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Water Audit Update FY2008 – FY2017

Technical Memorandum

Sewerage and Water Board of New Orleans

March 4, 2019

Water Audit Update
Sewerage and Water Board of New Orleans
Fiscal Years 2008 – 2017

Technical Memorandum

To: Yvette Downs, Chief Financial Officer, SWBNO

From: Nora Freeman, Freeman LLC

Date: March 4, 2019

Executive Summary

Introduction
A water audit update for the Sewerage and Water Board of New Orleans (SWBNO) was performed using the standard methodology outlined in the American Water Works Association's (AWWA) M36 Manual: *Water Audits and Loss Control Programs.* This methodology was co-developed by AWWA and the International Water Association (IWA) and includes specific steps to conduct the audit along with standard definitions.

The objectives of the water audit update were to: 1) prepare the FY2016 and FY2017 Infrastructure Leak Index (ILI) without additional data development and field work; 2) document source data; 3) identify water audit key indicator trends over the last ten years (FY2008 – FY2017); 4) provide benchmark data from other water utilities that publish their ILI; and 5) present recommendations to improve the SWBNO ILI.

Audit Methodology
A water audit is an account of all the finished water within the water system and provides a quantified understanding of the integrity of the water system including distribution, metering and billing operations. The water audit can be used as a first step in formulating a plan to address water losses and includes financial considerations.

At the macro-level, the water audit consists of:

1. Determining the volume of finished water input into the distribution system over a 1-year timeframe

2. Calculating Authorized Water Consumption over that same 1-year timeframe
    a. Authorized consumption includes both billed metered water and unbilled metered water. Unbilled metered water is water that is metered but no use or service fee is collected for that water use. Unbilled metered water is often used for public purposes such as street cleaning, filling municipal swimming pools, a water quality flushing program, etc.

3. Calculating Water Losses (water losses = system input volume – authorized consumption), which have 2 components for quantification:
    a. Apparent Losses, which includes estimates for: 1) customer metering inaccuracies, 2) water theft and illegal connections and 3) data handling issues and errors in the billing system

    b. Real Losses, which includes estimates for: 1) transmission and distribution main leakage and 2) service connection leakage

The water audit performed for SWBNO is called a "top down" water audit because it used only readily available utility data with no new field work for data collection or data validation. This kind of "top down" audit is how most utilities begin their first water audit efforts. SWBNO is restricted, however, in its ability to extract data from the current information systems and thus inputs and estimates in the water audit are quite limited. The computation of both Apparent and Real Water Losses for the audit were most impacted by the difficulty of data extraction from current information systems, with almost no estimation occurring in these categories. Due in part to existing data constraints, this water audit shows considerable Water Loss for SWBNO.

Audit Results

The AWWA water audit methodology contains eight performance indicators that summarize utility performance with both financial and operational measures. The eight performance indicators are useful to compare performance of one utility over time and well as to compare performance amongst utilities for benchmarking purposes, and are included in the body of the report. Of the eight performance indicators, there are two key performance indicators that are most useful to summarize here and discuss: the Infrastructure Leak Index (ILI) and Non-Revenue Water (NRW).

The ILI is a performance indicator of the real (i.e., physical) water loss from the distribution system. It is a ratio of the annual real water loss to the technically lowest limit of water leakage that could be achieved if all of today's best technology could be successfully applied, which is based on the utility's miles of water main, system pressure, number of metered connections and average length of the service line from a curb-stop to the customer's meter. ILI is an index number that makes comparison of ILI between water utilities possible. A low ILI is more favorable than a high ILI.

SWBNO's ILI has decreased over the last ten years of audits. The ILI in SWBNO's first audit in FY2008 was 46.0, reached a high in FY2009 of 46.6, achieved a low of 34.7 in FY2015 and was 36.9 in FY2017.

Non-Revenue Water (NRW) is defined as water that was treated but not billed to a consumer because of water losses or unbilled authorized consumption (e.g., street cleaning, distribution system flushing). NRW calculated as a percentage of the annual cost of running the water system is a key indicator that represents inefficient use of water resources and can help utilities decrease water costs while also increasing billing revenue, in an effort to keep rate increases minimal.

Along with the ILI, SWBNO's NRW as a percentage of cost has also decreased in the last ten years of water audits. The NRW as a percentage of cost in SWBNO's first audit in FY2008 was 22.9%, reached a high in FY2009 of 24.3%, achieved a low of 16.2% in FY2011 and was 18.9% in FY2017.

SWBNO's ILI and NRW as a percent of cost for the past ten years is as follows:

Fiscal Year	ILI	NRW % by Cost
2008	46.0	22.9%
2009	46.6	24.3%
2010	41.9	20.1%
2011	44.7	16.2%
2012	43.2	16.5%
2013	36.8	17.1%
2014	37.1	16.5%
2015	34.7	17.5%
2016	37.5	20.8%
2017	36.9	18.9%

Benchmarking

SWBNO performance indicators were benchmarked against the first and only validated water audit data set from North American water utilities, which was performed in 2011. Twenty-one utilities provided their detailed water audits to members of the AWWA Water Loss Control Committee for review and careful validation of the inputs, assumptions and methodology.

The NRW percent by cost and ILI for these twenty-one utilities are shown below and contain the average and a minimum and maximum range for each key performance indicator. SWBNO's FY2017 results are presented in the last column for comparison.

Validated Key Performance Indicator	Average Utility	Range	SWBNO FY2017 Results
NRW % by Cost	10.0%	1.7% - 23.0%	18.9%
ILI	3.6	1.2 – 12.7	36.9

Although SWBNO's ILI has decreased over the last ten years, this key performance indicator is not in a range of other water utilities benchmarked. NRW as a percent of cost is within the range of the twenty-one benchmarked utilities yet still significantly above the average. The major reason for the differences in SWBNO's ILI and NRW as a percent of cost key indicators and benchmarked utilities is due to SWBNO's lack of estimates for both Apparent Losses (metering inaccuracies, water theft/illegal connections, billing/data handling errors) and Real Losses (water main and service connection leakage).

Recommendations

1. The first step recommended to improve SWBNO's ILI is to allocate resources to reduce the data gaps in the water audit inputs. This will require creating estimates for Apparent and Real Water Losses by extracting data from current information systems, perhaps new field work and making reasonable assumptions and estimates. This work is essential to develop reliable assumptions based on SWBNO's actual operations.

2. To close the water audit data gaps, it is recommended that a cross functional team be established consisting of members who intimately understand the processes and work flows in Metering, Distribution and Plant Operations, Engineering, Customer Service, Customer Billing, Information Technology and Finance departments. One member of the team should be identified to lead and organize the group, but all team members should share in the responsibility and accountability for the audit work. Ideally over time, the water audit can be updated on a regular basis (annually or every other year) by these team members and it will become part of a larger utility effort at water loss control.

3. As SWBNO works to develop estimates for Apparent and Real Water Loss component of the audit, SWBNO should also take the opportunity to examine and ensure the accuracy of the Water System Input Volume. This figure relies almost exclusively on the exactness of the SWBNO production master meters. The testing results and routines for these production meters should be considered, and adjustments to the System Input Volume made accordingly.

4. Once additional water audit inputs are obtained, SWBNO can prioritize implementation of water loss control programs that are likely to have the most positive impact on revenue and water losses and are also cost-effective. Activities that positively impact revenue most tend to be within the Apparent Losses category of the audit and can include improved meter testing and repair practices for residential, commercial and/or industrial customers, enhanced enforcement programs to deter water theft and streamlined billing practices that catch and correct under-billing errors more quickly.

5. Efforts to improve Real Losses should also be evaluated, which include opportunities to improve the integrity of the SWBNO distribution system. Considerations may involve the cost-effectiveness of expanded distribution and transmission main survey efforts to identify leaks on active mains or abandoned service lines, response and repair time for

main breaks when they occur, along with maintenance efforts to repair leaks on service lines before the meter.

6. Current SWBNO databases should be examined to identify low-cost data capture techniques and estimate for authorized water losses around fire-fighting, fire hydrant testing, water main flushing, finished water storage tank turnover or drainage. These activities are part of every water utility's normal operation and involve water losses that if quantified in the audit will improve data and decision-making for which system and operational improvements and investments are most cost-effective.

7. NRW can be impacted by the above efforts and also by examining unbilled authorized consumption and "free water" provided to public services and/or agencies. The water industry as a whole has moved to greater accountability for all its water use, including water that is provided for public or charitable purposes. Many utilities in the country use an inter-fund transfer for payment of water and related services to other city or public agencies/departments.

8. SWBNO should only consider target-setting for its ILI once additional data can be validated and input into the water audit for the Apparent and Real Water Losses components. When that is complete, which may take several years, AWWA recommends that ILI target-setting be an internal process for each utility and that the goal should be improvement to the ILI over time, not reaching some "ideal target" or mean of ILI comparable utilities.

Summary

A water audit is an effective means of accounting for all water used within a water utility. The structured approach provided by the AWWA water audit methodology allows a utility to reliable track water use and provides information to address water losses as well as revenue losses.

SWBNO's "top down" water audit was performed using no new data collection and relied solely on data easily available from existing information systems. Unfortunately, there was not much data that could be easily extracted from these systems so the audit includes very few estimates of Real or Apparent Losses. The result is that the audit's key performance indicators that are not reasonably comparable to other water utilities, not within a range of AWWA recommendations, and not yet helpful to decision-making about how to reduce water loss most cost-effectively.

SWBNO staff is to be commended, however, for taking these first steps in a "top down" audit to understand their current water accounting opportunities and data shortfalls. SWBNO has a tremendous opportunity to use this audit work to: 1) create awareness within the utility about the important role a water audit can play in water loss control; 2) authorize staff across the utility to collaborate on closing water audit data gaps; 3) revise audit inputs; and 4) create a water audit management tool that facilitates discussions across departments about the most cost-effective ways to reduce water loss in the future.

Introduction

The water audit performed used data available from SWBNO and the standard methodology outlined in the AWWA M36 Manual: *Water Audits and Loss Control Programs*. This methodology was co-developed by AWWA and the International Water Association (IWA) and includes clear steps to conduct the audit along with standard definitions.

The scope of work for the SWBNO water audit included:

- Customizing the basic AWWA water audit spreadsheet software application for SWBNO, updating the FY2008 - FY2015 water audit model with FY2016 and FY2017 results;
- Gathering the data needed to populate the water audit model without additional field work;
- Documenting source data and identifying estimates used for the calculations;
- Computing SWBNO's ILI for past two years and trending water audit key ;performance indicators for the last ten years;
- Obtaining ILI data from other water utilities that publish data publicly; and
- Preparing a final water audit report along with the electronic version of the water audit model.

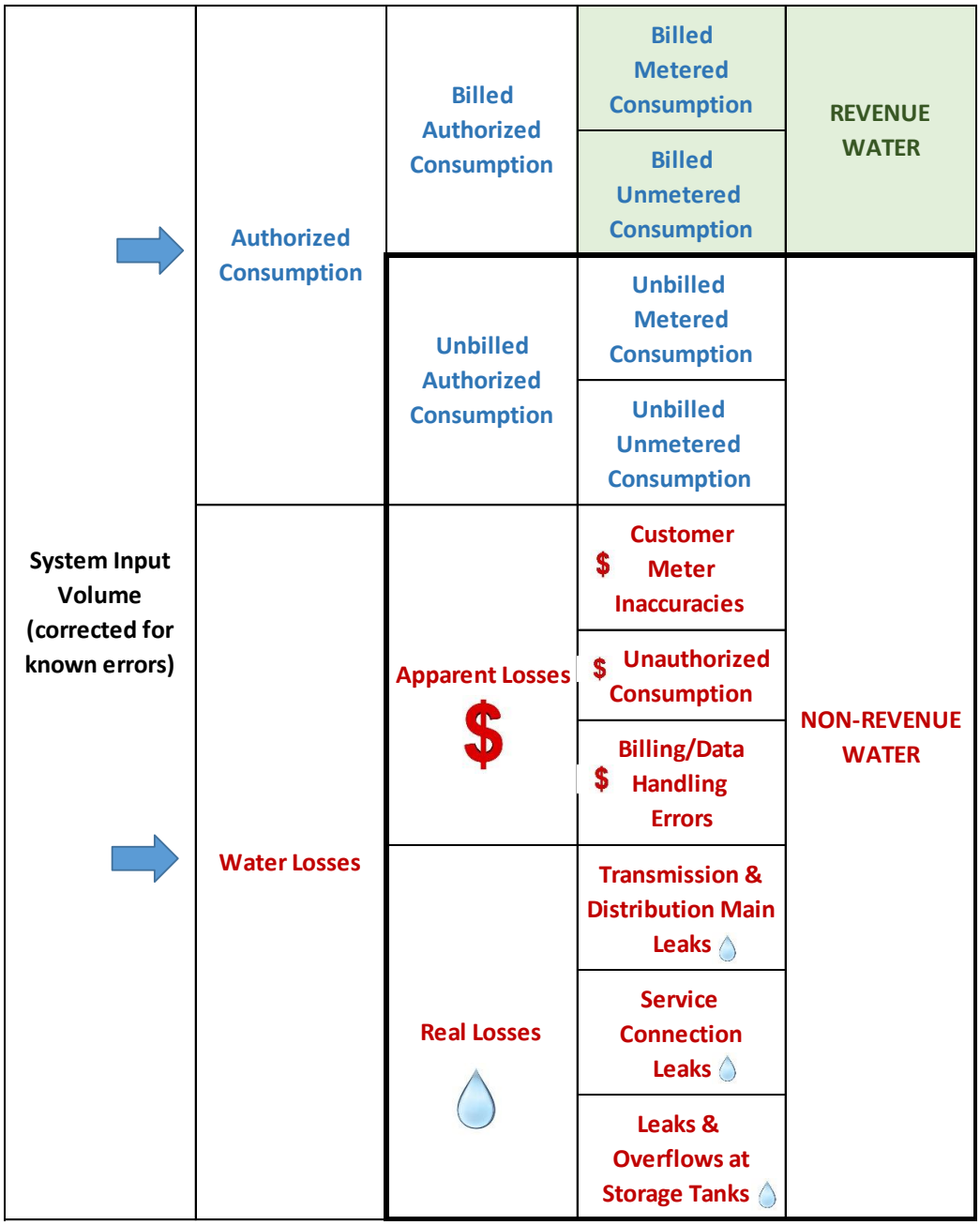
To accompany the M36 Manual: *Water Audits and Loss Control Programs*, free water audit software, in Excel format, is available on AWWA's website. The software can be found by copying or typing the below into your web browser:
https://www.awwa.org/Resources-Tools/Resources/Water-Loss-Control

The AWWA software is a useful start for those utilities that want to complete a water audit for a single year. Since SWBNO desired multiple years of data for this water audit, a more detailed water audit Excel model and workbook was built exclusively for SWBNO. This Detailed Water Audit workbook is based upon AWWA's model, the work of George Kunkel at the Philadelphia Water Department (PWD), a national leader in water auditing, and the Louisville Water Company (LWC), which has been piloting annual water audits using the new methodology, in beta form beginning in 2005. This customized Excel model will also be maximally beneficial for SWBNO's future water auditing work.

SWBNO staff are to be commended for their forward-thinking in taking this first step in improved water accounting and setting this baseline upon which future improvements in water loss control can be quantitatively measured.

AWWA Water Audit Methodology

The AWWA M36 Manual: *Water Audits and Loss Control Programs* was first published in 2009 and was last updated in 2016 with its 4th edition. The M36 manual provides definitions to standardize the calculation of water loss for the first time in US water industry's history. These standard definitions and calculations assist with target-setting for the utility along with benchmarking across utilities (although most utilities are often reluctant to share their data). The AWWA water audit methodology is based on the IWA's methodology and is summarized in the following diagram, called the Water Balance:



Definitions for the above components of the water audit can be found in Appendix A.

SWBNO Water Audit Results

The Water Audit Model and calculation spreadsheets that comprise the SWBNO Detailed Water Audit for FY2008 – FY2017 can be found in Appendix B. The results of the water audit performance indicators for fiscal years 2008 -2017 are summarized below. The change in the indicators from FY2008 and FY2017 are presented, and green indicates a change that shows improved/stronger performance. Just about all of the key performance indicators have shown improvement in FY2017 compared to FY2008. The 10-year average has also been calculated for each performance indicator.

PERFORMANCE INDICATOR	FISCAL YEAR										Change	10 Year AVG
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	FY17 vs. 08	FY08-17
Financial Indicators												
Non-Revenue Water as % by Cost	22.9%	24.3%	20.1%	16.2%	16.5%	17.1%	16.5%	17.5%	20.8%	18.9%	-4.0%	19.1%
Non-Revenue Water as % by Volume	75.1%	75.2%	71.3%	73.5%	73.8%	71.1%	72.1%	70.2%	75.2%	71.6%	-3.5%	72.9%
Water Resources Indicators												
Inefficiency of use of Water as a Resource	58.3%	59.7%	53.9%	57.0%	57.6%	54.6%	55.4%	53.4%	59.2%	55.3%	-3.0%	56.4%
Operational Efficiency Indicators												
Apparent Losses - % of System Input Volume	0.75%	0.74%	0.86%	0.80%	0.79%	0.87%	0.84%	0.89%	0.75%	0.85%	0.1%	0.8%
Real Losses per Service Connection per Day	819.4	811.8	704.5	725.7	707.5	616.9	620.0	578.1	618.6	606.9	-212.6	680.9
Real losses per Mile of Main per Day	46,931	49,695	48,565	56,731	53,730	43,074	43,752	41,253	45,768	45,046	-1,885	47,454
Real Losses per Serv Conn per Day per psi	13.2	13.1	11.4	11.7	11.4	9.9	10.0	9.3	10.0	9.8	-3.4	11.0
Unavoidable Annual Real Losses (UARL)	1.83	1.91	1.84	1.93	1.99	2.11	2.13	2.16	2.22	2.23	0.4	2.0
Infrastructure Leakage Index (ILI)	46.0	46.6	41.9	44.7	43.2	36.8	37.1	34.7	37.5	36.9	-9.2	40.6

Infrastructure Leak Index

The ILI is a performance indicator of the real (i.e., physical) water loss from the distribution system. It is a ratio of the annual real water loss to the technically lowest limit of water leakage that could be achieved if all of today's best technology could be successfully applied, which is called the Unavoidable Annual Real Losses (UARL). UARL is based on the utility's miles of water main, system pressure, number of metered connections and average length of the service line from a curb-stop to the customer's meter. ILI is an index number that makes comparison of ILI between water utilities possible.

SWBNO's ILI has decreased by 9.2 since the first water audit in FY2008. The ILI in SWBNO's first audit in FY2008 was 46.0, reached a high in FY2009 of 46.6, achieved a low of 34.7 in FY2015 and was 36.9 in FY2017. The ILI is the ratio of Annual Real Losses to the UARL.

The lower ILI results in recent years are driven by two factors: 1) Reduction in Real Losses in those years and 2) the UARL in recent years is higher than the early years of water audit calculations.

To better understand drivers of the ILI ratio, the table to the below summarizes the macro results of the audit for each fiscal year. In the table, Total Water Loss is calculated by subtracting Authorized Consumption from the Total System Input Volume.

FY	Total System Input	-	Authorized Consumption	=	Total Water Losses
2008	52,656.00	-	21,583.29	=	31,072.71
2009	54,451.00	-	21,559.66	=	32,891.34
2010	52,264.00	-	23,621.20	=	28,642.80
2011	55,151.00	-	23,258.44	=	31,892.56
2012	54,469.00	-	22,682.46	=	31,786.54
2013	51,958.00	-	23,113.83	=	28,844.17
2014	52,195.00	-	22,821.11	=	29,373.89
2015	51,301.00	-	23,452.40	=	27,848.60
2016	51,568.00	-	20,590.20	=	30,977.80
2017	54,471.00	-	23,837.30	=	30,633.70

The next step in ILI calculation is to break Total Water Loss into its 2 subcategories: 1) Real Losses and 2) Apparent Losses.

For this audit, SWBNO's Apparent Losses includes only a conservative estimate of water loss due to meter slippage, 3% across all meter classes. Estimates of other Apparent Losses (e.g., water theft and/or billing/data handling errors) were not feasible to include in the audit due to SWBNO's limited ability to extract data from its current information systems.

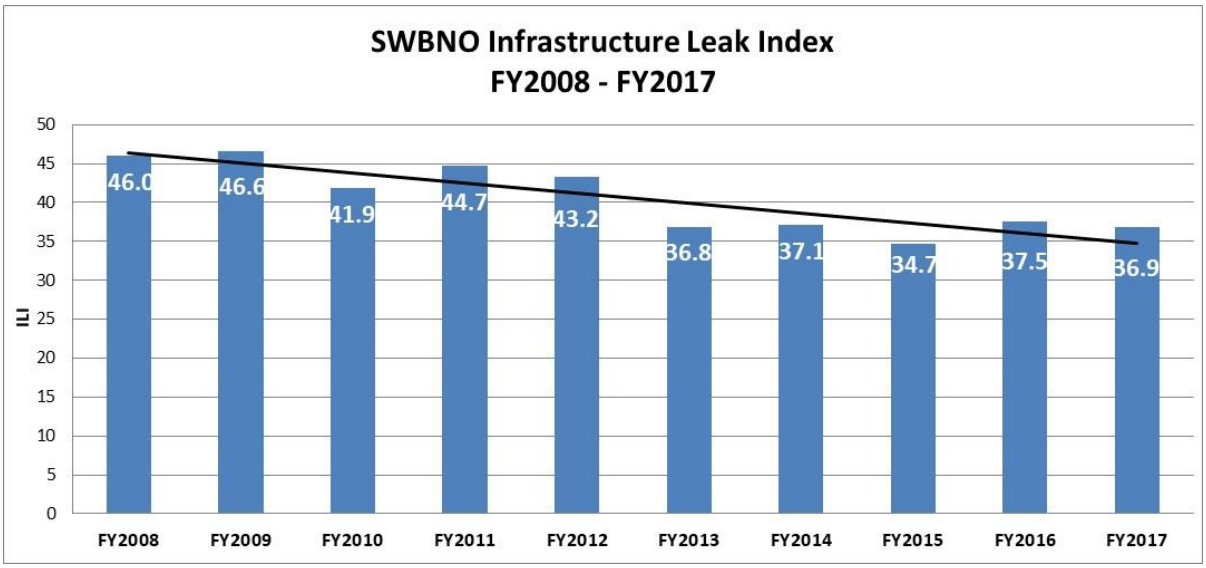
Real Losses include all other water losses, extracting Apparent Losses. Calculated, Real Losses equals Total Water Losses minus Apparent Losses. This below table illustrates how as Real Losses reached relatively lower levels in recent years and the UARL has also increased over those same years, the ILI correspondingly decreases.

FY	Total Water Losses	-	Apparent Losses	=	Real Losses	/	UARL	ILI*
2008	31,072.71	-	393.09	=	30,679.62	/	1.83	46.0
2009	32,891.34	-	405.12	=	32,486.22	/	1.91	46.6
2010	28,642.80	-	450.45	=	28,192.35	/	1.84	41.9
2011	31,892.56	-	438.87	=	31,453.69	/	1.93	44.7
2012	31,786.54	-	428.01	=	31,358.53	/	1.99	43.2
2013	28,844.17	-	450.00	=	28,394.17	/	2.11	36.8
2014	29,373.89	-	437.00	=	28,936.89	/	2.13	37.1
2015	27,848.60	-	459.00	=	27,389.60	/	2.16	34.7
2016	30,977.80	-	383.16	=	30,594.64	/	2.22	37.5
2017	30,633.70	-	462.24	=	30,171.46	/	2.23	36.9

*ILI = Real Losses / UARL / Days in year

The UARL increase in recent years is driven by both an increase in miles of main and an increase in the number of customers. In FY2013, according to the data provided by SWBNO, the number of miles of main increased by 207 miles over FY2012. The number of miles of main since FY2013 has increased only slightly each year, again based on the data provided. Similarly in FY2013, the number of customers increased by 4,671 customers over FY2012, using the data provided by SWBNO. Since FY2013, the number of customers has increased by a total of 9,429 over those four years. It may be helpful to this and future water audit analyses if SWBNO validates both the miles of main and number of customers for the last 5-10 years.

Future improvements in estimating Real and Apparent Losses within the water audit will directly impact the ILI index in a positive direction. The following chart illustrates SWBNO's ILI improving performance between FY2008 - FY2017.



Non-Revenue Water

Non-Revenue Water (NRW) is finished water that is treated but never reaches a customer for billing. It includes Apparent and Real Losses as well as Unbilled Authorized Consumption. It is calculated both as a percent of cost of production and as a percent of water volume. Along with the ILI, Non-Revenue Water measures are key performance indicators as a part of the water audit.

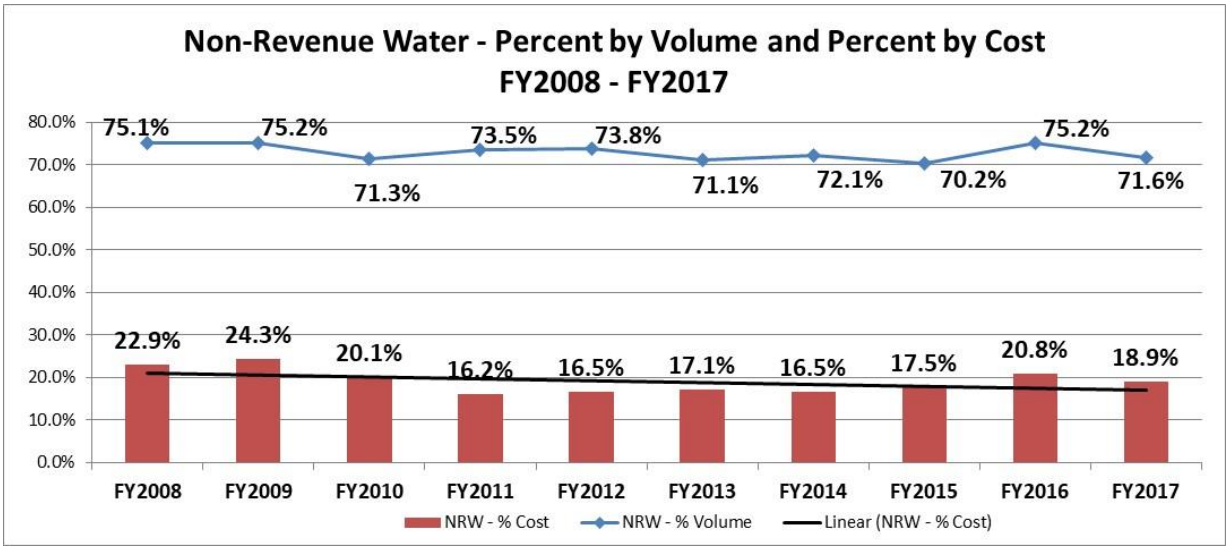
NRW as a Percent of Cost

NRW is calculated as a percentage of the annual cost of running the water system. SWBNO's NRW as a percentage of cost has decreased over the last ten years of water audits. The NRW as a percentage of cost in SWBNO's first audit in FY2008 was 22.9%, reached a high in FY2009 of 24.3%, achieved a low of 16.2% in FY2011 and was 18.9% in FY2017.

NRW as a Percent of Volume

NRW calculated as a percent of volume of the total volume of finished water delivered to the distributed system. SWBNO's NRW as a percentage of volume has also decreased over the last ten years of water audits. The NRW as a percentage of volume in SWBNO's first audit in FY2008 was 75.1%, reached a high in FY2009 of 75.2%, achieved a low of 70.2% in FY2015 and was 71.6% in FY2017.

The below chart illustrates NRW as a percent of cost and as a percent of volume for FY2008 – FY2017.



It should be noted that SWBNO's NRW by volume (70+%) is extremely high for municipal water utilities. This is a direct result of SWBNO's limited ability to extract data from its current information systems. For purely comparative purposes to get a better understanding of where SWNBO's NRW ratios could be with improved water audit data inputs, the Philadelphia Water Department (PWD) may be a good example examine. PWD has a great depth of water audit experience, it is of relative similar age, size, demographics and infrastructure to SWBNO. Keeping in mind that PWD has been a national leader in water loss control and water accounting for over two decades, its NRW by cost in FY2008 was 15.1% and its NRW by volume 32.4% in FY2008.

ILI Comparisons

SWBNO's ILI performance exceeds any other large water utility in the United States currently performing water auditing and publicly sharing their results (due to the lack of SWBNO data estimates in Apparent and Real Water Losses). SWBNO staff is to be commended, however, for taking these first steps in a "top down" audit to understand their current water accounting opportunities and data shortfalls. The audit work is a significant first step to improving water loss in the coming years across the utility.

AWWA's water audit methodology is becoming standard for many US water utilities and several states and commissions, particularly where water is a scarce resource. Utilities that are using the AWWA water audit approach do not regularly share their water audit and ILI data outside of their own utility so benchmarking efforts have been limited.

In 2011, twenty-one water utilities provided their water audit data to members of the AWWA Water Loss Control Committee for review and careful validation of the data. This is the first validated ILI data set from individual North American water utilities, and this work remains unrepeated since 2011. This data was presented at the 2011 AWWA Annual Conference and Exposition and at the 2011 AWWA Distribution System Symposium.

The key performance indicators for these twenty-one utilities are shown below and contain the average and a minimum and maximum range for each key performance indicator. SWBNO's FY2017 results are presented in the last column for comparison.

Validated Key Performance Indicator for Benchmarking	# of utilities	Average	Range	SWBNO FY2017 Results
NRW - % by Cost	21	10.0%	1.7% - 23.0%	18.9%
NRW - % by Volume	21	22.6%	6.8% - 45.5%	71.6%
Apparent Losses (gals/conn/day)	21	14.95	2.36 - 65.89	0.09
Real Losses (gals/conn/day)	18	63.32	17.07 - 149.71	607
Real Losses (gals/mile of main/day)	3	1,821.15	645.42 - 3,496.21	45,046
Infrastructure Leak Index (ILI)	21	3.57	1.15 - 12.68	36.9

As SWNBO is a large utility, the below table may be most helpful for comparison purposes as it outlines the differences in the water audit key performance indicators for large and small utilities (defined as less than 50,000 connections and greater than 50,000 connections).

Validated Key Performance Indicator for Benchmarking	# connections < 50,000			# connections > 50,000		
	# of utilities	Average	Range	# of utilities	Average	Range
NRW - % by Cost	10	9.3%	3.1% - 17.5%	11	10.6%	1.7% - 23.0%
NRW - % by Volume	10	24.1%	12.2% - 45.5%	11	21.4%	6.8% - 39.6%
Apparent Losses (gals/conn/day)	7	10.38	2.36 - 20.64	11	19.11	6.45 - 65.89
Real Losses (gals/conn/day)	3	58.71	26.08 - 149.71	11	66.24	17.07 - 124.4
Real Losses (gals/mile of main/day)	10	1,821	645 - 3,496	0		
Infrastructure Leak Index (ILI)	10	3.51	1.24 - 12.68	11	3.62	1.15 - 9.89

The twenty one utilities that participated in this 2011 AWWA water audit data validation study include:

1. City of Asheboro (NC)
2. Austin Water Utility (TX)
3. City of Belmont (NC)
4. Birmingham Water Works Board (AL)
5. City of Calgary, Alberta (Canada)
6. Greater Cincinnati Water Works (OH)
7. Cobb County Water System (GA)
8. Dalton Utilities (GA)
9. DC Water and Sewer Authority (Washington DC)
10. Golden State Water Company, Clearlake (CA)
11. Golden State Water Company, Ojai (CA)
12. Halifax Regional Water Commission, Nova Scotia (Canada)
13. Louisville Water Company (KY)
14. Orange County Utilities Department (FL)
15. Philadelphia Water Department (PA)
16. Pennsylvania American Water, Pittsburgh (PA)
17. City of Rio Rancho (NM)
18. Washington County Service Authority (VA)
19. City of Wauwatosa Water Utility (WI)
20. City of Wilmington (DE)
21. Water and Wastewater Authority of Wilson County (TN)

For more specific utility-level ILI performance, below is 2012 ILI data provided by the American Water Works Association.

Utility	2012 ILI
DC Water & Sewer Authority (Washington DC)	7.2
Greater Philadelphia (107 systems)	4.0
Birmingham Water Works	4.0
Pennsylvania American Water, Pittsburgh	3.3
Metro Water Services (Nashville)	3.3
Austin Water Utility	3.0
Louisville Water Company	2.4
Greater Cincinnati Water Works	2.4
Orange County (FL) Utilities Department (Orlando)	1.3
Cobb County Water System (Atlanta)	1.1

It needs to be pointed out that many utilities found in the table above have been conducting water audits for many years and over that time have developed sophisticated methods for estimating water losses across the audit. As SWBNO continues to refine its water audit methodology and develop confident estimates of water loss, their ILI will reduce.

Recommendations for Improvement

The water audit performed for SWBNO is called a "top down" water audit because it used only readily available utility data with no new field work for data collection. This kind of "top down" audit is how most utilities begin their first water audit efforts. SWBNO, however, is restricted in its ability to extract data from the current information systems and thus inputs and estimates in the water audit are quite limited. The computation of both Apparent and Real Water Losses for the audit were most impacted by the difficulty of data extraction from current information systems, with almost no estimation occurring in these categories. The result is an ILI figure for SWBNO that is not usefully comparable to other water utilities at present nor in a range of AWWA recommendations. The current audit is a SWBNO's ILI results will certainly be reduced when estimates for Apparent and Real Losses can be obtained.

The following suggestions are offered to SWBNO as ways to improve its water loss and ILI performance over time:

1. **Improve Water Audit Inputs** - Allocate staff resources to reduce the data gaps in the water audit inputs. This will require staff to create estimates for key water audit elements by extracting data from current information systems and perhaps new field work. This work is essential to develop reliable assumptions based on SWBNO actual operations.

2. **Establish a Cross Functional Team** - A water audit is most accurate when it is performed by cross functional team in the utility consisting of members who intimately understand the processes and work flows in Metering, Distribution and Plant Operations, Engineering, Customer Service, Customer Billing, Information Technology and Finance departments. One member of the team should be identified to lead and organize the group but all team members should share in the responsibility and accountability for the audit work. Ideally over time, the water audit will become part of a larger utility effort at water loss control. Water audits are typically performed annually or every-other year to maximize its effectiveness as a management tool.

3. **Validate the Accuracy of Water System Input Volume** – The System Input Volume is perhaps the most important piece of data in the water audit. All water loss categories are calculated and figured from this number. Therefore, is it vital that the System Input Volume be recorded accurately. The System Input Volume should include corrections for meter accuracy of the master production meters at the water treatment plants. SWBNO staff should look at the last time the production meters were tested and include appropriate adjustments to System Input Volume within the water audit based on the testing frequency and results. Other factors to consider are SCADA and plant instrumentation outage/maintenance histories, mass balance comparisons of flows into and out of water treatment plants and any specific operational history at the treatment plant facility that could impact production meter accuracy or data reporting.

4. **Add and Refine Estimates of Apparent Losses.** Apparent Losses consist of customer water use that is not recorded due to meter error, billing error, leak adjustments/credits and unauthorized consumption. The economic impact of Apparent Losses is greater than Real Losses, since the marginal cost of Apparent Losses occurs at the retail rate charged to customers. For this audit, SWBNO Apparent Losses were all input at zero since accurate estimates of loss could not be confidently obtained, with the exception of customer meter under-registration. A conservative estimate of 3% loss for each customer class was used to estimate loss. Apparent Losses are absolutely occurring with the SWBNO metering and billing systems, and are part of all water utility operations. For reference and perhaps a future benchmark, PWD Apparent Losses for its 2008 water audit (including meter inaccuracy, unauthorized consumption and systematic data handling errors) were 8.2% of total system input volume. Current SWBNO databases should be examined to identify low-cost data capture techniques and estimating methods for Apparent Losses that may include might include:

    - Unauthorized Consumption or Theft. This includes illegal connections by-passing the meter, water taken out of fire hydrants for heat relief, irrigation, etc. and illegal water restorations of water service after a turn-off for non-payment.
    - Billing Procedure Errors. This can include occurrences of accounts not entered into/created in the billing system but a customer is receiving water service and accounts with active consumption but not billed (or held) for some reason. The losses associated with these types of errors are generally more complicated for utilities to discover and estimate but internal discussions and options for estimating these losses should be considered by SWBNO.
    - Broken or Defective Meters. There are Apparent Losses for the utility between the time a broken or defective meter is identified in the field and ultimately repaired or exchanged.
    - Missing Meters. There are Apparent Losses for the utility between the time a meter is identified as missing in the field and when a new meter is placed into service in that location.
    - Aging Meters. Meters slow down (i.e., register less usage) with age, and data from a meter maintenance, testing and replacement program can provide reliable estimates on how much meters slow down at certain size, age and flow. This is a routine source of Apparent Losses for water utilities.
    - Leak Adjustments. These are adjustments made to customer accounts, through internal policies, for leaks that occur on the customer side of the meter.

5. **Add and Refine Estimates of Real Losses.** Real Losses are the physical escape of water from the distribution system and include leakage and overflows prior to the point of end use (i.e., customer meter). This is water loss that could be recoverable within the distribution system. For this audit, SWBNO Real Losses were all input at zero since accurate estimates of loss could not be confidently obtained. Real Losses are part of all water utility operations, and are typically the largest volume of water lost by utilities within the water audit framework. For reference and perhaps a future benchmark, PWD Real Losses for its 2008 water audit were 9.9% of total system input volume. Current

SWBNO databases should be examined to identify low-cost data capture techniques and estimating methods for Real Losses that may include:

- water lost before a transmission or distribution main break is repaired, both for reported breaks and breaks/leaks that SWBNO thinks goes unreported
- unreported and reported leaks on fire hydrants
- unreported and reported leaks on distribution system valves
- assumed leaks on abandoned service lines before detection and service discontinuance
- storage tank errors or overflows that are captured through the SCADA system
- water leakage or seepage that occurs at the finished water storage sites.

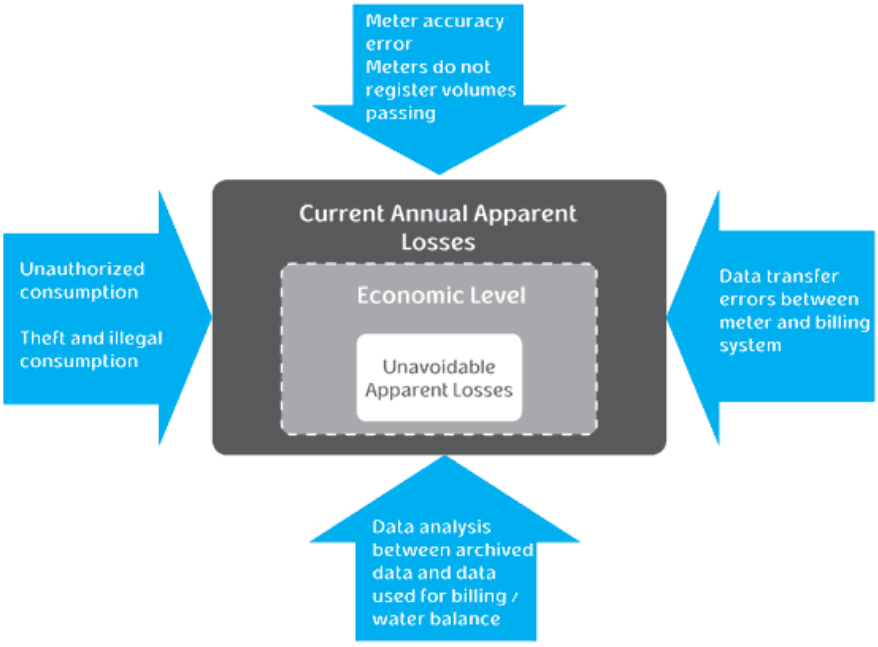
Although real water loss occurs at the cost of production (involving treatment, operations and maintenance costs), improvements in distribution system integrity are typically high priorities for water utilities. It should be noted, however, that even with improvements to the distribution system and added water audit refinement to Apparent Loss volumes, Real Losses are always likely to be higher than Apparent Losses.

6. **Add and Refine Estimates of Unbilled and Unmetered Water Loss in the Audit**. Authorized Unbilled and Unmetered water is part of every water utility's water loss. Current SWBNO databases should be examined to identify low-cost data capture techniques and estimating for water lost during activities including but not limited to:

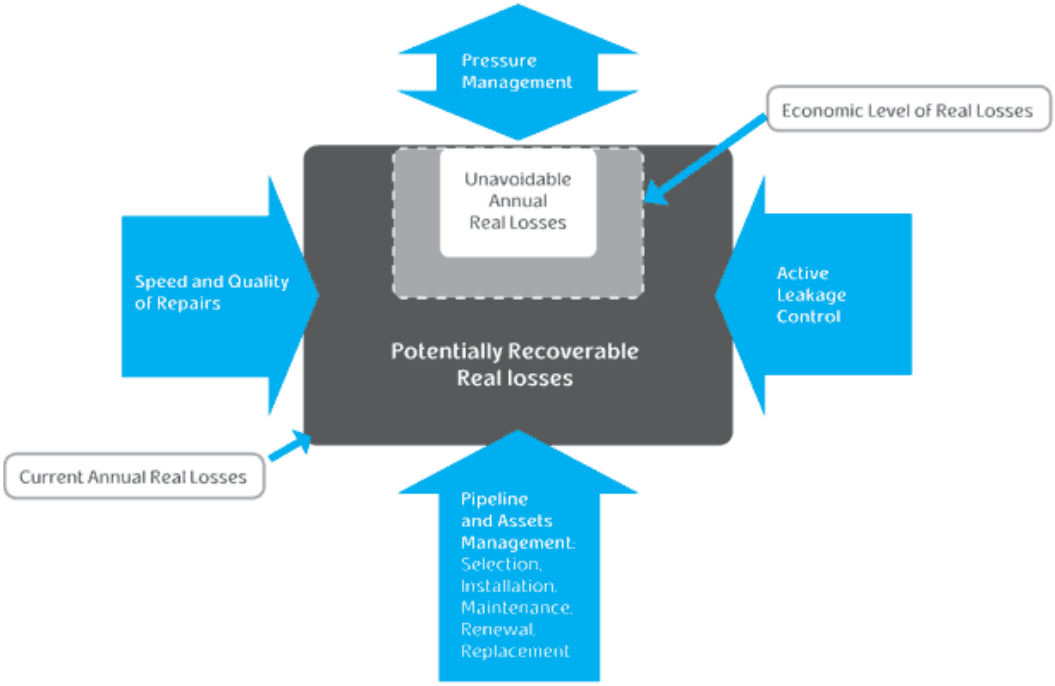
   - all water main flushing, including after a main break repair, after a new main installation and to address and maintain distribution water quality
   - fire hydrant testing
   - fire-fighting
   - finished water storage tank draining

7. **Identify and Implement Processes to reduce Apparent and Real Losses.** Once confident estimates of Real and Apparent Loss are developed (and this process can take several years) and an updated water audit has been validated, methods to reduce Real and Apparent Loss volumes through metering, distribution and billing process improvements should be evaluated. This evaluation should include calculating the economic level of loss for both Real and Apparent Losses. This should be balanced with the cost-effectiveness of any new investments, process or procedures.

Factors to consider in the management of Apparent Losses are outlined below. The diagram illustrates how approaches from multiple aspects can work together to make reductions (until the cost-effectiveness of the effort is no longer viable):



Similarly, the below diagram illustrates factors to consider in the management of Real Losses:



8. **Review Free Water Provided** – Utilities all over the country have experienced water consumption decline across each customer class as a result of water conservation efforts, and this trend is pronounced in water utilities serving an urban population. Corresponding to the water conservation trend, the water industry has experienced an increased accountability in tracking and ensuring payment for the water consumed. This development can be seen in the establishment of revenue protection units and departments within water utilities and also in the decline of water provided for completely free, even for public or charitable purposes. Many water utilities track water use at public agencies. Many times inter-fund transfers are charged for the water and related services. SWBNO has an opportunity to consider investigating changes in how free water is provided to city and public agencies.

9. **ILI Target Setting** - SWBNO should consider target-setting for its ILI once additional data can be input into the water audit for the Apparent and Real Water Losses components. Once that is complete, the AWWA M36 Manual recommends that ILI target-setting be an internal process for each utility and that the goal should be improvement to the ILI over time, not reaching some "ideal target" or mean ILI of comparable utilities. SWBNO needs to focus, therefore, not on reaching a certain target ILI range, but rather on the incremental year-over-year improvement to its ILI as part of its internal processes and annual goal-setting.

AWWA's Water Loss Control Committee and the M36 Manual recommends the following financial, operational and water resource considerations be evaluated by a utility when looking to set an ILI target:

Target ILI Range	Financial Considerations	Operational Considerations	Water Resource Considerations
<1.0	Two possibilities exist if the ILI is less than 1.0: 1) You are maintaining your leakage at low levels in a class with the top worldwide performers in leakage control or 2) A portion of your data may be flawed, causing your losses to be greatly understated. This is likely if you calculate a low ILI but do not employ extensive leakage control practices in your operations.		
1.0 – 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulations or low ratepayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0 – 5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions are included in the long-term planning.
>5.0-8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
Greater than 8.0	Although operational and financial considerations may allow a long-term ILI greater than 8.0, such a level of leakage is not an effective use of water as a resource. Setting a target level greater than 8.0, other than as an incremental goal to a smaller long-term target, is discouraged.		

10. **Update the Water Audit Regularly.** The water audit should be updated on a frequency that is cost-effective for SWBNO. Many utilities conduct water audits on an annual or every other year basis. The water audit should receive the same rigorous attention as the annual financial audit and ideally the updating of the water audit should coincide with the financial audit. The water audit can become part of a long-term strategy to track changes in SWBNO operations management, customer demand and utility policy. The implementation of water auditing is growing in popularity all across the US and water audits are now part of state reporting requirements for California, Texas, North Georgia,

New Mexico and the Delaware River Basin Commission (DRBC) which encompasses New York, Pennsylvania, Delaware and the Army Corps of Engineers.

Conclusion

The goal of the water audit is to as accurately as possible document all the places that water is lost across the utility's operations. As more water is accounted for within the audit confidently, improvements to the performance indicators will be seen. Then, decisions can be considered about process changes needed to drive increased recovery of operational costs. The water audit data can drive, for instance, discussions on whether it is more economical to implement a program to stop leaking abandoned service lines and ferrules (Real Losses) or to implement a replacement program to update failing meters (Apparent Losses).

The SWBNO's ILI and NRW key performance indicators are too high presently to provide meaningful information to management about water loss control approaches that could be cost-effective to implement. Further, SWBNO's ILI and NRW are so high the results are not usefully comparable to other water utilities nor in a range of AWWA recommendations. The high results are directly caused by SWBNO's current inability to provide estimates for Apparent and Real Losses occurring as part of normal utility operations.

SWBNO staff is to be commended, however, for taking these first steps in a "top down" audit to understand their current water accounting opportunities and data shortfalls. SWBNO has a tremendous opportunity to use this audit work to: 1) create awareness within the utility about the important role a water audit can play in water loss control; 2) authorize staff across the utility to collaborate on closing water audit data gaps; 3) revise audit inputs; and 4) create a water audit management tool that facilitates discussions across departments about the most cost-effective ways to reduce water loss in the future.

Appendix A
Water Audit
Components and Definitions

Sewerage and Water Board of New Orleans

March 4, 2019

The format and components of the water audit are contained in what AWWA refers to as the Water Balance as follows:

<table>
<tr><td rowspan="9">System Input Volume (corrected for known errors)</td><td rowspan="5">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">REVENUE WATER</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">NON-REVENUE WATER</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="4">Water Losses</td><td rowspan="3">Apparent Losses $</td><td>$ Customer Meter Inaccuracies</td></tr>
<tr><td>$ Unauthorized Consumption</td></tr>
<tr><td>$ Billing/Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Transmission & Distribution Main Leaks</td></tr>
<tr><td>Service Connection Leaks</td></tr>
<tr><td>Leaks & Overflows at Storage Tanks</td></tr>
</table>

The components of the water audit are defined as:

System Input Volume: The annual volume of water input into the water supply system.

Authorized Consumption: The annual volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are authorized to do so.

Water Losses: The difference between system Input Volume and Authorized Consumption, consisting of Apparent Losses plus Real Losses.

Apparent Losses: Unauthorized Consumption, all types of metering inaccuracies and systematic data handling errors.

Real Losses: The annual volumes lost through all types of leaks, breaks and overflows on mains, service reservoirs and storage tanks and service connections, up to the point of the customer's meter.

Revenue Water: Those components of System Input Volume that are metered, billed and produce revenue.

Non-Revenue Water (NRW): The difference between System Input Volume and Billed Authorized Consumption.

Unavoidable Annual Real Losses (UARL): A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. It is a key variable in the calculation of the ILI.

UARL (gallons/ day) = 5.41Lm + 0.15Nc) + 7.5Lp x P where
Lm = length of water mains, miles
Nc = number of service connections
Lp = total length of private pipe, miles = Nc x average distance from curbstop to customer meter
P = average pressure in the system, psi

Infrastructure leak Index (ILI): Ratio of Annual Real Losses to Unavoidable Annual Real Losses (UARL); good for operational benchmarking for Real Loss control.

Definitions are taken from the M36 Manual: *Water Audits and Loss Control Program*

Appendix B

Detailed Water Audit
FY 2008 – FY2017
Excel Workbook Model and Spreadsheets

Sewerage and Water Board of New Orleans

March 4, 2019

SWBNO Detailed Water Audit for FY 2008 - 2017

using American Water Works Association Format

	Category / Components	Consumption Amount										Annual Cost										Source and Notes
1	**I. System Input Volume**	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
2	**I-a. Finished water delivered from plants**	54,471	51,568	51,301	52,195	51,958	54,469	55,151	52,264	54,451	52,656											2013 & 2014 CAFR IV-20 & IV-21, 2012, 2011, 2010 CAFR Table IV-E, 2009 CAFR IV-8, 2008 CAFR IV-8
3	**II. Authorized Usage**																					
4	**a. Billed Metered**																					
5	**Retail customers**	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
6	**Residential**	7,860	6,898	7,734	7,366	7,511	6,639	6,801	7,122	7,153	6,674											2013 & 2014 Report SABR190, 2012, 2011, 2010, 2009 and 2008 CAM Residential + Multi-Family
		FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
7	**Commercial**	7,337	5,717	7,326	6,977	7,323	7,434	7,625	7,632	6,024	6,067											2013 & 2014 Report SABR190, 2012, 2011, 2010, 2009 and 2008 CAM Commercial
		FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
8	**Industrial**	211	157	238	227	158	194	203	261	327	362											2013 & 2014 Report SABR190, 2012, 2011, 2010, 2009 and 2008 CAM Industrial
9	**b. Billed Unmetered**	0	0	0	0	0	0	0	0	0	0											
10	**c. Unbilled Metered**																					
11	**Non-Revenue Water**	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	
12	**City of New Orleans & public instit.**	1,365	1,043	1,450	1,415	1,339	1,295	1,423	1,744	972	1,599	$573,947	$438,428	$482,356	$465,091	$336,751	$278,014	$308,489	$439,384	$267,378	$554,120	2013 & 2014 Tiffany Julien, 2012, 2011, 2010, 2009 and 2008 Water Contributed for Public Purposes Rpt
					2.7%	2.6%	2.4%	2.6%	3.3%	1.8%	3.0%											
13	**d. Unbilled Unmetered**	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
14	**Capital main construction flushing**	1	1	1	1	1	1	1	1	1	1											Estimate based on 49 chlorination jobs in 2011 and 51 in 2012 with 25K gallons used to flush on each job. (25K estimate is based on 12.5K gal/hr measured on auto flushing device used in system for 2 hour flush).
15	**Fire-fighting, street cleaning, flushing sewers, cleaning public spaces**	5,447	5,157	5,130	5,220	5,196	5,447	5,515	5,226	5,445	5,266											Assume 10% of water pumped in 2008-2017.
16	**Distribution Water Quality**	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
17	**Flushing for Carrollton & Algiers**	30.7	30.7	33.9	57.5	27.8	38.3	36.3	10.0	6.7	34.7											Carrollton estimate based on metered automatic flushing (in 2009) and manual flushing (2008 & 2009). Manual flushing during JuneSep, 3x per wk, 8 hrs per flush. Auto flushing gal/hr used to estimate manual flushing volume. Only data for Venetial Isles subdivision used for this estimate. Other flushing amounts not quantified (very few).Estimate of additional 30 MG used during boil advisory in Sept - Oct of 2008 due to hurricanes Gustav & Ike. Algiers (.1MG per year) estimate based on 2-3 flushing events per year for 2-3 hour duration. Flushing volume not metered but assumed to be approximately equal to 12K gallons/hr. 2010 assumes similar auto and manual flushing in Venetian Isles to maintain water quality. No emergency flushing in 2010. Limited flushing in Algiers.
18	**Plant Usage**	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
19	**Carrollton**	1,483.0	1,488.0	1,428.0	1,450.4	1,435.3	1,507.2	1,526.1	1,501.2	1,513.0	1,466.0											Estimate based on approximately 3% of production.
20	**Algiers**	103.0	99.0	111.0	107.7	123.5	126.8	128.4	123.2	118.1	113.7											Estimate based on approximately 3% of production.
21	**Total Authorized Water Consumption**	**23,837**	**20,590**	**23,452**	**22,821**	**23,114**	**22,682**	**23,258**	**23,621**	**21,560**	**21,583**											

SWBNO Detailed Water Audit for FY 2008 - 2017

using American Water Works Association Format

III.Water Losses (Item I - Item II)	**30,634**	**30,978**	**27,849**	**29,374**	**28,844**	**31,787**	**31,893**	**28,643**	**32,891**	**31,073**											
IV. Documented Water Losses																					
A. Apparent Losses																					
Customer meter under registration	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	
Residential, Commercial, Industrial	462	383	459	437	450	428	439	450	405	393	$194,431	$161,109	$162,258	$143,636	$113,215	$ 91,872	$ 95,175	$113,461	$111,464	$136,196	Assume 3% loss of consumption for each customer class.
Unauthorized Consumption (theft)	0	0	0	0	0	0	0	0	0	0											
Customer meter malfunction (broken meter)	0	0	0	0	0	0	0	0	0	0											
Accounts lacking proper billing	0	0	0	0	0	0	0	0	0	0											
Accounts not entered into system																					
Conversion of data																					
Internal process failures																					
Leak adjustments (actual revenue loss)	0	0	0	0	0	0	0	0	0	0											
Apparent Loss Total	**462**	**383**	**459**	**437**	**450**	**428**	**439**	**450**	**405**	**393**											
B. Real Losses	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
Operator error /overflows	0	0	0	0	0	0	0	0	0	0											
Known																					
Unknown-SCADA problems																					
Unavoidable annual real loss (UARL)	**814**	**813**	**782**	**779**	**771**	**727**	**704**	**682**	**697**	**668**											See UARL worksheet for calculation.
Recoverable leakage																					
Transmission and distribution main leaks	0	0	0	0	0	0	0	0	0	0											
Service lines	0	0	0	0	0	0	0	0	0	0											
Leaks on private properties	0	0	0	0	0	0	0	0	0	0											
Other Estimated Loss from Distribution Sys	0	0	0	0	0	0	0	0	0	0											
	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	
Real Loss Total	**814**	**813**	**782**	**779**	**771**	**727**	**704**	**682**	**697**	**668**	$342,530	$341,969	$276,424	$256,123	$193,920	$156,064	$152,577	$171,830	$191,818	$231,517	
	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08	
Documented Water Losses	**1,277**	**1,196**	**1,241**	**1,216**	**1,221**	**1,155**	**1,142**	**1,133**	**1,102**	**1,061**	**$536,961**	**$503,078**	**$438,682**	**$399,759**	**$307,134**	**$247,936**	**$247,752**	**$285,290**	**$303,282**	**$367,713**	
	FY17	FY16	FY15	FY14	FY13	FY12	FY11	FY10	FY09	FY08											
Undocumented Water Losses	**29,357**	**29,781**	**26,608**	**28,158**	**27,623**	**30,631**	**30,750**	**27,510**	**31,789**	**30,011**											Item III - Item IV. Also referred to "Balancing Error (Gap)"

Unavoidable Annual Real Loss Calculation FY2008 - FY2017

Assumptions

	FY2017	FY2016	FY2015	FY2014	FY2013	FY2012	FY2011	FY2010	FY2009	FY2008	Notes
Miles of Main	1,826	1,823	1,819	1,812	1,806	1,599	1,519	1,590	1,791	1,791	2014, 2013, 2012, 2011, 2010 CAFR IV-32. 2008 CAFR. 2009 data duplicated 2
Average psi	62	62	62	62	62	62	62	62	62	62	Post Katrina East Bank psi avg is 62-68 psi. West Bank maintains 62 psi exiting treatment plants (Info on Recovery Drive).
Days in year	365	366	365	365	365	366	365	365	365	366	2008, 2012 and 2016 were leap years w/ 366 days.
Curb stop to meter connections	135,535	134,872	129,809	127,876	126,106	121,435	118,745	111,834	109,640	102,575	B&V Final Report on Operations
Average length of curb-stop to meter (ft)	30	30	30	30	30	30	30	30	30	30	Estimate used based on industry average (30)
		0.5%	3.9%	1.5%	1.4%	3.8%					

Calculation

Component	UARL factor	FY 2017 Calculation	
Mains (gal/mile/day/psi)	5.41	223,554,076	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	460,073,558	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	130,702,715	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2017 Total		814,330,348	**814.33**

Component	UARL factor	FY 2016 Calculation	
Mains (gal/mile/day/psi)	5.41	223,798,262	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	459,077,314	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	130,419,691	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2016 Total		813,295,267	**813.30**

Component	UARL factor	FY 2015 Calculation	
Mains (gal/mile/day/psi)	5.41	222,697,078	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	434,075,082	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	125,180,867	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2015 Total		781,953,026	**781.95**

Component	UARL factor	FY 2014 Calculation	
Mains (gal/mile/day/psi)	5.41	221,840,080	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	434,075,082	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	123,316,785	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2014 Total		779,231,946	**779.23**

Component	UARL factor	FY 2013 Calculation	
Mains (gal/mile/day/psi)	5.41	221,105,510	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	428,066,817	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	121,609,891	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2013 Total		770,782,218	**770.78**

Component	UARL factor	FY 2012 Calculation	
Mains (gal/mile/day/psi)	5.41	196,299,188	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	413,340,453	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	117,426,265	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2012 Total		727,065,906	**727.07**

Component	UARL factor	FY 2011 Calculation	
Mains (gal/mile/day/psi)	5.41	185,968,588	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	403,079,903	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	114,511,336	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2011 Total		703,559,826	**703.56**

Component	UARL factor	FY 2010 Calculation	
Mains (gal/mile/day/psi)	5.41	194,715,233	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	379,620,513	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	107,846,737	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2010 Total		682,182,482	**682.18**

Component	UARL factor	FY 2009 Calculation	
Mains (gal/mile/day/psi)	5.41	219,269,085	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	372,172,980	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	105,730,960	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2009 Total		697,173,026	**697.17**

Component	UARL factor	FY 2008 Calculation	
Mains (gal/mile/day/psi)	5.41	219,869,823	Mains x miles of main x avg. psi x days
Service Connections			
Units rate per gal/service connection/day/psi	0.15	349,144,785	units rate per gal x connections x avg. psi x days
Units rate per gal/mile/day/psi	7.5	99,188,859	units rate per gal/mile/day/psi x connections x avg. psi x days x avg length of curb-stop to meter
FY 2008 Total		668,203,467	**668.20**

FY 2017 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**54,471**	**148.83**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	15,408.00	42.21	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,364.50	3.74	
	Unbilled Unmetered:	7,064.80	19.36	
	Total Authorized Consumption:	**23,837.30**	**65.31**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	462	1.27	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**462**	**1.27**	"Paper loss"
Real Losses				
	Total Real Losses:	**30,171**	**82.25**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**30,634**	**83.52**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,826	1,826	length (miles) of all pipelines except service connections
	Number of Service Connections:	135,535	135,535	number of customers
	Connection Density:	**74**	74	# of connections / length of mains (miles)
(pipe length between curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi
COST DATA				
	Total Annual Cost of Operating Water System Per Year:	$ 100,246,949		Total O&M
	Customer Retail Unit Cost Per MG:	$ 5,976.86		Total O&M / Total Consumption Sold (Total Consumption is Billed and Unbilled Metered)
	Short-Term Marginal Production Cost Per MG:	$ 420.63		Energy & Chemicals / Total Finished Water Delivered
PERFORMANCE INDICATORS				
Financial Indicators				
	Non-revenue water as percent by volume:		**71.6%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
	*** Non-revenue water as percent by cost:**		**18.9%**	See footnote for formula
Water Resources Indicators				
	Inefficiency of use of water as a resource:		**55.3%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators				
	Apparent Losses per as percent of system input volume:		**0.9%**	Total Apparent Losses / Total System Input Volume
	Real losses per service connection per day (when system is pressurized):		**606.88**	Total Real Losses / Number of Service Connections
	Real losses per mile of main per day (when system is pressurized):		**45,046**	Total Real Losses / Length of Mains
	Real losses per service connection per day per psi (when system is pressurized):		**9.79**	Total Real Losses / Number of Service Connections / Average Operating Pressure
	**** Unavoidable Annual Real Losses (UARL):**		**2.23**	UARL estimated using IWA method (See footnote)
	Infrastructure Leakage Index (ILI) [Real Losses/UARL]:		**36.87**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**44,312.20**
total apparent losses x customer retail unit cost	**7,569.17**
total nonrevenue water x 365 days	**18,936,699.36**
total nonrevenue water per day / total annual cost of operating water system	**18.89%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2017:**

length of mains x unit rate for UARL per gal/miles/day/psi	**9,879**
# of service connections x unit rate for UARL per gal/service/day/psi	**20,330.25**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,775.64**
add totals	**35,984.55**
total x avg operating pressure	**2,231,042.05**
divide by 1,000,000 to calculate per MG per day	**2.23**

FY 2016 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**51,568**	**140.90**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	12,772.00	34.99	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,042.70	2.86	
	Unbilled Unmetered:	6,775.50	18.56	
	Total Authorized Consumption:	**20,590.20**	**56.41**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	383	1.05	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**383**	**1.05**	"Paper loss"
Real Losses				
	Total Real Losses:	**30,595**	**83.43**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**30,978**	**84.48**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,823	1,823	length (miles) of all pipelines except service connections
	Number of Service Connections:	134,872	134,872	number of customers
	Connection Density:	**74**	74	# of connections / length of mains (miles)
(pipe length betw een curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 89,478,097	Total O&M	
Customer Retail Unit Cost Per MG:	$ 6,477.02	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 420.47	Energy & Chemicals / Total Finished Water Delivered	

PERFORMANCE INDICATORS		
Financial Indicators		
Non-revenue water as percent by volume:	**75.2%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
*** Non-revenue water as percent by cost:**	**20.8%**	See footnote for formula
Water Resources Indicators		
Inefficiency of use of water as a resource:	**59.2%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators		
Apparent Losses per as percent of system input volume:	**0.7%**	Total Apparent Losses / Total System Input Volume
Real losses per service connection per day (when system is pressurized):	**618.62**	Total Real Losses / Number of Service Connections
Real losses per mile of main per day (when system is pressurized):	**45,768**	Total Real Losses / Length of Mains
Real losses per service connection per day per psi (when system is pressurized):	**9.98**	Total Real Losses / Number of Service Connections / Average Operating Pressure
**** Unavoidable Annual Real Losses (UARL):**	**2.22**	UARL estimated using IWA method (See footnote)
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**37.55**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**44,088.60**
total apparent losses x customer retail unit cost	**6,799.27**
total nonrevenue water x 366 days	**18,624,963.92**
total nonrevenue water per day / total annual cost of operating water system	**20.82%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2016:**

length of mains x unit rate for UARL per gal/miles/day/psi	**9,862**
# of service connections x unit rate for UARL per gal/service/day/psi	**20,230.80**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,747.39**
add totals	**35,840.62**
total x avg operating pressure	**2,222,118.21**
divide by 1,000,000 to calculate per MG per day	**2.22**

FY 2015 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**51,301**	**140.55**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	15,298.00	41.91	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,450.40	3.97	
	Unbilled Unmetered:	6,704.00	18.37	
	Total Authorized Consumption:	**23,452.40**	**64.25**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	459	1.26	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**459**	**1.26**	"Paper loss"
Real Losses				
	Total Real Losses:	**27,390**	**75.04**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**27,849**	**76.30**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,819	1,819	length (miles) of all pipelines except service connections
	Number of Service Connections:	129,809	129,809	number of customers
	Connection Density:	**71**	71	# of connections / length of mains (miles)
(pipe length betw een curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 84,854,293	Total O&M	
Customer Retail Unit Cost Per MG:	$ 5,066.41	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 353.50	Energy & Chemicals / Total Finished Water Delivered	

PERFORMANCE INDICATORS		
Financial Indicators		
Non-revenue water as percent by volume:	**70.2%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
*** Non-revenue water as percent by cost:**	**17.5%**	See footnote for formula
Water Resources Indicators		
Inefficiency of use of water as a resource:	**53.4%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators		
Apparent Losses per as percent of system input volume:	**0.9%**	Total Apparent Losses / Total System Input Volume
Real losses per service connection per day (when system is pressurized):	**578.08**	Total Real Losses / Number of Service Connections
Real losses per mile of main per day (when system is pressurized):	**41,253**	Total Real Losses / Length of Mains
Real losses per service connection per day per psi (when system is pressurized):	**9.32**	Total Real Losses / Number of Service Connections / Average Operating Pressure
**** Unavoidable Annual Real Losses (UARL):**	**2.16**	UARL estimated using IWA method (See footnote)
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**34.74**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**34,424.51**
total apparent losses x customer retail unit cost	**6,371.19**
total nonrevenue water x 365 days	**14,890,428.75**
total nonrevenue water per day / total annual cost of operating water system	**17.55%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2015:**

length of mains x unit rate for UARL per gal/miles/day/psi	**9,841**
# of service connections x unit rate for UARL per gal/service/day/psi	**19,471.35**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,531.63**
add totals	**34,843.77**
total x avg operating pressure	**2,160,313.96**
divide by 1,000,000 to calculate per MG per day	**2.16**

FY 2014 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**52,195**	**143.00**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	14,570.00	39.92	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,415.00	3.88	
	Unbilled Unmetered:	6,836.61	18.73	
	Total Authorized Consumption:	**22,821.61**	**62.52**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	437	1.20	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**437**	**1.20**	"Paper loss"
Real Losses				
	Total Real Losses:	**28,936**	**79.28**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**29,373**	**80.48**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,812	1,812	length (miles) of all pipelines except service connections
	Number of Service Connections:	127,876	127,876	number of customers
	Connection Density:	**71**	71	# of connections / length of mains (miles)
(pipe length between curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 88,562,278	Total O&M	
Customer Retail Unit Cost Per MG:	$ 5,540.34	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 328.69	Energy & Chemicals / Total Finished Water Delivered	
PERFORMANCE INDICATORS			
Financial Indicators			
Non-revenue water as percent by volume:	**72.1%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume	
*** Non-revenue water as percent by cost:**	**16.5%**	See footnote for formula	
Water Resources Indicators			
Inefficiency of use of water as a resource:	**55.4%**	Total Real Losses / Total System Input Volume	
Operational Efficiency Indicators			
Apparent Losses per as percent of system input volume:	**0.8%**	Total Apparent Losses / Total System Input Volume	
Real losses per service connection per day (when system is pressurized):	**619.96**	Total Real Losses / Number of Service Connections	
Real losses per mile of main per day (when system is pressurized):	**43,752**	Total Real Losses / Length of Mains	
Real losses per service connection per day per psi (when system is pressurized):	**10.00**	Total Real Losses / Number of Service Connections / Average Operating Pressure	
**** Unavoidable Annual Real Losses (UARL):**	**2.13**	UARL estimated using IWA method (See footnote)	
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**37.13**		

Non-Revenue Water as Percent by Cost:	
(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**33,488.19**
total apparent losses x customer retail unit cost	**6,633.22**
total nonrevenue water x 365 days	**14,644,315.69**
total nonrevenue water per day / total annual cost of operating water system	**16.54%**

IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2014:	
length of mains x unit rate for UARL per gal/miles/day/psi	**9,803**
# of service connections x unit rate for UARL per gal/service/day/psi	**19,181.40**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,449.26**
add totals	**34,433.58**
total x avg operating pressure	**2,134,882.04**
divide by 1,000,000 to calculate per MG per day	**2.13**

FY 2013 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**51,958**	**142.35**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	14,992.00	41.07	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,338.50	3.67	
	Unbilled Unmetered:	6,783.53	18.59	
	Total Authorized Consumption:	**23,114.03**	**63.33**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	450	1.23	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**450**	**1.23**	"Paper loss"
Real Losses				
	Total Real Losses:	**28,394**	**77.79**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**28,844**	**79.02**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,806	1,806	length (miles) of all pipelines except service connections
	Number of Service Connections:	126,106	126,106	number of customers
	Connection Density:	**70**	70	# of connections / length of mains (miles)
(pipe length betw een curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 64,170,327	Total O&M	
Customer Retail Unit Cost Per MG:	$ 3,929.48	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 251.59	Energy & Chemicals / Total Finished Water Delivered	

PERFORMANCE INDICATORS		
Financial Indicators		
Non-revenue water as percent by volume:	**71.1%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
*** Non-revenue water as percent by cost:**	**17.1%**	See footnote for formula
Water Resources Indicators		
Inefficiency of use of water as a resource:	**54.6%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators		
Apparent Losses per as percent of system input volume:	**0.9%**	Total Apparent Losses / Total System Input Volume
Real losses per service connection per day (when system is pressurized):	**616.88**	Total Real Losses / Number of Service Connections
Real losses per mile of main per day (when system is pressurized):	**43,074**	Total Real Losses / Length of Mains
Real losses per service connection per day per psi (when system is pressurized):	**9.95**	Total Real Losses / Number of Service Connections / Average Operating Pressure
**** Unavoidable Annual Real Losses (UARL):**	**2.11**	UARL estimated using IWA method (See footnote)
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**36.84**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**25,169.83**
total apparent losses x customer retail unit cost	**4,844.56**
total nonrevenue water x 365 days	**10,955,254.03**
total nonrevenue water per day / total annual cost of operating water system	**17.07%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2013:**

length of mains x unit rate for UARL per gal/miles/day/psi	**9,770**
# of service connections x unit rate for UARL per gal/service/day/psi	**18,915.90**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,373.84**
add totals	**34,060.20**
total x avg operating pressure	**2,111,732.10**
divide by 1,000,000 to calculate per MG per day	**2.11**

FY 2012 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**54,469**	**149.23**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	14,267.00	39.09	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,295.20	3.55	
	Unbilled Unmetered:	7,120.36	19.51	
	Total Authorized Consumption:	**22,682.56**	**62.14**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	428	1.17	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**428**	**1.17**	"Paper loss"
Real Losses				
	Total Real Losses:	**31,358**	**85.91**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**31,786**	**87.09**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,599	1,599	length (miles) of all pipelines except service connections
	Number of Service Connections:	121,435	121,435	number of customers
	Connection Density:	**76**	76	# of connections / length of mains (miles)
(pipe length between curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi
COST DATA				
	Total Annual Cost of Operating Water System Per Year:		$ 61,988,096	Total O&M
	Customer Retail Unit Cost Per MG:		$ 3,983.25	Total O&M / Total Consumption Sold (Total Consumption is Billed and Unbilled Metered)
	Short-Term Marginal Production Cost Per MG:		$ 214.65	Energy & Chemicals / Total Finished Water Delivered
PERFORMANCE INDICATORS				
Financial Indicators				
	Non-revenue water as percent by volume:		**73.8%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
	*** Non-revenue water as percent by cost:**		**16.5%**	See footnote for formula
Water Resources Indicators				
	Inefficiency of use of water as a resource:		**57.6%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators				
	Apparent Losses per as percent of system input volume:		**0.8%**	Total Apparent Losses / Total System Input Volume
	Real losses per service connection per day (when system is pressurized):		**707.49**	Total Real Losses / Number of Service Connections
	Real losses per mile of main per day (when system is pressurized):		**53,730**	Total Real Losses / Length of Mains
	Real losses per service connection per day per psi (when system is pressurized):		**11.41**	Total Real Losses / Number of Service Connections / Average Operating Pressure
	**** Unavoidable Annual Real Losses (UARL):**		**1.99**	UARL estimated using IWA method (See footnote)
	Infrastructure Leakage Index (ILI) [Real Losses/UARL]:		**43.25**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**23,390.31**
total apparent losses x customer retail unit cost	**4,670.88**
total nonrevenue water x 365 days	**10,242,331.32**
total nonrevenue water per day / total annual cost of operating water system	**16.52%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2012:**

length of mains x unit rate for UARL per gal/miles/day/psi	**8,651**
# of service connections x unit rate for UARL per gal/service/day/psi	**18,215.25**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,174.79**
add totals	**32,040.63**
total x avg operating pressure	**1,986,518.87**
divide by 1,000,000 to calculate per MG per day	**1.99**

FY 2011 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**55,151**	**151.10**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	14,629.00	40.08	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,422.50	3.90	
	Unbilled Unmetered:	7,206.84	19.74	
	Total Authorized Consumption:	**23,258.34**	**63.72**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	439	1.20	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**439**	**1.20**	"Paper loss"
Real Losses				
	Total Real Losses:	**31,454**	**86.17**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**31,893**	**87.38**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,519	1,519	length (miles) of all pipelines except service connections
	Number of Service Connections:	118,745	118,745	number of customers
	Connection Density:	**78**	78	# of connections / length of mains (miles)
(pipe length between curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi
COST DATA				
	Total Annual Cost of Operating Water System Per Year:	$ 64,677,227		Total O&M
	Customer Retail Unit Cost Per MG:	$ 4,029.36		Total O&M / Total Consumption Sold (Total Consumption is Billed and Unbilled Metered)
	Short-Term Marginal Production Cost Per MG:	$ 216.86		Energy & Chemicals / Total Finished Water Delivered
PERFORMANCE INDICATORS				
Financial Indicators				
	Non-revenue water as percent by volume:		**73.5%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
	*** Non-revenue water as percent by cost:**		**16.2%**	See footnote for formula
Water Resources Indicators				
	Inefficiency of use of water as a resource:		**57.0%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators				
	Apparent Losses per as percent of system input volume:		**0.8%**	Total Apparent Losses / Total System Input Volume
	Real losses per service connection per day (when system is pressurized):		**725.71**	Total Real Losses / Number of Service Connections
	Real losses per mile of main per day (when system is pressurized):		**56,731**	Total Real Losses / Length of Mains
	Real losses per service connection per day per psi (when system is pressurized):		**11.71**	Total Real Losses / Number of Service Connections / Average Operating Pressure
	**** Unavoidable Annual Real Losses (UARL):**		**1.93**	UARL estimated using IWA method (See footnote)
	Infrastructure Leakage Index (ILI) [Real Losses/UARL]:		**44.71**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**23,815.29**
total apparent losses x customer retail unit cost	**4,844.83**
total nonrevenue water x 365 days	**10,460,945.02**
total nonrevenue water per day / total annual cost of operating water system	**16.17%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2011:**

length of mains x unit rate for UARL per gal/miles/day/psi	**8,218**
# of service connections x unit rate for UARL per gal/service/day/psi	**17,811.75**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**5,060.16**
add totals	**31,089.70**
total x avg operating pressure	**1,927,561.17**
divide by 1,000,000 to calculate per MG per day	**1.93**

FY 2010 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**52,264**	**143.19**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	15,015.00	41.14	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,744.40	4.78	
	Unbilled Unmetered:	6,861.80	18.80	
	Total Authorized Consumption:	**23,621.20**	**64.72**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies & Leak Adjustments:	450	1.23	3% Customer meter under registration and leak adjustments
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**450**	**1.23**	"Paper loss"
Real Losses				
	Total Real Losses:	**28,192**	**77.24**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**28,643**	**78.47**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,590	1,590	length (miles) of all pipelines except service connections
	Number of Service Connections:	109,640	109,640	number of customers
	Connection Density:	**69**	69	# of connections / length of mains (miles)
(pipe length between curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 53,161,832	Total O&M	
Customer Retail Unit Cost Per MG:	$ 3,172.06	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 251.88	Energy & Chemicals / Total Finished Water Delivered	

PERFORMANCE INDICATORS		
Financial Indicators		
Non-revenue water as percent by volume:	**71.3%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
***** **Non-revenue water as percent by cost:**	**20.1%**	See footnote for formula
Water Resources Indicators		
Inefficiency of use of water as a resource:	**53.9%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators		
Apparent Losses per as percent of system input volume:	**0.9%**	Total Apparent Losses / Total System Input Volume
Real losses per service connection per day (when system is pressurized):	**704.48**	Total Real Losses / Number of Service Connections
Real losses per mile of main per day (when system is pressurized):	**48,565**	Total Real Losses / Length of Mains
Real losses per service connection per day per psi (when system is pressurized):	**11.36**	Total Real Losses / Number of Service Connections / Average Operating Pressure
****** **Unavoidable Annual Real Losses (UARL):**	**1.84**	UARL estimated using IWA method (See footnote)
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**41.91**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**25,394.29**
total apparent losses x customer retail unit cost	**3,914.67**
total nonrevenue water x 365 days	**10,697,769.69**
total nonrevenue water per day / total annual cost of operating water system	**20.12%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2010:**

length of mains x unit rate for UARL per gal/miles/day/psi	**8,604**
# of service connections x unit rate for UARL per gal/service/day/psi	**16,446.00**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**4,672.16**
add totals	**29,722.46**
total x avg operating pressure	**1,842,792.25**
divide by 1,000,000 to calculate per MG per day	**1.84**

FY 2009 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**54,451**	**149.18**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	13,504.00	37.00	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	971.80	2.66	
	Unbilled Unmetered:	7,083.86	19.41	
	Total Authorized Consumption:	**21,559.66**	**59.07**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies:	405.12	1.11	Customer meter under registration
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**405.12**	**1.11**	"Paper loss"
Real Losses				
	Total Real Losses:	**32,486.22**	**89.00**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**32,891.34**	**90.11**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,791	1,791	length (miles) of all pipelines except service connections
	Number of Service Connections:	109,640	109,640	number of customers
	Connection Density:	**61**	61	# of connections / length of mains (miles)
(pipe length betw een curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 51,983,969	Total O&M	
Customer Retail Unit Cost Per MG:	$ 3,591.09	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 275.14	Energy & Chemicals / Total Finished Water Delivered	

PERFORMANCE INDICATORS		
Financial Indicators		
Non-revenue water as percent by volume:	**75.2%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
*** Non-revenue water as percent by cost:**	**24.3%**	See footnote for formula
Water Resources Indicators		
Inefficiency of use of water as a resource:	**59.7%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators		
Apparent Losses per as percent of system input volume:	**0.7%**	Total Apparent Losses / Total System Input Volume
Real losses per service connection per day (when system is pressurized):	**811.78**	Total Real Losses / Number of Service Connections
Real losses per mile of main per day (when system is pressurized):	**49,695**	Total Real Losses / Length of Mains
Real losses per service connection per day per psi (when system is pressurized):	**13.09**	Total Real Losses / Number of Service Connections / Average Operating Pressure
**** Unavoidable Annual Real Losses (UARL):**	**1.91**	UARL estimated using IWA method (See footnote)
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**46.60**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**30,560.51**
total apparent losses x customer retail unit cost	**3,985.82**
total nonrevenue water x 365 days	**12,609,409.84**
total nonrevenue water per day / total annual cost of operating water system	**24.26%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2009:**

length of mains x unit rate for UARL per gal/miles/day/psi	**9,689**
# of service connections x unit rate for UARL per gal/service/day/psi	**16,446.00**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**4,672.16**
add totals	**30,807.47**
total x avg operating pressure	**1,910,063.08**
divide by 1,000,000 to calculate per MG per day	**1.91**

FY 2008 PERFORMANCE INDICATORS

		MG Per Year	MG Per Day	
FINISHED WATER DELIVERED	**Total System Input Volume:**	**52,656**	**144.26**	Plant Pumpage
AUTHORIZED CONSUMPTION	Billed Metered:	13,103.00	35.90	
	Billed Unmetered:	-	0.00	
	Unbilled Metered:	1,599.30	4.38	
	Unbilled Unmetered:	6,880.99	18.85	
	Total Authorized Consumption:	**21,583.29**	**59.13**	
WATER LOSSES				
Apparent Losses				
	Unauthorized Consumption:	0.00	0.00	Theft or illegal use
	Customer Metering Inaccuracies:	393.09	1.08	Customer meter under registration
	Data Handling Errors:	-	0.00	Accounts lacking proper billing (no estimation available)
	Total Apparent Losses:	**393.09**	**1.08**	"Paper loss"
Real Losses				
	Total Real Losses:	**30,679.62**	**84.05**	Physical loss of water from the distribution system
	TOTAL WATER LOSSES:	**31,072.71**	**85.13**	Apparent Losses plus Real Losses
SYSTEM DATA				
	Length of Mains:	1,791	1,791	length (miles) of all pipelines except service connections
	Number of Service Connections:	102,575	102,575	number of customers
	Connection Density:	**57**	57	# of connections / length of mains (miles)
(pipe length between curbside customer meter or property boundary)	Average Length (feet) of Private Pipe:	30.0	30	length between stop & main (not included in length of main)
	Average Operating Pressure:	62.00	62	psi

COST DATA			
Total Annual Cost of Operating Water System Per Year:	$ 66,989,084	Total O&M	
Customer Retail Unit Cost Per MG:	$ 4,556.37	Total O&M / Total Consumption Sold	Total Consumption is Billed and Unbilled Metered
Short-Term Marginal Production Cost Per MG:	$ 346.48	Energy & Chemicals / Total Finished Water Delivered	

PERFORMANCE INDICATORS		
Financial Indicators		
Non-revenue water as percent by volume:	**75.1%**	Unbilled Metered & Unmetered plus Total Water Losses / Total System Input Volume
*** Non-revenue water as percent by cost:**	**22.9%**	See footnote for formula
Water Resources Indicators		
Inefficiency of use of water as a resource:	**58.3%**	Total Real Losses / Total System Input Volume
Operational Efficiency Indicators		
Apparent Losses per as percent of system input volume:	**0.7%**	Total Apparent Losses / Total System Input Volume
Real losses per service connection per day (when system is pressurized):	**819.44**	Total Real Losses / Number of Service Connections
Real losses per mile of main per day (when system is pressurized):	**46,931**	Total Real Losses / Length of Mains
Real losses per service connection per day per psi (when system is pressurized):	**13.22**	Total Real Losses / Number of Service Connections / Average Operating Pressure
**** Unavoidable Annual Real Losses (UARL):**	**1.83**	UARL estimated using IWA method (See footnote)
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	**46.04**	

* **Non-Revenue Water as Percent by Cost:**

(unbilled metered + unbilled unmetered + total real losses) x short-term marginal production cost	**37,172.58**
total apparent losses x customer retail unit cost	**4,907.02**
total nonrevenue water x 365 days	**15,359,055.14**
total nonrevenue water per day / total annual cost of operating water system	**22.93%**

** **IWA/AWWA Calculation for Unavoidable Annual Real Loss (UARL) for FY2008:**

length of mains x unit rate for UARL per gal/miles/day/psi	**9,689**
# of service connections x unit rate for UARL per gal/service/day/psi	**15,386.25**
(# of service connections x avg length of pipe / 5280 ft/mile) x unit rate per gal/mile/day/psi	**4,371.09**
add totals	**29,446.65**
total x avg operating pressure	**1,825,692.53**
divide by 1,000,000 to calculate per MG per day	**1.83**

SWBNO Detailed Water Audit
Cost Data FY2008 - FY2017

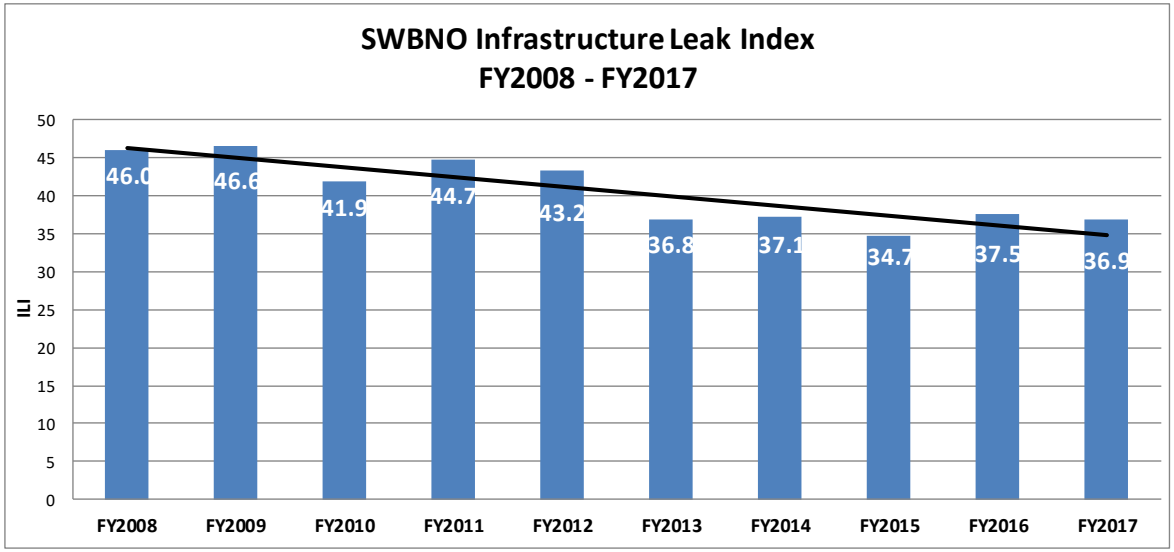
Annual Costs	FY2017	FY2016	FY2015	FY2014	FY2013	FY2012	FY2011	FY2010	FY2009	FY2008	Source
O&M Costs	100,246,949	89,478,097	84,854,293	88,562,278	$64,170,327	$61,988,096	$64,677,227	$53,161,832	$51,983,969	$66,989,084	2014 CAFR II-71, Schedule 2, 2013 CAFR II-67, 2012, 2011, 2010 CAFR II-258, 2009 and 2008 CAFR II-57
Total Chem and Energy	22,912,020	21,682,981	18,135,108	17,155,785	$13,072,012	$11,691,736	$11,960,257	$13,164,393	$14,981,504	$18,244,072	AFIN 880C-13th 2014, 2013, 2012, 2011, 2010, 2009, 2008

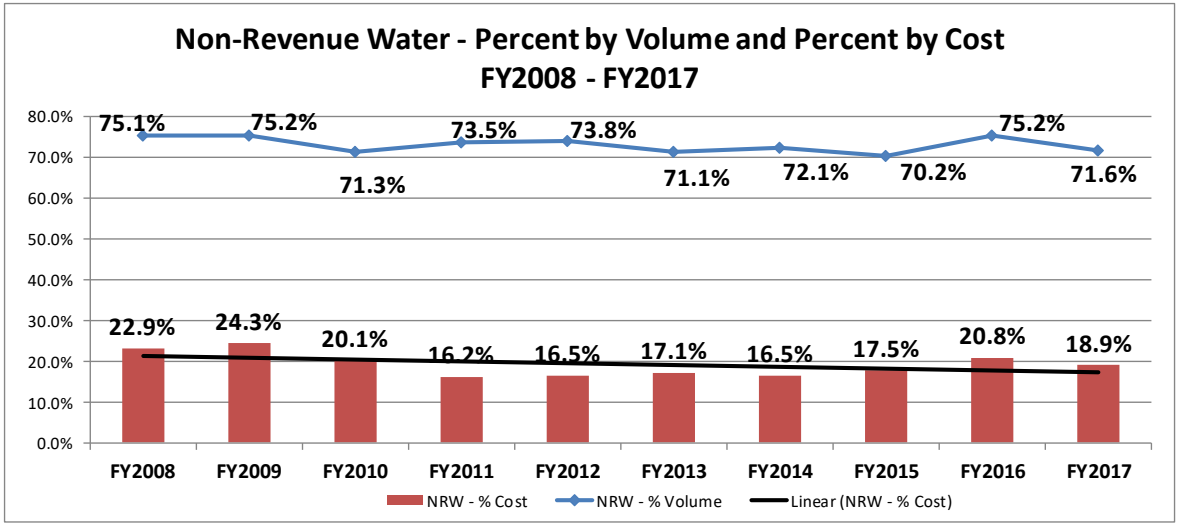
Total Metered Sales Revenue	FY2017	FY2016	FY2015	FY2014	FY2013	FY2012	FY2011	FY2010	FY2009	FY2008	
	90,464,810	83,158,940	78,007,937	70,818,255	$64,397,609	$60,256,304	$59,890,312	$55,079,772	$50,677,054	$43,995,732	2014 CAFR II-71, Schedule 2, 2013 CAFR II-67, 2012, 2011, 2010 CAFR II-58, 2009 and 2008CAFR II-57

Total Consumption	FY2017	FY2016	FY2015	FY2014	FY2013	FY2012	FY2011	FY2010	FY2009	FY2008	Source
	19,250	13,107	13,810	13,353	13,600	13,802	14,083	13,745	13,379	13,284	2013 & 2014 CAFR IV-8, 2012, 2011, 2010, 2009, 2008 CAFR IV-9

Revenue / Consumption	FY2017	FY2016	FY2015	FY2014	FY2013	FY2012	FY2011	FY2010	FY2009	FY2008	Source
	469,947	634,462	564,866	530,355	473,512	436,577	425,267	400,726	378,781	331,193	Total metered sales revenue / total consumption

SWBNO Detailed Water Audit
ILI and NRW Charts
FY 2008 - FY2017





SWBNO Detailed Water Audit
FY2008 - FY2017
Performance Indicator Summary

PERFORMANCE INDICATOR	FISCAL YEAR										Change	10 Year AVG
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	FY17 vs. 08	FY08-17
Financial Indicators												
Non-Revenue Water as % by Cost	22.9%	24.3%	20.1%	16.2%	16.5%	17.1%	16.5%	17.5%	20.8%	18.9%	-4.0%	19.1%
Non-Revenue Water as % by Volume	75.1%	75.2%	71.3%	73.5%	73.8%	71.1%	72.1%	70.2%	75.2%	71.6%	-3.5%	72.9%
Water Resources Indicators												
Inefficiency of use of Water as a Resource	58.3%	59.7%	53.9%	57.0%	57.6%	54.6%	55.4%	53.4%	59.2%	55.3%	-3.0%	56.4%
Operational Efficiency Indicators												
Apparent Losses - % of System Input Volume	0.75%	0.74%	0.86%	0.80%	0.79%	0.87%	0.84%	0.89%	0.75%	0.85%	0.1%	0.8%
Real Losses per Service Connection per Day	819.4	811.8	704.5	725.7	707.5	616.9	620.0	578.1	618.6	606.9	-212.6	680.9
Real losses per Mile of Main per Day	46,931	49,695	48,565	56,731	53,730	43,074	43,752	41,253	45,768	45,046	-1,885	47,454
Real Losses per Serv Conn per Day per psi	13.2	13.1	11.4	11.7	11.4	9.9	10.0	9.3	10.0	9.8	-3.43	11.0
Unavoidable Annual Real Losses (UARL)	1.83	1.91	1.84	1.93	1.99	2.11	2.13	2.16	2.22	2.23	0.41	2.0
Infrastructure Leakage Index (ILI)	46.0	46.6	41.9	44.7	43.2	36.8	37.1	34.7	37.5	36.9	-9.17	40.6