ICC Submittal

UFW Review
West Suburban District, Illinois

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June 2007

Earth Tech Project No. 99138

UFW TECHNICAL MEMORANDUM

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Appendix

EXECUTIVE SUMMARY

Background

The analysis described in this technical memorandum (TM) was performed to assist Illinois American Water Company in evaluating the level of unaccounted-for water (UFW) in the West Suburban District water system. In addition to substantiating the components of water use, the evaluation examines achievable levels of UFW given the individual water system characteristics, and establishes an ultimate target level of UFW based on practicality and cost-effectiveness.

Methodology

The methodology used in this evaluation quantifies recoverable losses and considers the economic cost of reducing UFW. Comparing the cost of loss reduction with the benefit of savings in water production or purchase identifies the "economic level of leakage" or optimum system operating point in terms of total cost to water customers. This approach is based on work performed by the International Water Association (IWA) Water Loss Task Force and is currently in the process of being adopted by the Water Loss Committee that is responsible for updating and maintaining the guidelines provided in American Water Works Association (AWWA) Manual M36.

Summary

The West Suburban District purchases water and distributes water to approximately 21,438 service connections through 354 miles of water main. The distribution system was separated into four district pressure zones with varying system pressures.
The UFW for West Suburban District in 2006 was approximately 5.2 percent and the infrastructure leakage index (ILI) was calculated to be approximately 0.3.

Recommendations

Table ES-1 summarizes the current ILI and UFW percentage along with the recommended target for the West Suburban District. The target ILI was established based on an economic leakage level where leak detection and sounding are economical and is consistent with the target ILIs guidelines summarized in the AWWA Water Loss Control Committee, *Applying Worldwide BMPs in Water Loss Control*, Journal AWWA, August 2003.

TABLE ES-1
SUMMARY OF RECOMMENDATIONS

Parameter	Current	Ultimate Target
ILI	0.3	3.5
UFW Percentage	5.2%	15.4%
Recommendations		
ALC Program	District metering and leak detection and sounding	
Water Balance and System Losses Evaluation	Complete annually	

Footnote:
[1] Percentage of UFW is defined as [(system input volume - authorized consumption)/system input volume] x 100

Since the West Suburban District has a relatively low ILI, the minimum annual cost is reactive leakage control. Unfortunately, from experience, it is known that the leakage level will continue to increase, which at a point will cause problems from both the perception of "wasting" water and supply limitations; therefore reactive leakage control is not a viable long-term ALC. At a minimum leak detection and sounding should be performed and the water balance and system losses evaluation be completed annually. By doing this, the ILI should be below the ultimate target of 3.5.

For this project, an evaluation of UFW was performed. This technical memorandum (TM) summarizes the results of the evaluation and will provide the following:

1. Establish the current level of water loss
2. Establish the economic level of leakage
3. Identify appropriate active leakage control (ALC) approach

1.0 BACKGROUND

The methodology used in this evaluation of UFW quantifies recoverable losses and considers the economic cost of reducing UFW. Comparing the cost of water loss reduction with the benefit of savings in water production or purchase identifies the "economic level of leakage" or optimum system operating point in terms of total cost to water customers. This approach is based on work performed by the International Water Association (IWA) Water Loss Task Force and is currently in the process of being adopted by the Water Loss Committee that is responsible for updating and maintaining the guidelines provided in American Water Works Association (AWWA) Manual M36, which provides guidelines for preparing a water audit.

With the adoption of AWWA's new approach for evaluating water loss within a water distribution system, it is important to provide definitions of some of the terms currently not widespread in the industry that now will be used. Appendix A includes definitions of terms for reference. The definitions are based on IWA's Blue Pages for Losses from Water Supply Systems Standard Terminology and Recommended Performance Measures and the Near Final Draft for Water Loss Control Committee Review of AWWA M36 Publication Rewrite.

2.0 WATER BALANCE

A water balance displays how quantities of water flow into and out of the distribution system and to the customer. Figure 1 and Table 1 illustrate the components of a water balance based on IWA recommended best practice. All data in the water balance is expressed as a volume per year. Each component of the water balance is specifically defined in the definition of terms provided in Appendix A.

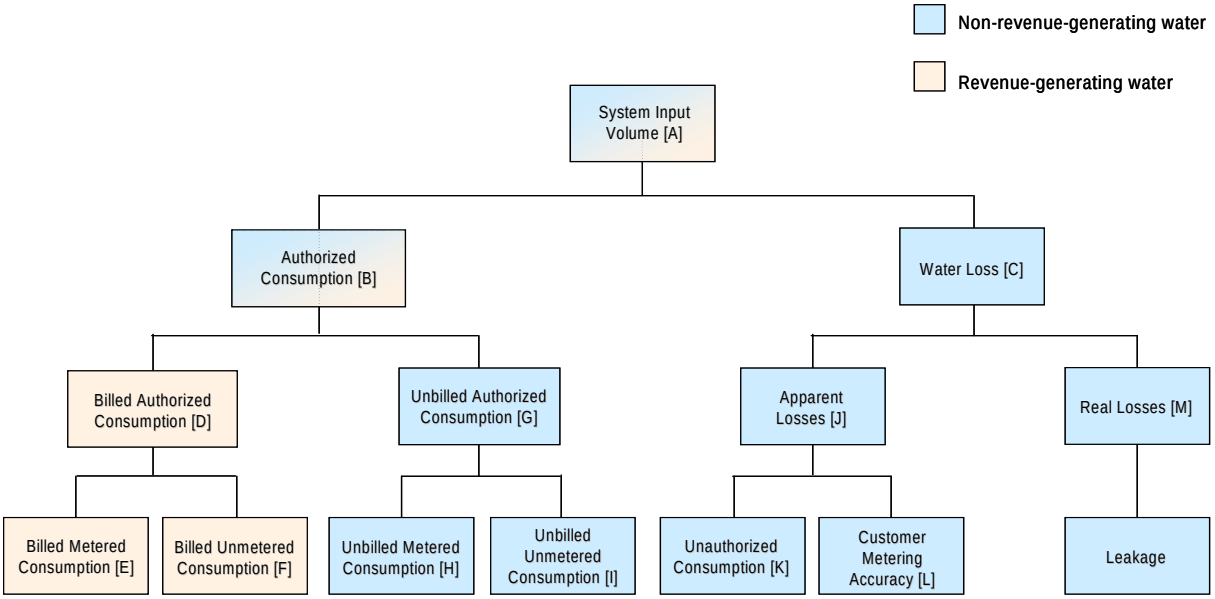


FIGURE 1
COMPONENTS OF A WATER BALANCE

TABLE 1
COMPONENTS OF A WATER BALANCE

System Input Volume [A]	Authorized Consumption [B]	Billed Authorized Consumption [D]	Billed Metered Consumption [E]	Revenue-Generating Water
			Billed Unmetered Consumption [F]	
		Unbilled Authorized Consumption [G]	Unbilled Metered Consumption [H]	Non-Revenue-Generating Water
			Unbilled Unmetered Consumption [I]	
	Water Losses [C]	Apparent Losses [J]	Unauthorized Consumption [K]	
			Metering Inaccuracies [L]	
		Real Losses [M]	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Point of Customer Metering	

2.1 Source of Data

The data for the water balance was provided by Illinois American Water personnel as part of the information request from Earth Tech for this project and is summarized in Appendix B for reference.

2.2 Description of Water System

The West Suburban District purchases water and distributes water to approximately 21,438 service connections through 354 miles of water main. The distribution system was separated into four district pressure zones with varying system pressures.

2.3 System Input Volume [A]

The system input volume for the West Suburban District is the volume of water entering the distribution system. The total system input volumes for 2004 through 2006 are as follows:

Year	Total Reported	Meter Accuracy	System Input Volume [A]
2004	3,018.0 MG	100.0%	3,018.0 MG
2005	3,661.6 MG	100.0%	3,661.6 MG
2006	3,454.6 MG	100.0%	3,454.6 MG

The West Suburban District supply meter accuracy included in the table above was reported.

2.4 Authorized Consumption [B]

Authorized consumption is any water used for all uses approved by the Utility. Most authorized consumption is metered, however, some is not. Authorized consumption is comprised of the following components:

1. Billed Authorized Consumption [D]

    a. Billed Metered Consumption [E]
    b. Billed Unmetered Consumption [F]

2. Unbilled Authorized Consumption [G]

    a. Unbilled Metered Consumption [H]
    b. Unbilled Unmetered Consumption [I]

2.4.1 Billed Authorized Consumption [D]

Billed authorized consumption is the annual volume of billed metered and unmetered water taken by registered customers and others who are authorized by the Utility for residential, commercial, public, and industrial purposes. Billed authorized consumption is comprised of the following two components:

1. Billed Metered Consumption [E]
2. Billed Unmetered Consumption [F]

2.4.2 Billed Metered Consumption [E]

Billed metered consumption is the component of billed authorized consumption that is metered. The billed metered consumption for the West Suburban District is summarized as:

Year	Billed Metered Consumption [E]
2004	2,831.7 MG
2005	3,292.7 MG
2006	3,232.5 MG

2.4.3 Billed Unmetered Consumption [F]

Billed unmetered consumption is the component of billed authorized consumption that is not metered. No billed unmetered consumption was reported for the West Suburban District in 2004 through 2006.

2.4.4 Unbilled Authorized Consumption [G]

Unbilled authorized consumption is the annual volume of unbilled metered and unmetered water taken by registered customers and others who are authorized by the Utility for residential, commercial, public, and industrial purposes.

Unbilled authorized consumption varies from community to community but generally covers the water needed to operate and maintain a water system and water used for public services such as swimming pools and irrigation. Unbilled authorized consumption is comprised of the following two components:

1. Unbilled Metered Consumption [H]
2. Unbilled Unmetered Consumption [I]

In the past, Illinois American Water Company has not tracked all forms of unbilled authorized consumption. For the purposes of this report, Illinois American Water Company has used in determining the UFW percentage the default percentage for unbilled authorized consumption given in the AWWA M36 manual of 1.25 percent.

The manual states:

> *It should also be recognized that Unbilled Authorized Consumption is usually a small portion of the volume of water supplied (WS). Based upon the findings of numerous water audits worldwide the worksheet in Figure 2.3 defaults to a value of 1.25% of the volume of water supplied (WS) for the water audit period. In order to quickly quantify this category, the default value can be used rather than attempting to quantify numerous minor water uses that are authorized by the utility. Generally, the auditor's time will be better served if dedicated to the quantification and control of real and apparent losses. However, under conditions such as severe drought, publicly visible use of water for flushing or other operations could generate negative public perceptions for the water utility. In such cases auditing should review all instances of unbilled authorized consumption and ensure that they are efficiently managed.*

In addition to consideration of the AWWA Manual provisions, Illinois American Water Company reviewed data from 34 Pennsylvania water districts where accurate tracking of unbilled authorized consumption is now available. The average percentage of unbilled authorized consumption in these districts was 1.34 percent. After using existing American Water data to verify the AWWA M36 manual estimate, Illinois American Water Company adopted the AWWA default percentage of 1.25 percent for unbilled authorized consumption.

Table 2 summarizes the Utility's unbilled water use (metered and unmetered) for public services and general operations.

TABLE 2
UNBILLED METERED AND UNMETERED CONSUMPTION

Description		Consumption (1.25% of [A])
2004	Unbilled Metered and Unmetered Consumption [H] + [I] = [G]	37.7 MG
2005	Unbilled Metered and Unmetered Consumption [H] + [I] = [G]	45.8 MG
2006	Unbilled Metered and Unmetered Consumption [H] + [I] = [G]	43.2 MG

2.5 Water Losses [C]

Water losses, also known as UFW, are equal to the difference between the system input volume and authorized consumption. The IWA defines two categories under which all types of water loss occurrences fall:

1. Apparent Losses [J]
2. Real Losses [K]

Using the formula of "water losses = system input volume - authorized consumption" results in overall water losses of the following:

Year	Water Losses [C]
2004	148.6 MG
2005	323.2 MG
2006	178.9 MG

2.5.1 Apparent Losses [J]

Apparent losses are essentially "paper" losses and consist of water use, which is not recorded due to metering error, incorrect assumptions of unmetered use, and unauthorized consumption; therefore, the two components of apparent losses are:

1. Unauthorized Consumption [K]
2. Customer Metering Accuracy [L]

Unauthorized Consumption [K]

Unauthorized consumption includes such things as meter or meter reading tampering, illegally opened fire hydrants, unauthorized tapping into service mains, or unauthorized restoration of water service connection after discontinuance by the Utility.

At this stage, there is no known unauthorized consumption.

Customer Metering Accuracy [L]

The accuracy of customer meters can have a dramatic effect on the water balance. Customer meter replacement was started in 2004 to improve accuracy of billed metered data. AWWA C700 establishes accuracy of new meters must be between 98.5 percent and 100.5 percent. Therefore, customer meter accuracy was assumed to be the average required accuracy of 99.5 percent.

Customer meter replacement has not been completed for West Suburban District. Therefore, customer meter accuracy was calculated based on the reported meter replacement percentage of 16 percent. New customer meters were assumed to be 99.5 percent accurate as previously stated and, based on replaced meter testing data, existing meters are assumed to be 95 percent accurate. The customer meter accuracy was; therefore, prorated based on the percentage of customer meters replaced since 2004.

Therefore, the apparent losses due to customer metering accuracy are estimated to be as follows:

Year	Customer Metering Accuracy [L]
2004	127.2 MG
2005	147.9 MG
2006	145.2 MG

2.5.2 Real Losses [M]

Real losses are physical water losses in a water system up to the point of measurement of customer use. Real losses are calculated using the following equation:

Real losses = Water Losses - Apparent Losses

Table 3 summarizes the calculation of real losses for the West Suburban District for the years 2004 through 2006. The estimated real losses for the West Suburban District for the years 2004, 2005, and 2006 are 21.4 MG, 175.3 MG, and 33.7 MG, respectively.

TABLE 3
REAL LOSSES

Real Losses		Volume		
		2004	2005	2006
System Input Volume	[A]	3,018.0 MG	3,661.6 MG	3,454.6 MG
Authorized Consumption	[B]=[D]+[G]=[E]+[F]+[H]+[I]	2,869.4 MG	3,338.4 MG	3,275.7 MG
Water Losses	[C]=[A]-[B]	148.6 MG	323.2 MG	178.9 MG
Apparent Losses	[J]=[K]+[L]	127.2 MG	147.9 MG	145.2 MG
Real Losses	[M]=[C]-[J]	21.4 MG	175.3 MG	33.7 MG

3.0 EVALUATION OF SYSTEM LOSSES

The previous sections described in detail the components of the water balance for the West Suburban District for 2004 through 2006. The water balance establishes the real losses for the West Suburban District. Although the evaluation of system losses, or UFW, is completed for 2004 through 2006, the following sections (sensitivity analysis, unit cost of leakage, and economic level of leakage) is based on the most recent year with real losses greater than zero as the basis.

This section discusses in detail the process of evaluating leakage levels for the West Suburban District.

The following performance indicators are discussed:

1. Technical Indicator for Real Losses (TIRL)
2. Unavoidable Annual Real Losses (UARL)
3. Infrastructure Leakage Index (ILI)

The parameters used for the evaluation of system losses are consistent with the IWA Water Loss Task Force and the Near Final Draft for Water Loss Committee Review, AWWA M36 Publication Rewrite.

3.1 Water System Information

To evaluate the West Suburban District's system losses using the parameters used by the IWA Water Loss Task Force and the Near Final Draft for Water Loss Committee Review, AWWA M36 Publication Rewrite, the water system parameters summarized in Table 4 are required.

TABLE 4
WATER SYSTEM INFORMATION

Description	Entire System		
	2004	2005	2006
Length of Water Main	353.8 miles		
Number of Service Connections	21,438		
Number of Service Connections per Mile	60.6 connections/mile		
Distance Customer Meters are Located from Edge of Street	40 feet		
Percent of Time System Pressurized	100%		
Average System Pressure	54 psi		
Revised System Input Volume	3,018.0 MG	3,661.6 MG	3,454.6 MG
Note: psi = pounds per square inch			

3.2 TIRL

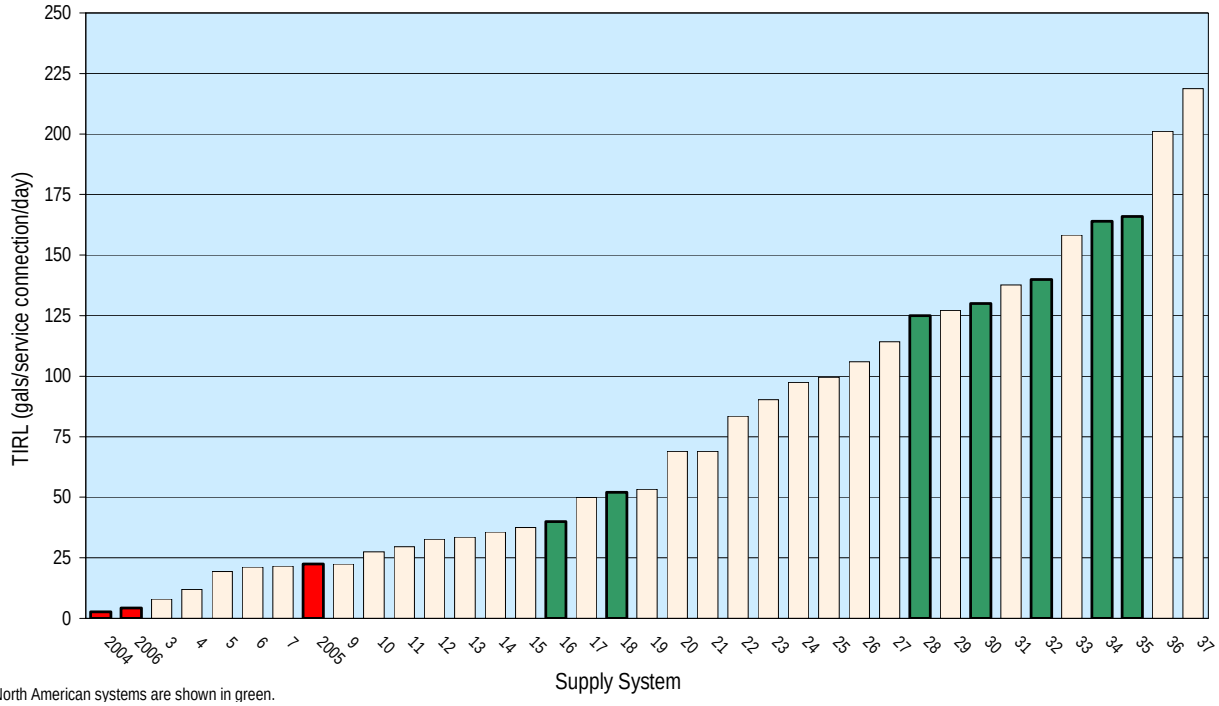
The TIRL is a performance indicator of the total volume of losses in a water distribution system. Typically, this has been defined as a percentage of the amount of water entering the distribution system. In the new approach of looking at water losses, it is recommended that TIRL be expressed in gallons per service connection per day. Table 5 summarizes the TIRL calculation for the West Suburban District.

TABLE 5
TIRL

Calculation of TIRL	Entire System		
	2004	2005	2006
Annual Volume of Real Losses	21.4 MG	175.3 MG	33.7 MG
Average Daily Real Losses when System Pressurized	0.06 MG	0.48 MG	0.09 MG
TIRL	3 gals/serv conn/day	22 gals/serv conn/day	4 gals/serv conn/day

Using the estimated real losses determined in the water balance and the total number of estimated service connections, the TIRLs for the West Suburban District ranged from approximately 3 gallons per service connection per day to 22 gallons per service connection per day.

Figure 2 compares the West Suburban District TIRLs with other communities' TIRLs throughout the world. The seven TIRLs indicated in green on the figure are North American communities. From this figure, it can be seen that the level of real losses for the West Suburban District is on the low end of those surveyed including the North American communities.



North American systems are shown in green.
Supply systems composed of 34 systems surveyed in 20 countries.
Source: Lambert, A., D. Huntington, and T.G. Brown, Water Loss Management in N.America: Just How Good Is It?, Water Loss Control Manual, 2002.

FIGURE 2
TIRL

3.3 UARL

The water industry has long recognized that it is impossible to achieve zero leakage. Previous terms that have been used to describe the level of leakage that cannot be completely recovered include the following: background leakage, intrinsic leakage, and non-recoverable leakage. The term UARL has been introduced to define the level of leakage which could be achieved at the current operating pressure if there were no financial or economic constraints on the level of ALC. Similar to TIRL, UARL has the unit of gallons per service connection per day.

The UARL consists of the following main elements:

- Background losses from undetectable leaks
- Losses from reported leaks
- Losses from unreported leaks

Using an approach adopted in the United Kingdom, an average UARL can be calculated for an individual water system. The parameter values used to calculate the UARL are based on published international data for minimum background loss rates, typical burst flow rates, and frequencies for infrastructure in good condition. The calculated values of the UARL for each component of infrastructure are shown in Table 6.

The calculated UARL should only be used as a guide. Once ALC has been implemented, the background losses and reported and unreported leaks can be better defined for the West Suburban District water system and a more accurate UARL can be established.

The Table 7 values presented as an equation in the most basic form are presented below.

UARL = (5.39 x *Lm* + 0.15 x *Nc* + 7.47 x *Lp*) x P

Where: *Lm* is the length of water mains in the distribution system (miles)
Nc is the number of service connections
Lp is the total length of pipe between the edge of the street and the customer meter (feet)
P is the average operating pressure pounds per square inch (psi)
UARL is in gallons per day (gpd)

The average operating pressure was determined by reviewing the percentage of customers in each pressure zone. Therefore, the average operating system pressure is 54 psi.

The characteristics of the West Suburban District water distribution system summarized in Table 4 were used for the UARL calculation.

TABLE 6
UARL

Components of UARL	Total UARL	Components of UARL				
		Background Losses	Reported Bursts	Unmetered Use	Total	Units
Mains	104,878 gpd	2.87	1.75	0.77	5.39	gallons/mile of main/day/psi of pressure
Service Connections, Main to Curb-Stop	176,864 gpd	0.11	0.01	0.03	0.15	gallons/serv conn/day/psi of pressure
Service Connections, Curb-Stop to Meter	70,182 gpd	4.8	0.57	2.12	7.47	gallons/mile of main/day/psi of pressure
UARL	351,923 gpd					
	16 gallons/ serv conn/day					

The total UARL for the West Suburban District was calculated to be approximately 16 gallons per service connection per day (351,923 gpd).

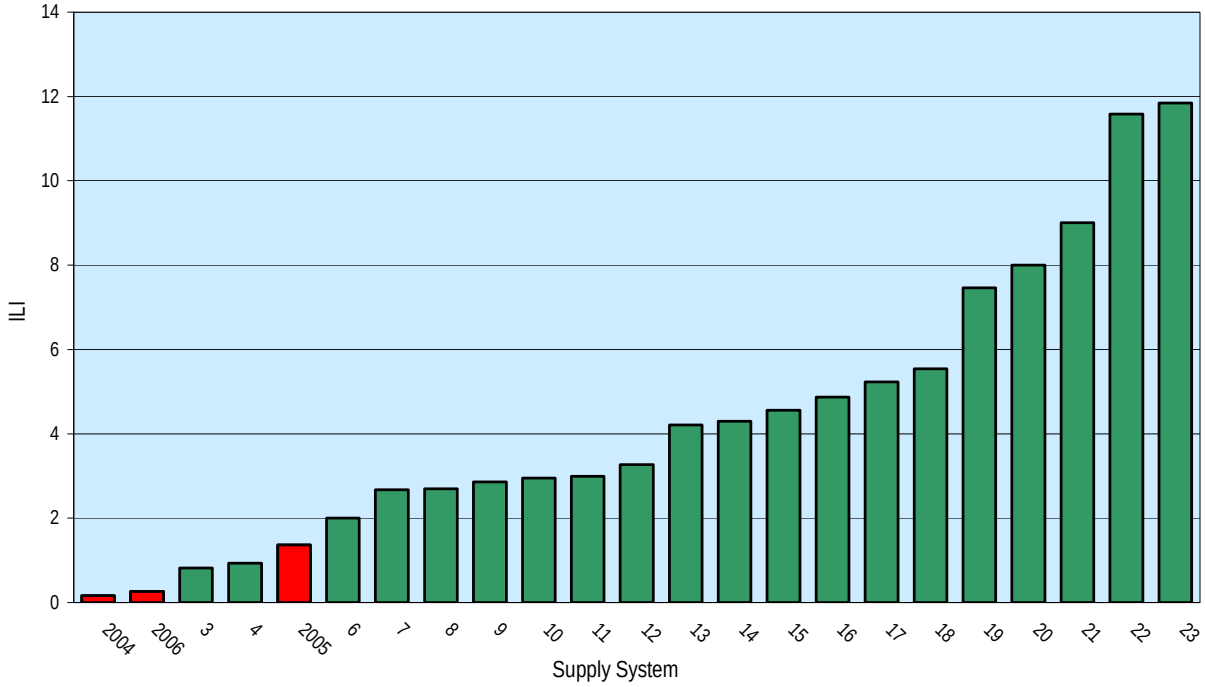
3.4 ILI

The difference between the TIRL and UARL represents the maximum potential for future savings in real losses. Also, the ratio of TIRL to UARL is in a useful, non-dimensional index of the overall condition and management of infrastructure. The ratio of TIRL to UARL is known as the ILI. Table 7 summarizes the ILI calculations for the West Suburban District.

TABLE 7
ILI

Calculation of ILI	Entire System		
	2004	2005	2006
TIRL	3 gallons/serv conn/day	22 gallons/serv conn/day	4 gallons/serv conn/day
UARL	16 gallons/serv conn/day		
ILI (ratio of TIRL to UARL)	0.2	1.4	0.3

Figure 3 illustrates the West Suburban District's ILIs along with the survey results of several other communities throughout the U.S. and Canada. From this figure, it can be seen that the West Suburban District is in the low range of communities surveyed.



Supply systems composed of systems surveyed in the U.S. and Canada
Source: McKenzie, R. and C. Seago, Assessment of Real Losses in Potable Water Distribution Systems: Some Recent Development, Water Science and Technology: Water Supply, 2005.

FIGURE 3
ILI

ILIs reported from England and Wales tend to be lower than other countries. McKenzie and Seago (2005) provide the following explanation:

> While there are many possible explanations for the different trends in the different countries, the cost of water and the presence of a strict regulator are possibly two of the key factors. In the UK for example, the system leakage is being driven down (often below the economic level of leakage) by the regulator, who is able to impose leakage targets for all water utilities.

The AWWA Water Loss Committee recently published Table 8 as a guideline for action based on a community's ILI.

TABLE 8
GENERAL GUIDELINES FOR SETTING A TARGET LEVEL ILI
(in lieu of having a determination of the system-specific economic level of leakage)

Target ILI Range	Water Resources Considerations	Operational Considerations	Financial Considerations
1.0 - 3.0	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.	Operating with system leakage above this level requires expansion of existing infrastructure and/or additional water resources to meet the demand.	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low ratepayer affordability.
3.0 - 5.0	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management, water conservation) are included in the long-term planning.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibility imposed and are tolerated by the customer population.
5.0 - 8.0	Water resources are plentiful, reliable, and easily extracted.	Superior reliability, capacity, and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Cost to purchase or obtain/treat water is low, as are rates charged to customers.
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 utilization 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.		

Source: AWWA Water Loss Control Committee, *Applying Worldwide BMPs in Water Loss Control*, Journal AWWA, August 2003.

The table indicates that communities with limited water sources are currently operating near the capacity of existing infrastructure or where there are financial limitations on developing additional supply sources that should set a target ILI of 1 to 3. The guidelines discourage setting a target ILI greater than 8, as such a level of leakage is not an effective utilization of water as a resource; therefore, the West Suburban District is below the minimum target ILI recommended.

4.0 UNIT COST OF LEAKAGE

To determine the annual cost of water losses, the cost of distributing water to customers must be established. In general, the cost to distribute water to the customers consists of all fixed and variable costs associated with treatment, distribution, and administration; however, only variable costs associated with treatment and distribution are directly affected by water consumption and leakage rates. Specifically, these variable costs may include:

- Chemical addition costs directly associated with treatment
- Electrical and power costs associated with treatment and distribution
- Cost of purchasing water

Over the long term, treatment capital costs may be reduced by an aggressive abatement of leakage, but these cost changes will be subtle and not easy to determine in advance and, therefore, are not included in this analysis. In addition, the reduction of water losses can also delay or upset the need for major capital improvements and expansion.

The determination of the unit cost of leakage for the West Suburban District is summarized in Table 9.

TABLE 9
UNIT COST OF LEAKAGE

Calculation of Unit Cost of Leakage for Entire System	
Variable Costs	
Purchase of Water	$2,715 per MG
Electricity Cost	$41 per MG
Chemical Cost	$0 per MG
TOTAL	$2,756 per MG
Unit Cost of Leakage	$2,756 per MG
Annual Cost of UARL	$354,000 per year
Annual Cost of TIRL	$92,800 per year
Annual Cost of Potential Recoverable Losses	$0 per year
Annual Cost of Potential Recoverable Losses as Percentage of Total	0%

5.0 SENSITIVITY ANALYSIS

A sensitivity analysis was performed on key input variables for 2006 to determine the effect on key water balance parameters and indicators. Table 10 summarizes the variations made to key input variables during the sensitivity analysis.

TABLE 10
SUMMARY OF SENSITIVITY ANALYSIS VARIATIONS

Parameter	Variation
System Input Volume [A]	Increased and decreased by 2 percent
Customer Meter Accuracy	Increased and decreased by 2 percent with a maximum of 100 percent accuracy
Billed Unmetered Consumption [F]	Increased by ½ and 1 percent of system input volume
Unbilled Authorized Consumption [G]	Increased and decreased by 5 percent
Unauthorized Consumption [K]	Increased by ½ and 1 percent of system input volume
UARL	Increased and decreased by 10 percent

Table 11 summarizes the results of the sensitivity analysis.

5.1 Conclusions

The sensitivity analysis indicated that changing the following parameters had minimal effect in the overall evaluation:

1. Unbilled Authorized Consumption (Metered and Unmetered) [G]

The greatest sensitivity was in the accuracy of measuring the system input volume and customer demands. This confirms that the accuracy of meters is critical in understanding water losses.

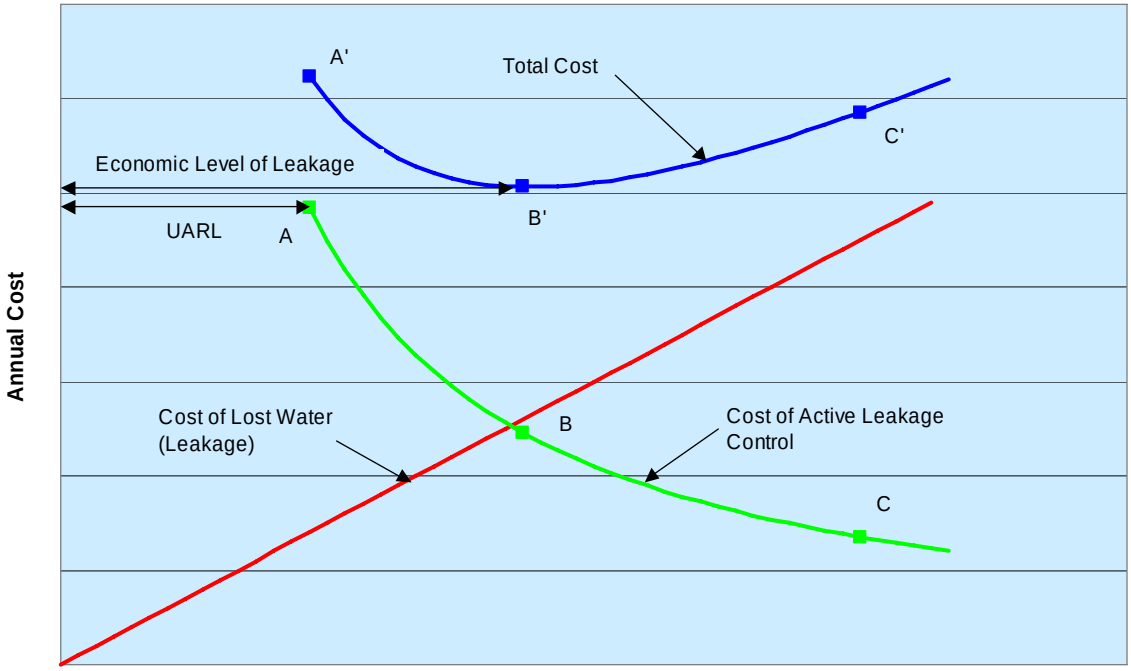
TABLE 11
SUMMARY OF SENSITIVITY ANALYSIS RESULTS

Parameter / Variable and Adjustment			Water Losses (MG)	Apparent Losses (MG)	Real Losses (MG)	TIRL (gals/serv conn/day)	ILI	Annual Cost of Potential Recoverable Losses
2006 Calculated Value			178.9	145.2	33.7	4	0.3	-$261,200
System Input Volume	+2%	Adjusted Value	248.0	145.2	102.8	13	0.8	-$70,700
		Change from 2006 calculated	38.6%	0.0%	205.1%	205.1%	205.1%	-72.9%
	-2%	Adjusted Value	109.8	145.2	-35.4	-5	-0.3	-$451,600
		Change from 2006 calculated	-38.6%	0.0%	-205.1%	-205.1%	-205.1%	72.9%
Customer Meter Accuracy	+2%	Adjusted Value	178.9	76.1	102.8	13	0.8	-$70,600
		Change from 2006 calculated	0.0%	-47.6%	205.3%	205.3%	205.3%	-73.0%
	-2%	Adjusted Value	178.9	217.3	-38.4	-5	-0.3	-$459,900
		Change from 2006 calculated	0.0%	49.7%	-214.0%	-214.0%	-214.0%	76.1%
Billed Unmetered Consumption	+1% of System Input Volume	Adjusted Value	161.6	145.2	16.4	2	0.1	-$308,800
		Change from 2006 calculated	-9.7%	0.0%	-51.3%	-51.3%	-51.3%	18.2%
	+½% of System Input Volume	Adjusted Value	144.3	145.2	-0.9	0	0.0	-$356,400
		Change from 2006 calculated	-19.3%	0.0%	-102.6%	-102.6%	-102.6%	36.4%
Unbilled Authorized Consumption	+5%	Adjusted Value	176.7	145.2	31.5	4	0.2	-$267,100
		Change from 2006 calculated	-1.2%	0.0%	-6.4%	-6.4%	-6.4%	2.3%
	-5%	Adjusted Value	181.0	145.2	35.8	5	0.3	-$255,200
		Change from 2006 calculated	1.2%	0.0%	6.4%	6.4%	6.4%	-2.3%
Unauthorized Consumption	+1% of System Input Volume	Adjusted Value	178.9	162.5	16.4	2	0.1	-$308,800
		Change from 2005 calculated	0.0%	11.9%	-51.3%	-51.3%	-51.3%	18.2%
	+½% of System Input Volume	Adjusted Value	178.9	179.7	-0.9	0	0.0	-$356,400
		Change from 2006 calculated	0.0%	23.8%	-102.6%	-102.6%	-102.6%	36.4%
UARL	+10%	Adjusted Value	178.9	145.2	33.7	4	0.2	-$296,600
		Change from 2006 calculated	0.0%	0.0%	0.0%	0.0%	-9.1%	13.6%
	-10%	Adjusted Value	178.9	145.2	33.7	4	0.3	-$225,800
		Change from 2006 calculated	0.0%	0.0%	0.0%	0.0%	11.1%	-13.6%

6.0 ECONOMIC LEVEL OF LEAKAGE

The economic level of leakage is defined as the amount of leakage with the overall annual lowest cost (cost of lost water and implementing ALC). Although this is commonly construed as a purely financial equation, other social, political, and environmental costs can be included in the savings through a reduction of water losses.

The concept of an optimum level of leakage is illustrated graphically in Figure 4.



Source: Lambert, A. O., T.G. Brown, M. Tkizawa, and D. Weimers, A Review of Performance Indicators for Real Losses from Water Supply Systems, IWSA, J Water SRT - Aqua 48, 227-237, 1999.

FIGURE 4
RELATIONSHIP BETWEEN UARL AND ECONOMIC LEVEL OF LEAKAGE

The following three parameters are shown in Figure 4 as a function of the annual real losses in the system:

1. Cost of lost water.
2. Annual cost of implementing ALC.
3. Total cost of lost water and annual cost of implementing ALC.

Figure 4 illustrates, as would be expected, that as leakage increases the cost of water lost increases. It also illustrates that if more stringent forms of ALC (more stringent forms of ALC have a higher annual cost) are implemented (A>B>C), the volume of leakage decreases, and therefore, the cost of leakage decreases. Adding the cost of lost water and the cost of implementing ALC results in the total cost curve (upper curve, A'B'C'). The minimum point on the curve represents the economic level of leakage, that is the level of leakage with the lowest overall annual cost (B').

6.1 Cost of Implementing ALC

To arrive at the economic level of leakage for the West Suburban District, the cost of implementing alternative ALC strategies must be established. Table 12 summarizes the ALC alternatives and corresponding ALC strategies considered for the West Suburban District water system.

TABLE 12
SUMMARY OF ALC ALTERNATIVES

ALC Alternatives	Reactive Leakage Control	Leak Detection and Sounding	District Metering	Step Testing
A	✓			
B	✓	✓		
C	✓	✓	✓	
D	✓	✓	✓	✓

Pressure control is also a recognized ALC. Leaks are not repaired but leakage is reduced due to the lower system pressures; however, reducing system pressures can also have an affect on customer service and fire flow capabilities. In this evaluation, pressure control was not considered, as a system-wide analysis would need to be performed to determine if there are any negative effects on customer service and fire flow capabilities.

Table 13 briefly summarizes the ALC strategies and estimated annual cost. A detailed evaluation of alternative ALC was not part of this project; therefore, estimated annual costs should only be used for comparison of alternatives.

TABLE 13
SUMMARY OF ALC ESTIMATED ANNUAL COST

ALC Strategy	Description	Capital Cost	Annual Operating and Maintenance Cost
Reactive Leakage Control	Limited to only fixing leaks that can be seen surfacing. No proactive work is performed to identify leaks. This ALC is currently being performed by the West Suburban District.	$0	$0
Leak Detection and Sounding	Using equipment to listen for leaks, including the use of noise correlation to pinpoint the leak location. This ALC is currently being performed by the West Suburban District.	$0	$75,800[1]
DMAs	Measuring the flow into isolated areas of the water system. By examining the flow (especially during the silent hours) into each DMA, an assessment of the level of leakage can be made. Once the level of leakage in each DMA has been established, priority can be set for leak detection surveys.	$114,000[2]	$80,000[3]
Step Testing	Consists of isolating smaller areas within each DMA. This form of ALC can identify smaller leaks. The implementation of step testing is labor intensive.	$0	$215,000[4]

Footnotes:
1 Based on the assumption of $200 per mile and a $5,000 mobilization fee.
2 Based on a capital cost of $100,000 per DMA annualized for 10 years, assuming an interest rate of 7 percent (assumed $100,000 per DMA and 8 DMAs).
3 Based on $10,000 per DMA.
4 Based on $5,000 per area, assuming approximately 500 properties per area per DMA.

6.1.1 Target Leakage Levels

To establish the most appropriate ALC, it is necessary to estimate the decrease in ILI by implementing alternative ALCs. No formal guidelines are available for quantifying the reduction of leakage by the implementation of each method of ALC. Table 14 summarizes the approach adopted for estimating the reduction in ILI for various ALCs, the target level of leakage, and the corresponding TIRL for each of the ALC alternatives.

TABLE 14
SUMMARY OF TARGET LEAKAGE LEVELS

ALC Alternative	Description	Current ILI	Target ILI	Current TIRL		Target TIRL	
				(gals/serv conn/day)	(MGY)	(gals/serv conn/day)	(MGY)
A	• Reactive leakage control[1]	0.3	3.5[2]	4	33.7	57	450.0
B	• Reactive leakage control[1] • Leak detection and sounding[1]		3.0			49	385.4
C	• Reactive leakage control[1] • Leak detection and sounding[1] • District metering		2.0			33	256.9
D	• Reactive leakage control[1] • Leak detection and sounding[1] • District metering • Step testing		1.5			25	192.7

Footnote:
[1] Existing ALC.
[2] Target ILI is set at 3.5 based on the guidelines summarized in Table 8 and the economic level of leakage in the following section.

6.1.2 Economic Level of Leakage

As stated earlier, the economic level of leakage is the amount of leakage that provides the lowest annual cost when considering the cost of implementing ALC. Figure 5 utilizes the target ILI to illustrate when an ALC other than reactive leakage control becomes economical for the West Suburban District system in terms of annual cost versus level of leakage. Since the current level of leakage is relatively low, the current economic level of leakage is reactive leakage control.

Similar to Figure 4, the following three parameters are shown in Figure 5 for the West Suburban District system as a function of the annual real losses in the system:

1. Annual cost of lost water.
2. Annual cost of implementing ALC.
3. Total cost of lost water, implementing ALC, and cost to repair leaks.

As illustrated in Figure 5, the minimum annual cost is near the ALC alternatives of C and D. For this analysis, the capital cost of the DMA program has been annualized for 10 years, assuming

an interest rate of 7 percent. It should also be noted that the cost of the ALC to this point has not included the cost to repair the leaks discovered during the ALC. It is reported that the cost of repairing the leaks will remain constant regardless of the level of leakage in the system; therefore, the cost of the repairs need not be taken into account in calculating the economic level of leakage. However, it is recognized that, initially, as the West Suburban District changes to additional ALC, additional leaks would need to be repaired.

As illustrated in the figure, the minimum annual cost with a target ILI of 3.5 is Alternative C, district metering and leak detection and sounding. At the current ILI reactive leakage control is the minimum annual cost. Unfortunately, from experience, it is known that the leakage level will continue to increase, which at a point will cause problems from the perception of "wasting" water and supply limitations. Alternative A is not considered a viable long-term ALC. At a minimum, Alternative C, district metering and leak detection and sounding should be performed.

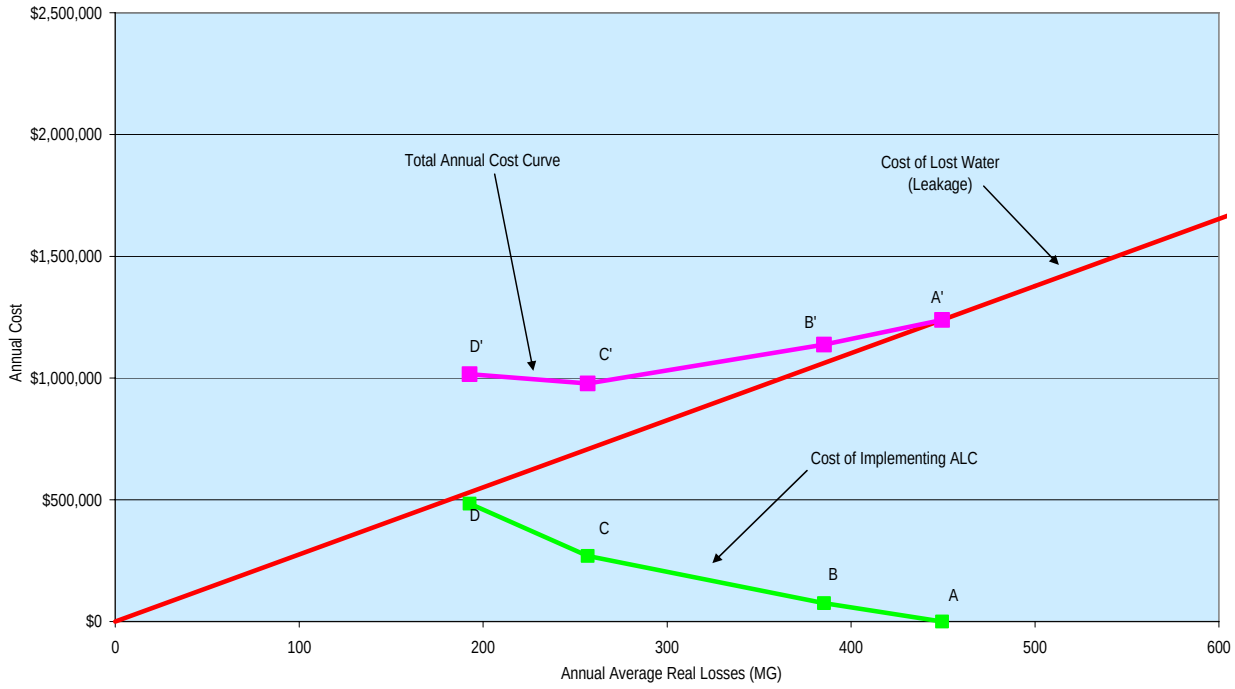


FIGURE 5
DETERMINATION OF ECONOMIC LEVEL OF LEAKAGE

7.0 SUMMARY

This TM summarizes the completion of the water balance and evaluation of system UFW for 2004 through 2006, sensitivity analysis on the key input parameters, determination of the economic level of leakage, and identification of the appropriate ALC approach. A completed water balance and evaluation of system losses for 2006 is included in Appendix C. Figure 6 summarizes the components of the 2006 water system balance. Table 15 summarizes some of the key components of the water system evaluation for 2006.

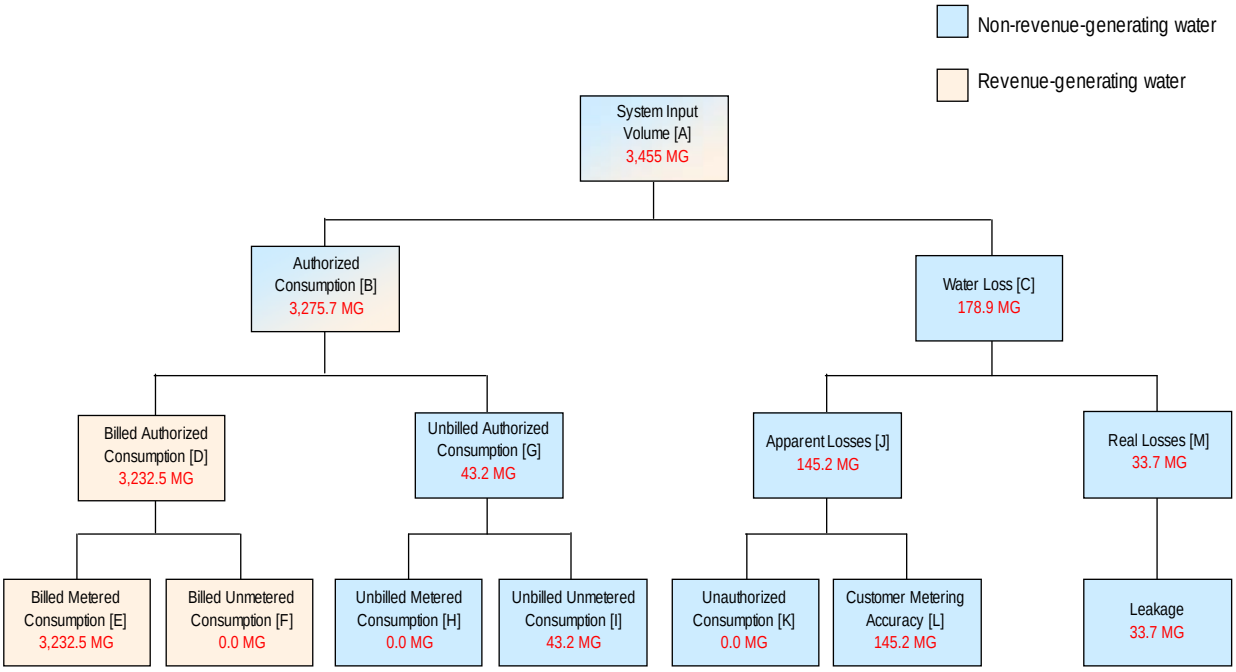


FIGURE 6
SUMMARY OF 2006 WATER BALANCE

TABLE 15
SUMMARY OF KEY COMPONENTS OF WATER SYSTEM EVALUATION

Parameter	Value	
TIRL	4 gallons/serv conn/day	92,292 gpd
UARL	16 gallons/serv conn/day	351,923 gpd
ILI		0.3
Percentage of UFW[1]		5.2%
Unit Cost of Leakage		$2,756 per MG
Annual Cost of Potential Recoverable Losses		$0 per year

Footnote:
[1] Percentage of UFW is defined as [(system input volume - authorized consumption)/system input volume] x 100

Table 16 summarizes the current ILI and UFW percentage along with the recommended target for the West Suburban District. The target ILI was established based on an economic leakage level where leak detection and sounding are economical and is consistent with the target ILIs guidelines summarized in the AWWA Water Loss Control Committee, *Applying Worldwide BMPs in Water Loss Control*, Journal AWWA, August 2003.

TABLE 16
SUMMARY OF RECOMMENDATIONS

Parameter	Current	Ultimate Target
ILI	0.3	3.5
UFW Percentage	5.2%	15.4%
Recommendations		
ALC Program	District metering and leak detection and sounding	
Water Balance and System Losses Evaluation	Complete annually	

Footnote:
[1] Percentage of UFW is defined as [(system input volume - authorized consumption)/system input volume] x 100

Since the West Suburban District has a relatively low ILI, the minimum annual cost is reactive leakage control. Unfortunately, from experience, it is known that the leakage level will continue to increase, which at a point will cause problems from both the perception of "wasting" water and supply limitations; therefore reactive leakage control is not a viable long-term ALC. At a minimum leak detection and sounding should be performed and the water balance and system losses evaluation be completed annually. By doing this the ILI should be below the ultimate target of 3.5.

APPENDIX A

ACRONYMS AND DEFINITIONS OF TERMS

APPENDIX A
ACRONYMS AND DEFINITIONS OF TERMS

ACRONYMS

gpcd	gallons per capita per day
gpd	gallons per day
psi	pounds per square inch
ALC	Active Leakage Control
AWWA	American Water Works Association
DMA	District Metering Area
ICI	Industrial, Commercial, and Institutional
ILI	Infrastructure Leakage Index
IWA	International Water Association
MG	Million Gallons
MGY	Million Gallons per Year
TIRL	Technical Indicator for Real Losses
TM	Technical Memorandum
UARL	Unavoidable Annual Real Losses
UFW	Unaccounted-For Water

DEFINITIONS OF TERMS

Apparent Losses	Unauthorized consumption (theft or illegal use) and all types of inaccuracies associated with production metering and customer metering.
Authorized Consumption	The volume of metered and/or unmetered water taken by registered customers, the water supplier, and others who are implicitly or explicitly authorized to do so by the water supplier, for domestic, commercial, and industrial purposes. It includes water exported. Note that authorized consumption includes items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, and building water. These may be billed or unbilled, metered or unmetered, according to local practice.
Billed Authorized Consumption	The annual volume of billed metered and unmetered water taken by registered customers and others who are authorized by the City for residential, commercial, public, and industrial purposes.
Billed Metered Consumption	The component of billed authorized consumption that is metered.
Billed Unmetered Consumption	The component of billed authorized consumption that is not metered.
District Metering Areas (DMAs)	The use of DMAs as a method of ALC relies on measuring the flow into isolated areas of the water system. DMAs are established by creating a discrete zone within the water distribution system, by closing valves in “connect-the-dot” fashion, leaving only one or two pipelines to supply water to the zone. Portable or permanent flow meters are used at this input point(s) to measure water supply into the zone on a continuous basis. By examining the flow (especially during the silent hours) into each DMA, an assessment of the level of leakage can be made. Once the level of leakage in each DMA has been established, priority can be set for leak detection surveys. The use of DMAs as a form of ALC is well established in other countries and has been shown to be successful in the management of leakage.
Economic Level of Leakage	The appropriate leakage level for water suppliers to target or the amount of leakage with the overall annual lowest cost (cost of lost water and implementing ALC). Although this is commonly construed as a purely financial equation, other social, political, and environmental costs can be included in the savings through a reduction of water losses.

Infrastructure Leakage Index (ILI)	The ratio of TIRL to UARL. The ILI is a useful non-dimensional numeric value, which provides a method of comparing leakage between different utilities.
Non-Revenue Generating Water	The difference between the system input volume and the billed authorized consumption.
Percentage of UFW	Percentage of UFW is calculated as [(system input volume - authorized consumption)/system input volume] x 100.
System Input Volume	The volume of water input to a transmission system or distribution system.
Real Losses	Physical water losses from the system up to the point of customer metering, and include leakage and overflows prior to the point of end use.
Recoverable Losses	Recoverable loss is the amount of water loss that could be prevented through active leakage control.
Technical Indicator for Real Losses (TIRL)	A performance indicator of the total volume of losses in a water distribution system. Typically, this has been defined as the percentage of the amount of water entering the distribution system. In the new approach of looking at water losses, it is recommended that TIRL be expressed in gallons per service connection per day.
Unaccounted-For Water (UFW)	UFW in a water system is calculated as system input volume minus authorized consumption.
Unauthorized Consumption	Unauthorized consumption includes such things as meter or meter reading tampering, illegally opened fire hydrants, unauthorized tapping into service mains, or unauthorized restoration of water service connection after discontinuance by utility.
Unavoidable Annual Real Losses (UARL)	The term UARL has been introduced to define the level of leakage which could be achieved at the current operating pressure if there were no financial or economic constraints on the level of ALC. Similar to TIRL, UARL has the unit of gallons per service connection per day. The UARL consists of the following main elements: 1. Background losses from undetected leaks 2. Losses from reported leaks 3. Losses from unreported leaks

Unbilled Authorized Consumption	The annual volume of unbilled metered and unmetered water taken by registered customers and others who are authorized by the City for residential, commercial, public, and industrial purposes.
Unbilled Metered Consumption	The component of unbilled authorized consumption that is metered.
Unbilled Unmetered Consumption	The component of unbilled authorized consumption that is not metered.
Water Balance	A water balance displays how quantities of water flow into and out of the distribution system and to the customer. All data in the water balance is expressed as a volume per year.
Water Losses	Water losses of a system are calculated as: "water loss = system input volumes - authorized consumption." Water losses consist of real and apparent losses.

APPENDIX B

SUMMARY OF INFORMATION NEEDS REQUEST

UNACCOUNTED-FOR WATER INVESTIGATION

Illinois American Water

Name of Community	Chicago Metro_West Suburban and Santa Fe(Bolingbrook and Woodridge)
Contact Person	Kevin Hillen
Telephone Number	630-739-8959
Fax Number	630-739-0488
Email	Kevin.Hillen@amwater.com
Cell Phone Number	630-281-0535

DESCRIPTION OF SYSTEM:

Source(s) of Water:	Wells	Surface	Purchase Water	Other	(Indicate All that Apply)	
Treatment Type:						
Number of Wells:	1	2	3	4	Other 17	(Indicate One)
Number of Pressure Zones:	1	2	3	4	Other_____	(Indicate One)
Number of Storage Facilities:	1	2	3	4	Other 11	(Indicate One)
List Capacity and Type of Each Storage Facility	Wells are emergency standby only. Seven Elevated Tanks: 1 - 0.2MG, 1 - 0.3MG, 1 - 0.4MG, 3 - 0.5MG, 1 - 0.75MG. 4 Ground Staorage Tanks: 1 - 5MG,1 - 3MG,1 - 1.2MG,1 - 0.75MG					
Number of Supply Meters:	2					
Schematic of Water System	Yes		No			

General Description of Water System

(not provided)

Other Information — Please attach any other information (previous studies, mapping, etc.) that may be helpful.

	Pressure Zone A	Pressure Zone B	Pressure Zone C	Pressure Zone D	Total	Responsible Personnel	Source of Data	Confidence in Accuracy of Data[1]
Name of Pressure Zone								
Average System Pressure:	55 psi	53 psi	42 psi	72 psi	54 psi			1 2 3 4 5
Number of Service Connections:	21,438				21438			1 2 3 4 5
Distance Customers Meters are Located From Edge of Street	40 ft	40 ft	40 ft	40 ft				1 2 3 4 5

	Pressure Zone A			Pressure Zone B			Pressure Zone C			Pressure Zone D			Total			Responsible Personnel	Source of Data	Confidence in Accuracy of Data[1]
	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006			
Billed Metered Consumption (MG):	2,831.65	3,292.65	3,232.50										2,831.65	3,292.65	3,232.50			1 2 3 4 5
Billed Unmetered Consumption (MG):	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			1 2 3 4 5
Examples:																		
Fill at Fire Stations																		1 2 3 4 5
Contractor Use																		1 2 3 4 5
Other (1)																		1 2 3 4 5
Other (2)																		1 2 3 4 5
Other (3)																		1 2 3 4 5
Unbilled Authorized Consumption (MG):																		1 2 3 4 5
Examples:																		
City Buildings													0.00	0.00	0.00			1 2 3 4 5
Parks													0.00	0.00	0.00			1 2 3 4 5
Cemeteries													0.00	0.00	0.00			1 2 3 4 5
Water Main Flushing			11.28										0.00	0.00	11.28			1 2 3 4 5
Firefighting and Training													0.00	0.00	0.00			1 2 3 4 5
Main Breaks													0.00	0.00	0.00			1 2 3 4 5
Reservoir Leakage/Overflow													0.00	0.00	0.00			1 2 3 4 5
Irrigation													0.00	0.00	0.00			1 2 3 4 5
Street Cleaning													0.00	0.00	0.00			1 2 3 4 5
Leaks Located													0.00	0.00	0.00			1 2 3 4 5
Construction Use			5.00										0.00	0.00	5.00			1 2 3 4 5
Illegal Connections													0.00	0.00	0.00			1 2 3 4 5
Sewage Treatment Plant													0.00	0.00	0.00			1 2 3 4 5
Other													0.00	0.00	0.00			1 2 3 4 5
Unauthorized Consumption (MG):													0.00	0.00	0.00			1 2 3 4 5
Supply into System (MG):	3017.99	3661.60	3454.57										3017.99	3661.60	3454.57			1 2 3 4 5
Break History (no. per year)																		1 2 3 4 5

Explain How Determined

EarthTech

UNACCOUNTED-FOR WATER INVESTIGATION

Illinois American Water

Name of Community	Chicago Metro_West Suburban and Santa Fe(Bolingbrook and Woodridge)
Contact Person	Kevin Hillen
Telephone Number	630-739-8959
Fax Number	630-739-0488
Email	Kevin.Hillen@amwater.com
Cell Phone Number	630-281-0535

	Pressure Zone A	Pressure Zone B	Pressure Zone C	Pressure Zone D	Total	Responsible Personnel	Source of Data	Confidence in Accuracy of Data[1]
Customer Meter Accuracy	95.7%				95.7%			1 2 3 4 5
When Last Tested (mm/dd/yy)	10 year meter change out program							1 2 3 4 5
Length of Water Main	353.8 miles				353.8 miles			1 2 3 4 5
Length of Main by Installation Date (miles)								
Before 1900								1 2 3 4 5
1900-1910								1 2 3 4 5
1910-1920								1 2 3 4 5
1920-1930								1 2 3 4 5
1930-1940								1 2 3 4 5
1940-1950								1 2 3 4 5
1950-1960								1 2 3 4 5
1960-1970								1 2 3 4 5
1970-1980								1 2 3 4 5
1980-1990	159.0 miles							1 2 3 4 5
1990-2000								1 2 3 4 5
2000-2010	194.7 miles							1 2 3 4 5
Length of Main by Material (miles)								
Cast Iron Unlined								1 2 3 4 5
Cast Iron Lined								1 2 3 4 5
Ductile Iron								1 2 3 4 5
PVC								1 2 3 4 5
HDPE								1 2 3 4 5
Transite								1 2 3 4 5
Steel								1 2 3 4 5
Concrete								1 2 3 4 5
Other								1 2 3 4 5
Indicate Types of Joints Used by Percentage								
Lead								1 2 3 4 5
Mechanical								1 2 3 4 5
T.J.								1 2 3 4 5
Bell	100%							1 2 3 4 5
Current Leakage Detection Performed	Leak detection study done in 2005							1 2 3 4 5
Typical Cost to Repair 8" Water Main Break	$3,400							1 2 3 4 5
Unit Cost of Leakage ($/MG)	$2,755							1 2 3 4 5
Unit Cost to Produce Water ($/MG)	$0	No water production						1 2 3 4 5
Unit Cost to Purchase Water ($/MG)	$2,715							1 2 3 4 5
Variable Cost of Power ($/year)	$141,637	($41/mg)						1 2 3 4 5
Variable Cost of Chemicals ($/year)	$0.00	No chemicals						1 2 3 4 5
% Soil Type	Clay	Silt	Sand	Other				1 2 3 4 5
	90%		10%					1 2 3 4 5

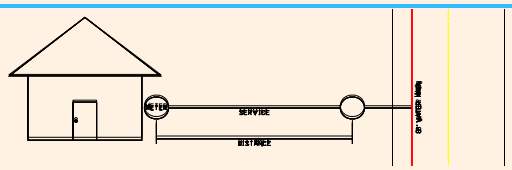
Supply Meter Accuracy:	Name/Location	Accuracy (Percent)	When Tested		Confidence in Accuracy of Data[1]
Meter 1		100.0%			1 2 3 4 5
Meter 2					1 2 3 4 5
Meter 3					1 2 3 4 5
Meter 4					1 2 3 4 5
Meter 5					1 2 3 4 5

*Please attach backup if available

Other Information

[1] Confidence in Accuracy of

1 > 85%	Very confident in data, good source such as as-built drawings, maintenance records, meter readings, etc.
2 50-85%	Confidence in data but may be dated or not complete data, source may include design drawings or notes.
3 25-50%	Some confidence in data, may be from personnel knowledge.
4 10-25%	Little confidence in data, based on best educated guess and knowledge of water system.
5 < 10%	No confidence in data, based on textbook, uneducated guess, or not understanding information required.



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APPENDIX C

2006 WATER BALANCE AND EVALUATION OF SYSTEM LOSSES

APPENDIX C
WATER BALANCE SUMMARY FOR 2006

SYSTEM INPUT VOLUME [A]

System Input Volume [A]

TABLE 1

Total	Actual Meter Flow
Total	3,454.6 MG
Meter Accuracy	100.0%
TOTAL	3,454.6 MG

AUTHORIZED CONSUMPTION [B]=[D]+[G]=[E]+[F]+[H]+[I]

Billed Authorized Consumption [D]=[E]+[F]

Billed Metered Consumption [E]

TABLE 2

Billed Metered Consumption	
Total [E]	3232.5 MG

Billed Unmetered Consumption [F]

TABLE 3

Billed Unmetered Consumption	UnMetered Use	Method of Estimating
Total [F]	0.0 MG	

Unbilled Authorized Consumption [G]=[H]+[I]

Unbilled Metered [H] and Unmetered [I] Consumption

TABLE 4

Consumption Category	Consumption	Method of Estimating Unmetered Use
Unbilled Metered and Unmetered Use [G]	43.18 MG	Refer to Section 2.4.4 of Report Text

WATER LOSSES [C]=[A]-[B]

Apparent Losses [J]=[K]+[L]

Unauthorized Consumption [K]

TABLE 5

Unauthorized Consumption	Consumption	Description
Estimated Unauthorized Consumption	0 MG	

Customer Metering Accuracy [L]

TABLE 6

Customer Meters	95.7%
Billed Metered Consumption	3,232.5 MG
Adjusted Metered Consumption	3,377.7 MG
Customer Metering Under Registration	145.2 MG

Real Losses [M]

Leakage (transmission and/or distribution mains, storage tanks, service connections up to point of customer metering)

TABLE 7

Real Losses		Volume
System Input Volume	[A]	3,454.6 MG
Authorized Consumption	[B]=[D]+[G]=[E]+[F]+[H]+[I]	3,275.7 MG
Water Losses	[C]=[A]-[B]	178.9 MG
Apparent Losses	[J]=[K]+[L]	145.2 MG
Real Losses	[M]=[C]-[J]	33.7 MG

APPENDIX C
EVALUATION OF SYSTEM LOSSES FOR 2006

Water System Information

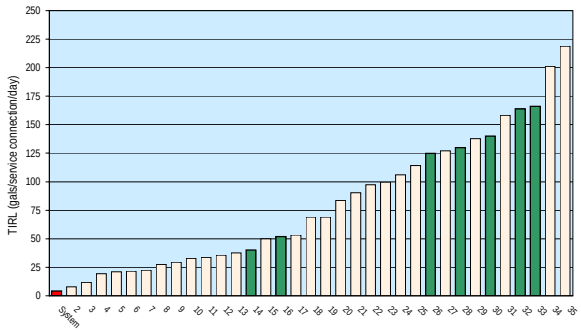
TABLE 8

Description	Entire System
Length of Water Main	354 miles
Number of Service Connections	21,438
Distance Customers Meters are Located from Edge of Stree	40. ft
Percent of Time System Pressurized	100%
Average System Pressure	54 psi
System Volume Input	3,455 MG

Technical Indicator for Real Losses (TIRL)

TABLE 9

Calculation of TIRL	Entire System
Annual Volume of Real Losses	34 MG
Percent of Time System Pressurized	100%
Number of Service Connections	21,438
Average Daily Real Losses when System Pressurized	0.09 MG
Technical Indicator for Real Losses (TIRL)	4 gal/serv conn/day



North American systems are shown in green.
Supply systems composed of 34 systems surveyed in 20 countries.
Source: Lambert, A., D. Huntington, and T.G. Brown, Water Loss Management in N.America: Just How Good Is It?, Water Loss Control Manual, 2002.

Unavoidable Annual Real Losses (UARL)

TABLE 10

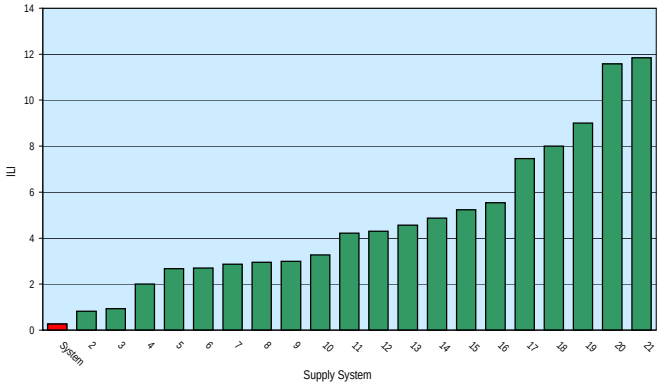
Calculation of UARL	Entire System
Length of Water Main	354 miles
Number of Service Connections	21,438
Distance Customers Meters are Located from Edge of Street	40 ft
Percent of Time System Pressurized	100%
Average System Pressure	55 psi

Components of UARL	Total UARL	Calculated Components of UARL: Background Losses	Reported Bursts	Unmetered Use	Total	Units
Mains	104,878 gal/day	2.87	1.75	0.77	5.39	Gals/mile of main/day/psi
Service Connections, Main to Curb-Stop	176,864 gal/day	0.11	0.01	0.03	0.15	Gals/mile of main/day/psi
Service Connections, Curb-stop to Meter	70,182 gal/day	4.8	0.57	2.12	7.47	Gals/mile of main/day/psi
Total Unavoidable Annual Real Losses (total)	351,923 gal/day					
Total Unavoidable Annual Real Losses (total)	16 gal/serv conn/day					

Infrastructure Leakage Index (ILI)

TABLE 11

Calculation of ILI	Entire System
TIRL	4 gal/serv conn/day
UARL	16 gal/serv conn/day
ILI (ratio of TIRL to UARL)	0.3



Supply systems composed of systems surveyed in the U.S. and Canada
Source: McKenzie, R. and C. Seago, Assessment of Real Losses in Potable Water Distribution Systems: Some Recent Development, Water Science and Technology: Water Supply, 2005.

Unit Cost of Leakage

TABLE 12

Calculations of Unit Cost of Leakage	
Variable Costs	
Purchase of Water	$2,715 per MG
Electricity Cost	$41 per MG
Chemical Cost	$0 per MG
TOTAL	$2,756 per MG
Unit Cost of Leakage	$2,756 per MG
Annual Cost of UARL	$354,000 per year
Annual Cost of TIRL	$92,800 per year
Annual Cost of Potential Recoverable Losses	$0 per year
Annual Cost of Potential Losses as Percentage of Total	0%

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