157.7	23.7%	270	121.5
1960s	34.6	5.2%	192.3	28.9%	201	96.9
1970s	49.3	7.4%	241.6	36.3%	59	20.0
1980s	23.8	3.6%	265.4	39.9%	37	25.9
1990s	145.1	21.8%	410.5	61.7%	57	6.5
2000s	188.6	28.4%	599.1	90.1%	37	3.3
2010s	66.0	9.9%	665.1	100.0%	36	9.1
Total	**665.1**	**100.0%**			**1310**	**197.0**

Exhibit C: 2013 - 2018 Water Main Breaks & Breaks Per 100 Miles

* AwwaRF Report 91165, "Main Break Prediction, Prevention and Control," Neil S. Grigg, 2007

As shown in Exhibit C, the water mains that result in water main break rates above the recommended maximums are those water mains that were installed prior to 1970. In addition, the City also identified some additional water mains installed in the 1980s and 1990s that have higher than desired water main break rates. Consequently, to address the water mains that have higher than desired water main break rates, approximately 192 miles of water main will need to be replaced. By replacing approximately 3.2% of water main annually, the City will reach this replacement goal by 2030. This is anticipated to reduce the amount of real losses by approximately 17% per year, ultimately allowing the Non-Revenue Water to reduce to 9.7% by 2030. A summary of the water main replacement program by installation year is provided in Table No. 4 below:

Table No. 4: Water Main Replacement Program 2022-2030

	Water Main To Be Replaced per Decade															
Project Year	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020	Total (ft)	Total (miles)
Miles of Main	7.6	27.4	18.0	20.5	3.6	42.9	28.4	32.4	49.3	23.6	145.1	188.6	66.0	11.7	3,511,694	665.1
Target Replacement Rate (mi/yr)	0.8	3.1	2.0	2.3	0.4	4.8	4.1	3.8	-	-	-	-	-	-	-	-
Target Replacement Rate (ft/yr)	4,457	16,054	10,586	12,052	2,091	25,143	16,685	19,023	-	-	-	-	-	-	-	-
2022	1,700	13,100	10,600	12,100	2,100	27,000	23,800	20,000	0	2,000	0	0	0	0	112,400	21.3
2023	1,000	13,000	10,600	12,100	1,000	27,000	19,200	19,300	0	0	9,200	0	0	0	112,400	21.3
2024	2,000	15,400	10,400	12,100	2,100	27,000	21,600	21,800	0	0	0	0	0	0	112,400	21.3
2025	4,500	13,000	10,000	11,000	2,100	25,700	23,200	19,600	3,300	0	0	0	0	0	112,400	21.3
2026	4,500	15,200	8,000	11,000	2,100	27,000	25,500	19,100	0	0	0	0	0	0	112,400	21.3
2027	3,000	11,300	11,000	12,500	2,100	27,000	23,500	20,000	2,000	0	0	0	0	0	112,400	21.3
2028	5,000	16,900	11,000	15,000	2,100	27,000	13,400	20,000	2,000	0	0	0	0	0	112,400	21.3
2029	7,300	24,000	11,000	17,000	2,100	27,000		20,000	4,000	0	0	0	0	0	112,400	21.3
2030	11,100	22,600	12,700	5,700	3,100	11,600		11,400	34,200	0	0	0	0	0	112,400	21.3
Total (ft)	40,100	144,500	95,300	108,500	18,800	226,300	150,200	171,200	45,500	2,000	9,200	0	0	0	1,011,600	
Total (miles)	7.6	27.4	18.05	20.5	3.6	42.9	28.4	32.4	8.6	0.4	1.7	0.0	0.0	0.0		191.6

This rate of replacement would eliminate the majority of the main constructed prior to 1970, which has been more prone to water main breaks. If the real loss reduction achieves that goal, the real losses would be very close to the Unavoidable Real Loss value calculated by the AWWA software. Furthermore, the analysis also assumed through the Apparent Loss action plan items, approximately 2.5% annually will be reduced through 2035 where the effects will equalize and be maintained through continued efforts.

6.0   Recommendations/Conclusions

It is recommended the City integrate a multi-faceted approach by implementing both Apparent and Real Loss reduction strategies to proactively manage and reduce the NRW below 10% by 2030.   Furthermore, it is recommended the City continue to focus on improving its data validity in the process.

From an apparent loss perspective, investigating and rectifying the systematic data handling inconsistencies is an initial critical step to reducing the water losses which will also result in a higher confidence in the data presented.   Several other apparent loss reduction strategies have also been identified such as a developing a customer meter accuracy testing program.

From a real loss perspective, the City intends to replace 3.2% of the water main annually to achieve a goal of a maximum of 10% NRW by 2030, which is estimated to equate to a 17.0% annual reduction rate at an estimated annual amount of $33,700,000. It has been determined the water mains with the highest break tendencies are the mains installed prior to 1970. By replacing 3.2% of the water main annually through 2030, 100% of the water main constructed prior to 1970 will be replaced. Such a program shall be monitored in tandem with the water loss audit initiatives to confirm and justify progress over time. Exhibit D graphically depicts the projected Apparent and Real Losses along with the NRW percentages from 2019 through 2030.

Exhibit D: Projected Apparent and Real Losses Assuming 3.2% Annual Water Main Replacement

Non-Revenue Water Reduction Strategies
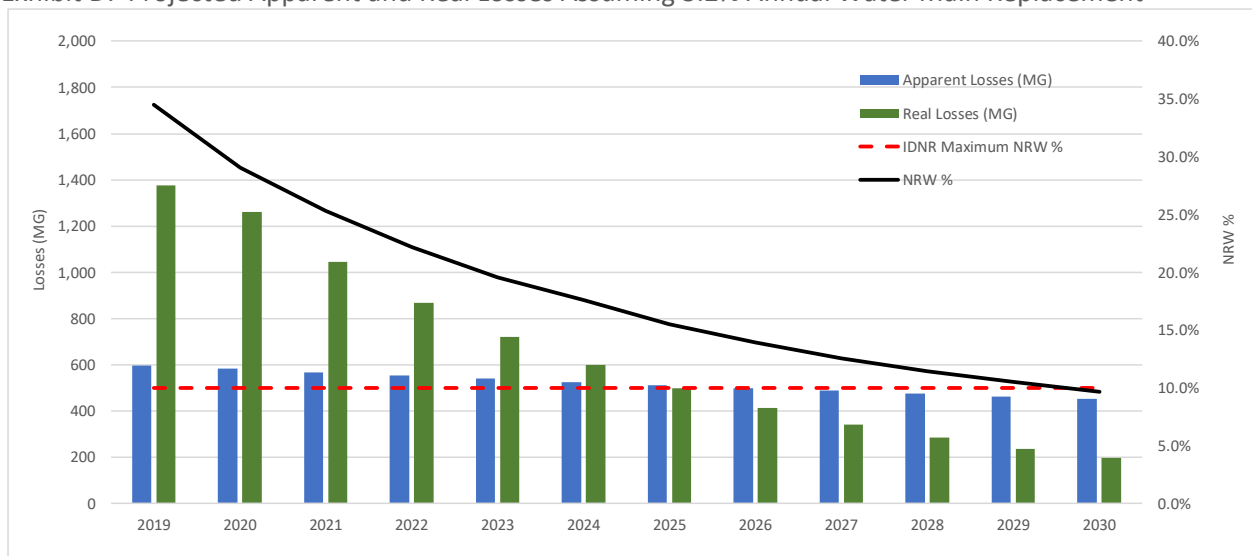
A detailed list of both the Apparent and Real Loss reduction strategies that are intended to be implemented is identified in Table No. 2 earlier in the report. However, the NRW Reduction Plan is intended to evolve as strategies are implemented and information is processed and uncovered. Therefore, the NRW Reduction Plan shall be reviewed, reevaluated and modified as appropriate on an annual basis in conjunction with the completion of the annual water audit.