Assessing Water Loss

Using "Big System" concepts on "Small Systems"

2004 Clean and Safe Drinking Water Workshop

Small Systems Operation, Maintenance and Treatment

Gander, NL – September 22, 2004

Alain Lalonde, P.Eng. - Principal

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Assessing Water Loss

What is in this presentation?

- New AWWA Water Auditing Procedure.
- Leakage Performance Indicators.
- Leakage Control Methods.
- Small System Case Study.

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September 22, 2004

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New AWWA Water Audit

- Old audit followed M36 Manual – Out!
- UFW and % loss – not to be used anymore.
- AWWA adopts IWA audit (Journal Aug. 03).
- IWA – true performance indicators that can be used for benchmarking comparison.
- Even the National Guide to Sustainable Municipal Infrastructure has adopted the IWA method.

(www.infraguide.ca)

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Assessing Water Loss

Why not UFW and %?

System A	
Length of Mains	25 km
Population	2,750
Residential Connections	900
ICI Connections	15
Per Capita Consumption	225 l/c/d
ICI Consumption	50,000 l/con./d
(Small ICI Users)	
Production	599,594 m3/yr
Billed Usage	499,594 m3/yr
Losses (Leakage)	100,000 m3/yr
UFW %	**17%**

System B	
Length of Mains	25 km
Population	2,750
Residential Connections	900
ICI Connections	15
Per Capita Consumption	325 l/c/d
ICI Consumption	150,000 l/con./d
(Large ICI Users)	
Production	1,247,469 m3/yr
Billed Usage	1,147,469 m3/yr
Losses (Leakage)	100,000 m3/yr
UFW %	**8%**

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Assessing Water Loss

AWWA – IWA Water Balance Sheet

<table>
<tr><td rowspan="8">System Input Volume</td><td rowspan="4">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="6">Non Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="4">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Meter Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission & Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Reservoirs</td></tr>
<tr><td>Leakage on Service Connections up to metering point</td></tr>
</table>

Assessing Water Loss

IWA Water Audit

- Non-Revenue Water Replaces UFW.
- Allows a comparison between Real & Apparent Losses.
- Allows for a true Performance Indicator.
- Litres / service connection / day – for urban areas.
- m^3 / km of main / day – for rural areas.
- Use Infrastructure Leakage Index for > 5000 con.

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Assessing Water Loss

ANNUAL WATER BALANCE EXAMPLE IN IWA STANDARD FORMAT, WITH 95% CONFIDENCE LIMITS

Data entry | Calculated Values

Note: It is recommended that the calculation is based on a 12.-month period, but the software will calculate for shorter or longer periods if required

Utility	Region of Peel		Jan 1 2001	to	Dec 31 2001	365	days
System	Whole System		% of period system pressurised =		100.0%	365.0	days

	WATER BALANCE VOLUMES COMPONENT OF WATER BALANCE			Volume in period 10^3 M^3	95% Confidence Limit as +/- %	Variance	Assessed Value of NRW components $/M^3	Assessed Value of NRW components $ x 10^3
SIV	System Input Volume (corrected for known errors)			171185.0	1.0%	762815		
BAC	BACE: Billed Authorised Consumption:Water Exported			0.0	1.0%	0		
	BACMR: Billed Authorised Consumption: Metered	Residential		104636.0	1.0%	285003		
	BACMN: Billed Authorised Consumption: Metered	Non-Residential		54572.0	1.0%	77522		
	BACU: Billed Authorised Consumption:Unmetered					0		
NRW	Non-Revenue Water			11977.0	17.4%	1125341	0.1498	1794.6
UAC	UACM: Unbilled Authorised Consumption: Metered					0	0.0500	0.0
	UACU: Unbilled Authorised Consumption: Unmetered: calculated as a % of SIV		1.000%	1711.9	100.0%	762815	0.0500	85.6
WL	Water Losses			10265.2	26.2%	1888156	0.1665	1709.0
AL	Apparent Losses - Unauthorised Consumption: calculated as a percentage of SIV		0.500%	855.9	100.0%	190704	0.3900	333.8
	Apparent Loss - meter under-registration: % of BACMR	Residential	1.500%	1569.5	25.0%	40079	0.3900	612.1
	Apparent Loss - meter under-registration: % of BACMN	Non-Residential	2.000%	1091.4	25.0%	19381	0.3900	425.7
	Sum of Apparent Loss Components			3516.9	27.9%	250163	0.3900	1371.6
RL	Real Losses			6748.2	42.5%	2138319	0.0500	337.4

	SYSTEM INFRASTRUCTURE AND COST DATA		95% CLs as +/- %
Lm	Mains Length, miles	2009.38	2.0%
	Mains Length, km	3215.00	2.0%
Nrnrc	Number of Service Connections (inc. Fire Services)	225566	2.0%
Nh	Number of hydrant connections	18516	2.0%
Nc	Total Number of Service Connections (Nh +Nc)	244082	1.9%
Nc/Lm	Density of Connections per km of mains	75.9	2.7%
Ls	Ave. distance, Curb-stop to Meter, (feet)	24.6	20.0%
	Ave. distance, Curb-stop to Meter, (metres)	7.5	20.0%
P	Average pressure when system pressurised (psi)	75.0	25.0%
P	Average pressure when system pressurised (m)	53.0	25.0%
CRS	Cost of running system in period ($ x 10^3)	0	

UNAVOIDABLE ANNUAL REAL LOSSES (UARL) when system is pressurised	Volume in thousand M^3/day	95% CLs as +/- %
Mains	3.07	25.1%
Service Conns. Main to Curb-stop	10.35	25.1%
Underground pipes, Curb-stop to Meter	2.24	32.1%
Unavoidable Annual Real Losses (UARL)	15.67	25.2%
CURRENT ANNUAL REAL LOSSES (CARL) when system is pressurised	18.49	42.5%
Calculation by	Alain Lalonde	
Date	4th October 2003	

PERFORMANCE INDICATOR	UNITS OF PERFORMANCE INDICATOR	Best estimate	Lowest Estimate	Highest Estimate
Non Revenue Water Basic (IWA Level 1, Fin36)	% of System Input by Volume	7.0	5.8	8.2
Non Revenue Water Basic (IWA Level 1, Fin37)	% of System Input by Value	#DIV/0!	#DIV/0!	#DIV/0!
Real Losses Basic (IWA Level 1, Op24)	Litres/service connection/day, when system pressurised	76	44	108
Real Losses Intermediate	Litres/serv. conn./day/psi, press. when system pressurised	1.01	0.51	1.51
Real Losses Detailed (IWA Level 3, Op 25)	Infrastructure Leakage Index ILI (non-dimensional)	1.18	0.60	1.76

IWA Water Audit
PI FastCalc for Canada with 95% Confidence Limit

Drinking Water Workshop, Gander NL
September 22, 2004

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Assessing Water Loss

How good is my system?

- Need to calculate appropriate Performance Indicator (PI) as follows:
  - Use L/con/day if you have more then 20 con/km.
  - Use m^3/km of main/day if you have less then 20 con/km.
  - Use the Infrastructure Leakage Index (ILI) if you have more then 5000 connections.

Assessing Water Loss

Steps to Determine proper PI to use.

1. Do you have more then 5000 connections?
   - If yes use ILI
   - If no go to 2
2. Divide your number of connections by to total km of watermains in your system.
   - If less then 20 use m^3/km of main/day
   - If more then 20 use L/con/day

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Assessing Water Loss

What is the ILI?

- The ILI is a ration of your current annual real losses (CARL) from IWA Water Balance divided by the unavoidable annual real losses (UARL) which is the best you can achieve.
- The unavoidable annual real losses is the technical minimum of leakage losses a system can achieve using all available best practices for control.

Assessing Water Loss

How Low **Can** I Go?

- For ILI calculations, the best achievable is an ILI of 1.0 – thus CARL = UARL.
- For L/con/day, the best systems are at 100 to 150.
- For m^3/km of main/day they are at 10 to 12.
- Therefore if you are above your respective PI minimum, you have not achieved your best performance yet! – But is it worth getting there?

Assessing Water Loss

How Low **Should** I Go?

- Must determine the cost of the Non-Revenue Water and Real Losses.
- From this, determine what is the Economic Level of Leakage (ELL).
- Effected by supply issues and cost of water.
- ELL is normally less then the CARL for systems with no active leakage control.

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Assessing Water Loss

Advantage of PIs vs. UFW %

System A	
Length of Mains	25 km
Population	2,750
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Per Capita Consumption	225 l/c/d
ICI Consumption	50,000 l/con./d
(No big ICI Users)	0
Billed Usage	499,594 m3/yr
Losses (Leakage)	100,000 m3/yr
Production	599,594 m3/yr
UFW %	**17%**
Connection Density	**36.6**
Performance (PI)	**299.4 l/con/d**

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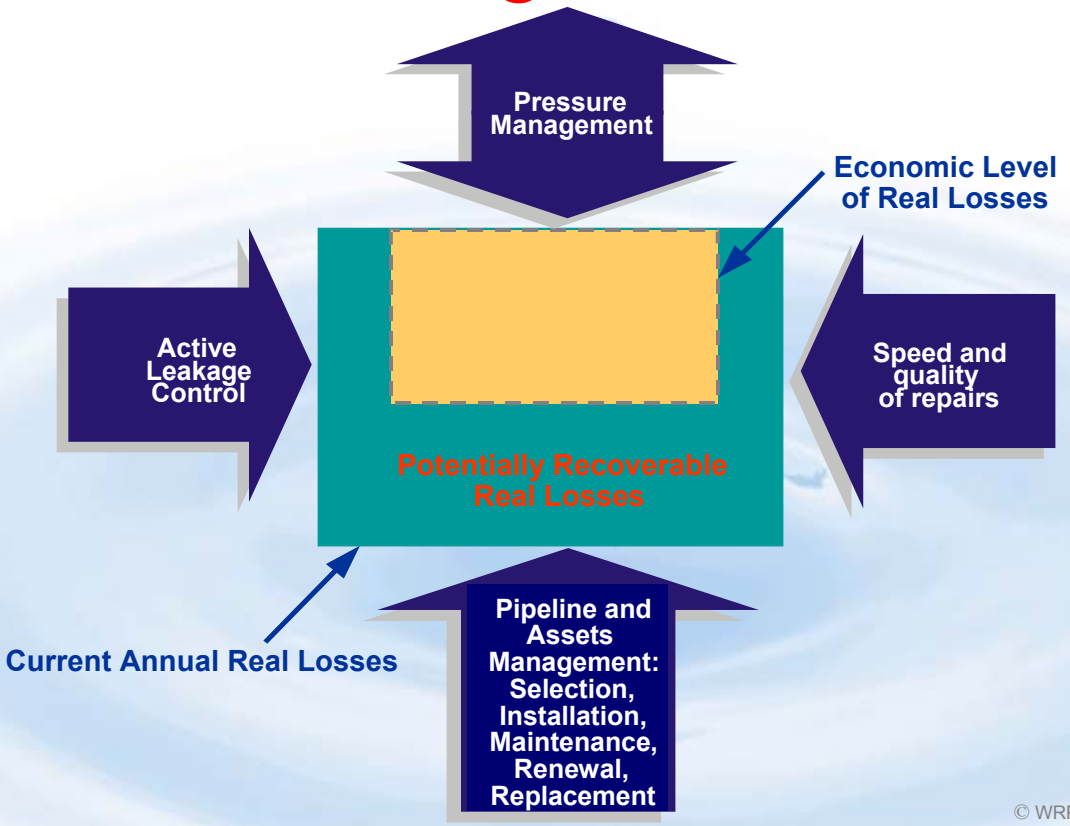
Assessing Water Loss

How To Manage Your Real Losses



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Assessing Water Loss

Active Leakage Control Measures

- Active leakage is defined as an active effort to locate and repair unreported main leaks.
  - Temporary or Permanent District Metered Area
  - Sonic Survey
  - Step Testing
  - Correlation Surveys
  - Noise Logging Surveys

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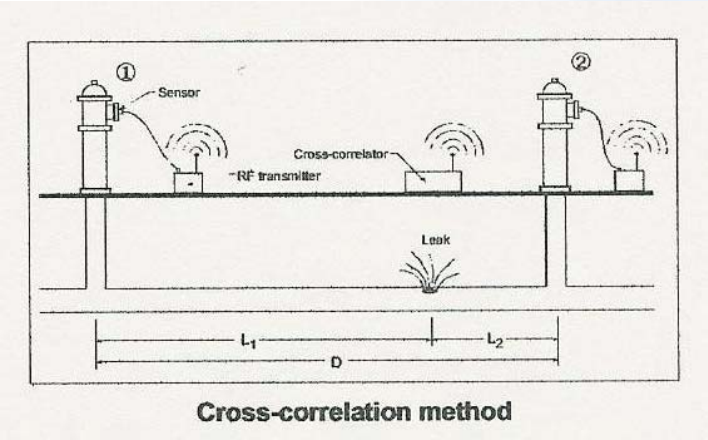
Assessing Water Loss

Active Leakage Control

- Sonic Surveys & Leak Correlation.



Cross-correlation method

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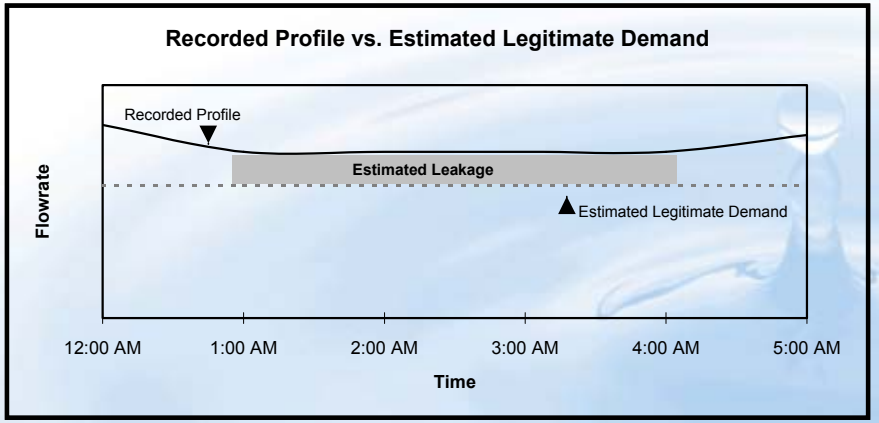
Sonic Leak Surveys

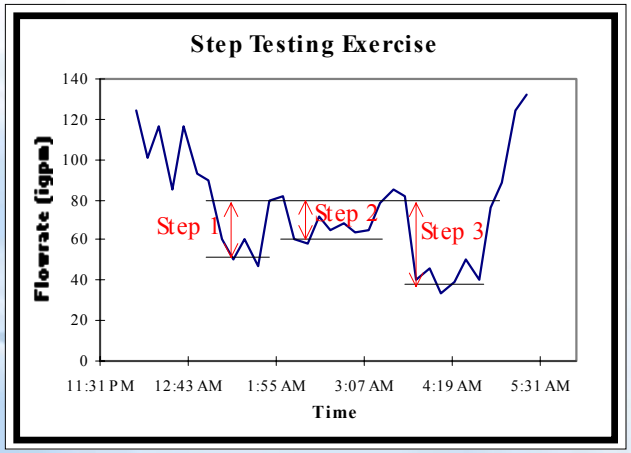
- Although sonic leak surveys are considered a pro-active approach, we consider it a preventive maintenance approach – should be done.
- Impossible to know how much leakage is found.
- Impossible to know how much leakage was not found.
- Currently not effective on non-metallic mains.
- Very labour intensive.

Assessing Water Loss

Proactive Leakage Control

- DMA & Step Testing.





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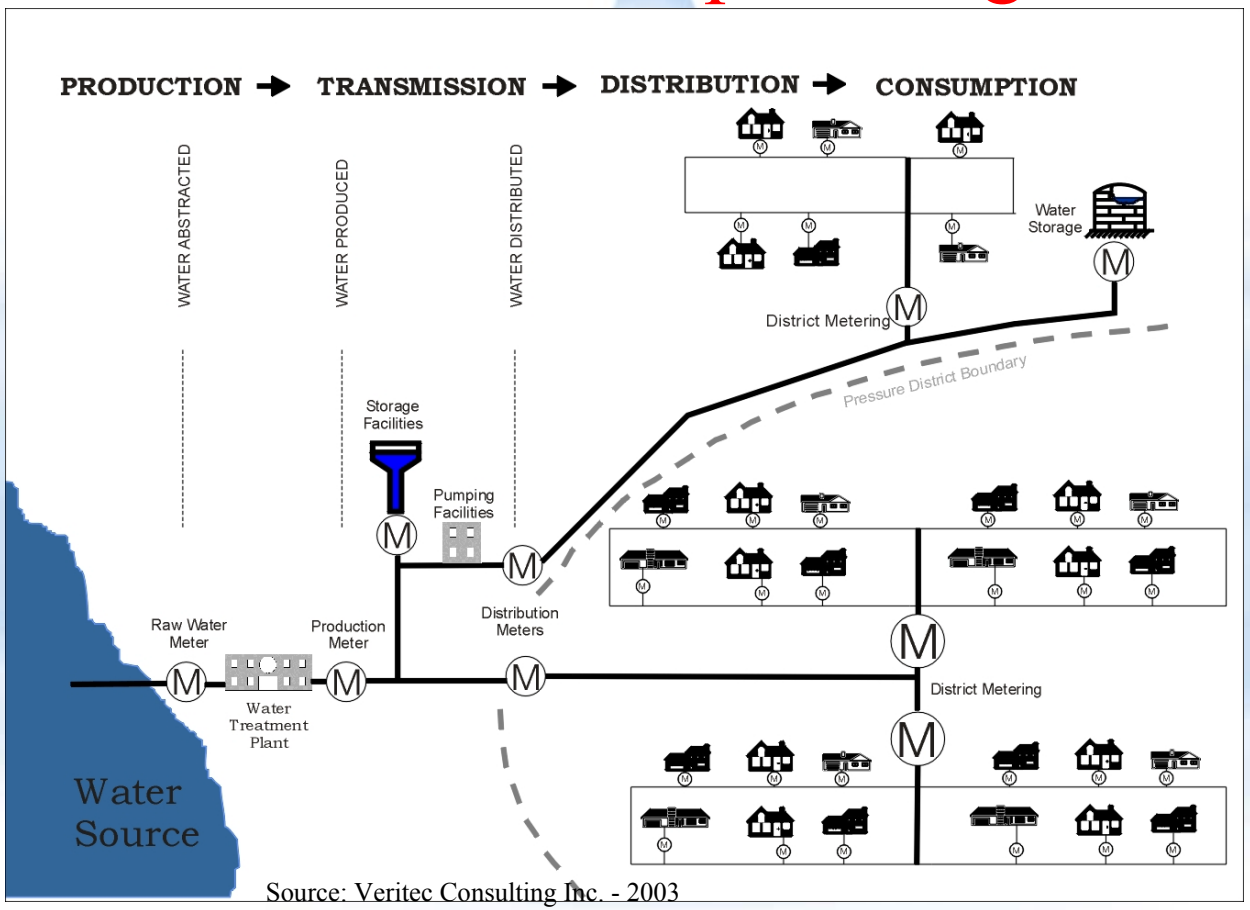
DMA & Step Testing

- District Metered Areas allow you to measure leakage levels and verify the IWA audit and PI calculations.
- Prioritizes areas for attention.
- Quantifies leakage rates and savings post repair.
- Determines level of effort required for sonic and correlation surveys and intervention schedule.

Assessing Water Loss

DMA & Step Testing



Source: Veritec Consulting Inc. - 2003

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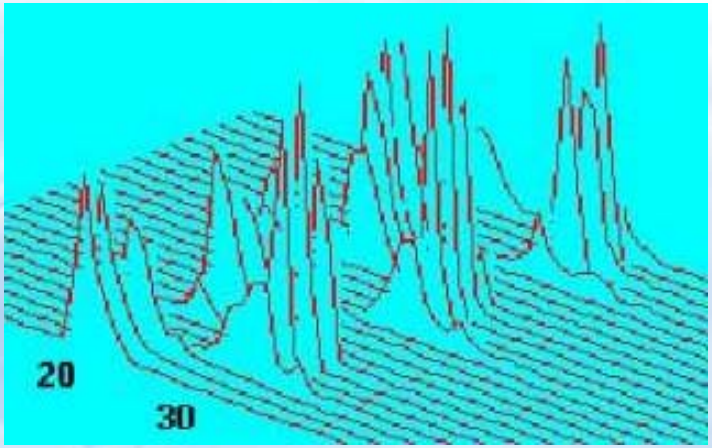
Active Leakage Control

- Noise Logging.



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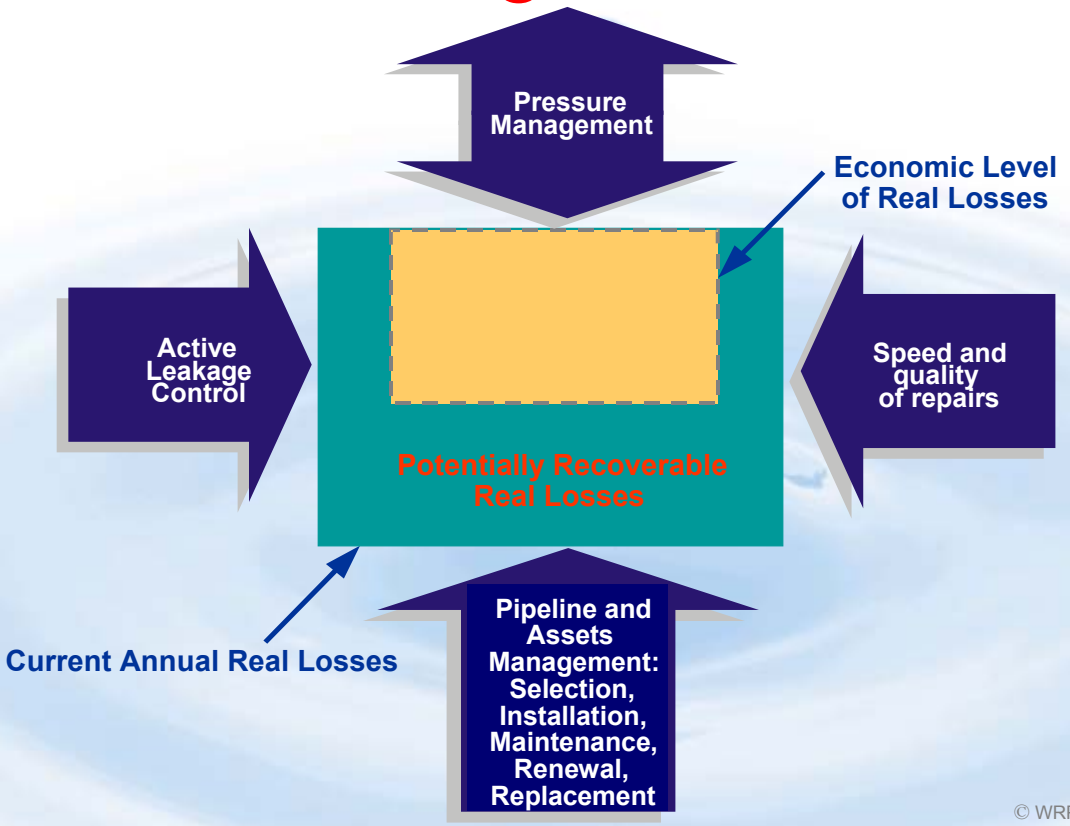
How To Manage Your Real Losses



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Assessing Water Loss

Pressure Management

- Concept is very simple:

  The lower the pressure to lower the leakage!
- The implementation of this concept is sometimes very difficult.
- It is made easier on small systems because of fewer pumping zones.

Assessing Water Loss

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Assessing Water Loss

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Pressure Management

- Use of Pressure Management Areas.
- Fixed Outlet PRV's.
- Modulating PRV's
- Critical Node Control
- Hydraulic Modeling and System Production Changes.

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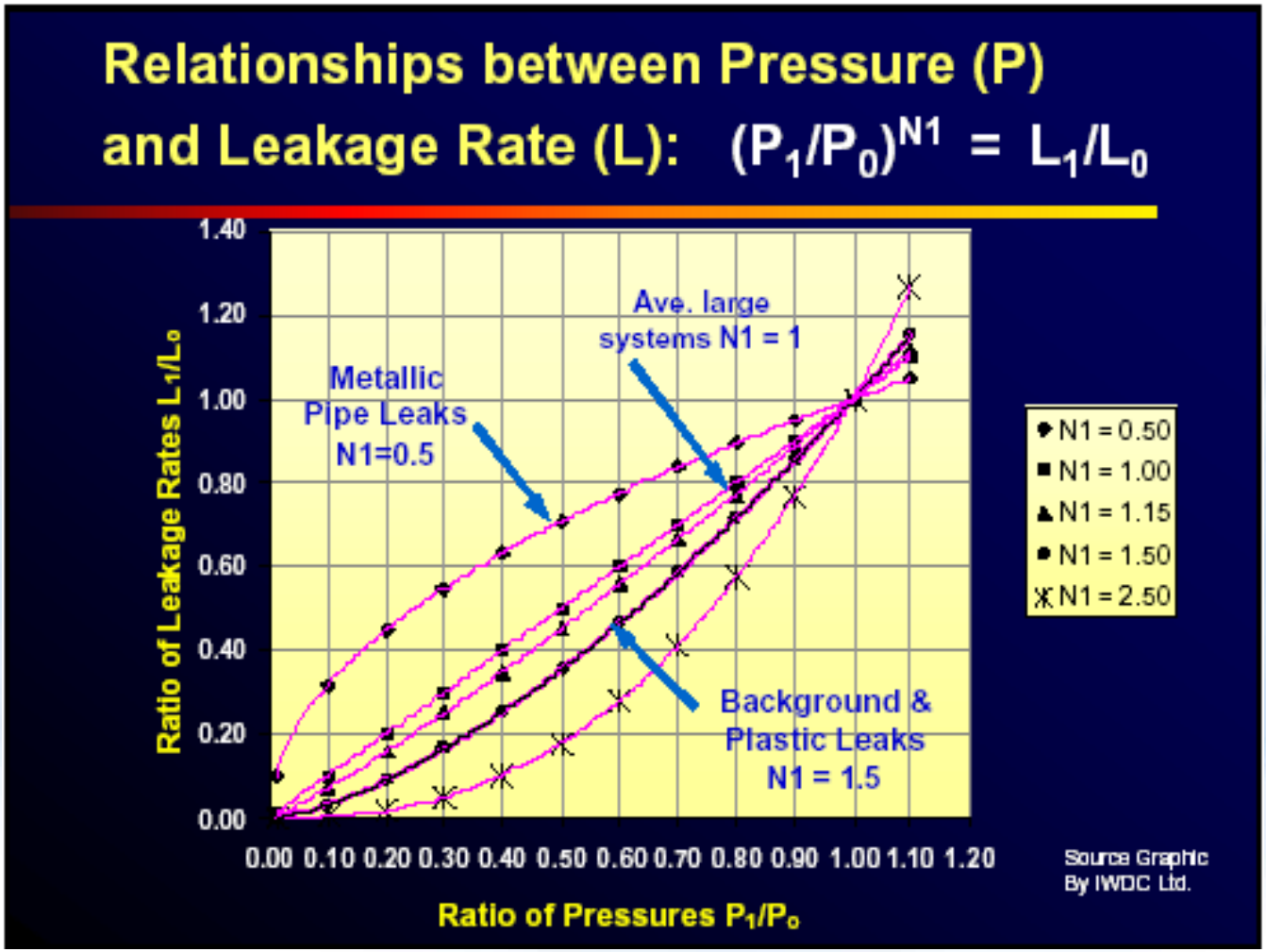
Pressure Management

- International studies show that pressure reduction and leakage have a one to one relationship.
- Breaks tend to follow the square root law (0.5 power).
- But background leakage can be at a power as high as 2.0 for PVC but averages 1.5.

Assessing Water Loss



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Pressure Management

- Must consider many factors:
  - Critical Node
  - Fire Flows
  - Seasonal Demands & Peak Demands
  - System layout – topography
  - System transmission and storage

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Assessing Water Loss

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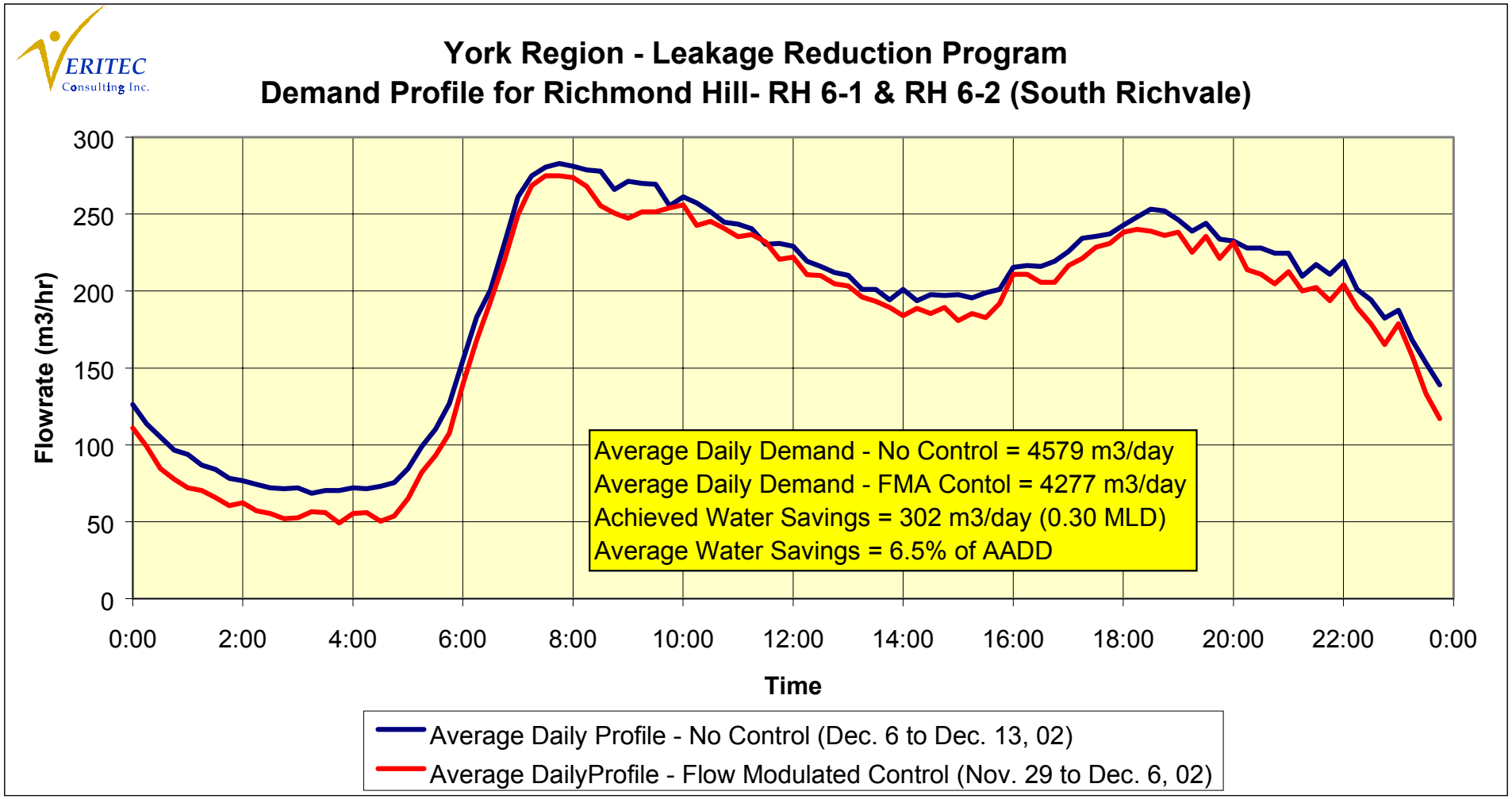

Assessing Water Loss

Can we really use these "BIG SYSTEM" methods on our "small systems"?

Case Study:

Acton, Ontario

2003 Leak Detection Survey

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September 22, 2004

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Assessing Water Loss

Acton Leakage Reduction Program

- Included well meter accuracy testing.
- Included a temporary DMA system leakage evaluation with step testing.
- Included a complete sonic survey of the system.
- Included an evaluation of benefit of pressure management.
- System is 43 km with 2236 connections (52 con/km).

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Acton Leakage Reduction Program

- Started in April 2003 with Meter Testing.
- Leak Detection completed in May 2003.
- Pressure Management data collection completed in June 2003.
- Post leakage repair profile completed in July 2003.

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Assessing Water Loss

Leak Detection Survey

- DMA approach was selected.
- Entire Acton distribution system treated as one DMA.
- Minimum night flow monitoring was completed at the existing reservoir on Churchill Rd.

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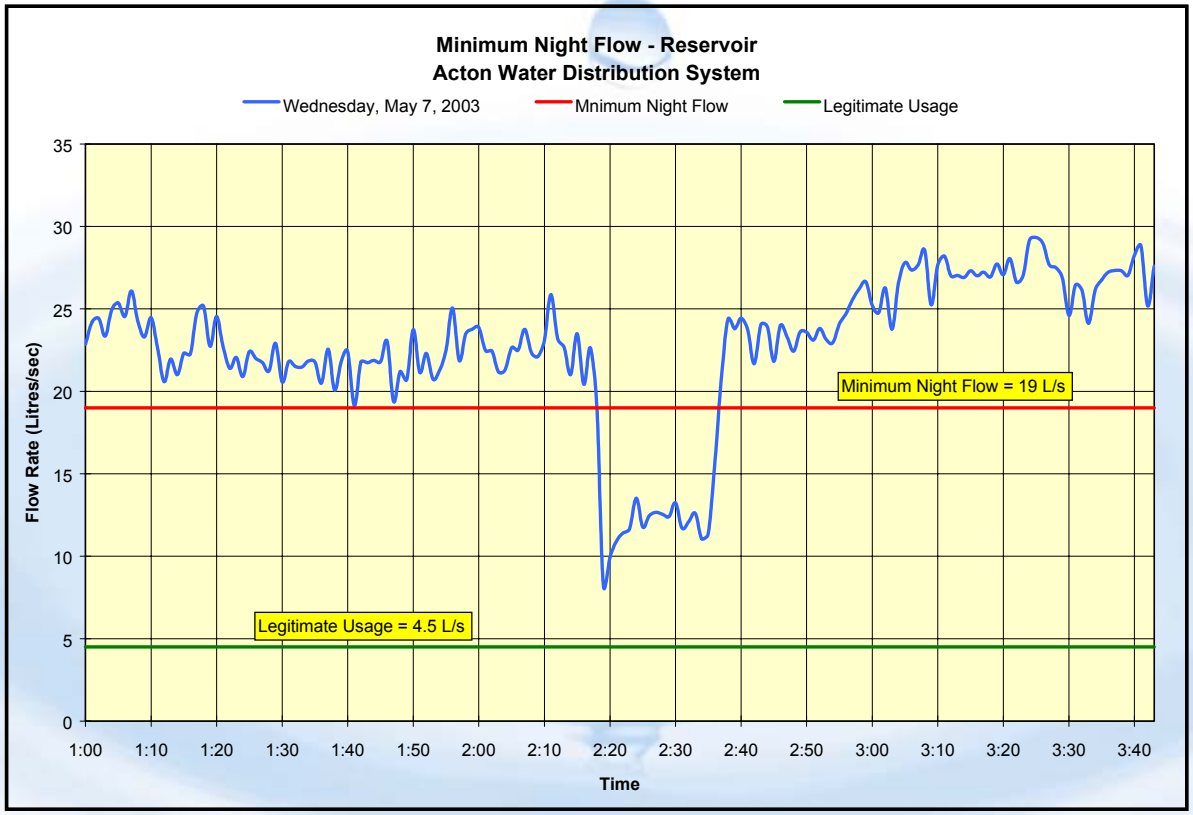
Assessing Water Loss

Leak Detection Survey



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Assessing Water Loss

Leak Detection Survey

Calculated Estimate of Net Night Flow

Acton

Components of Net Night Flows, Acton			Calculations (L/hour)	Calculations (L/s)
Distribution Losses	Mains	43	1720	0.48
	Communication Pipes	2200	6600	1.83
Supply Pipe Losses	Underground & Plumbing		2200	0.61
Estimated Customer Night Use(s)	Households	2200	3740	1.04
	Non-Households			
	Group A	7	6.3	0.00
	(e.g., churches, fire/police, banks, gardens/allotments)			
	Group B	20	124	0.03
	(e.g., shops, offices, large domestic properties)			
	Group C	5	63	0.02
	(e.g., hotels, schools/colleges, restaurants)			
	Group D	4	82	0.02
	(e.g., hospitals, factories, public toilets, works sites)			
	Group E		0	0
	(e.g., old age homes)			
Exceptional Customer Usage (Louisiana Pacific Canada) =			1800	0.50
Total assuming "Average" background losses =			16339.838	4.54
Corrected Total allowing for 5 minute monitoring interval =			16993.431	4.72
Corrected Total allowing for 5 "*Average Zone Night Pressure*" (m)=		50	16993.431	4.72

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Leak Detection Survey

- Recoverable Leakage Potential:

Actual MNF =		19.0 l/s
Net Night Flow	=	4.5 l/s
Recoverable Leakage =		14.5 l/s

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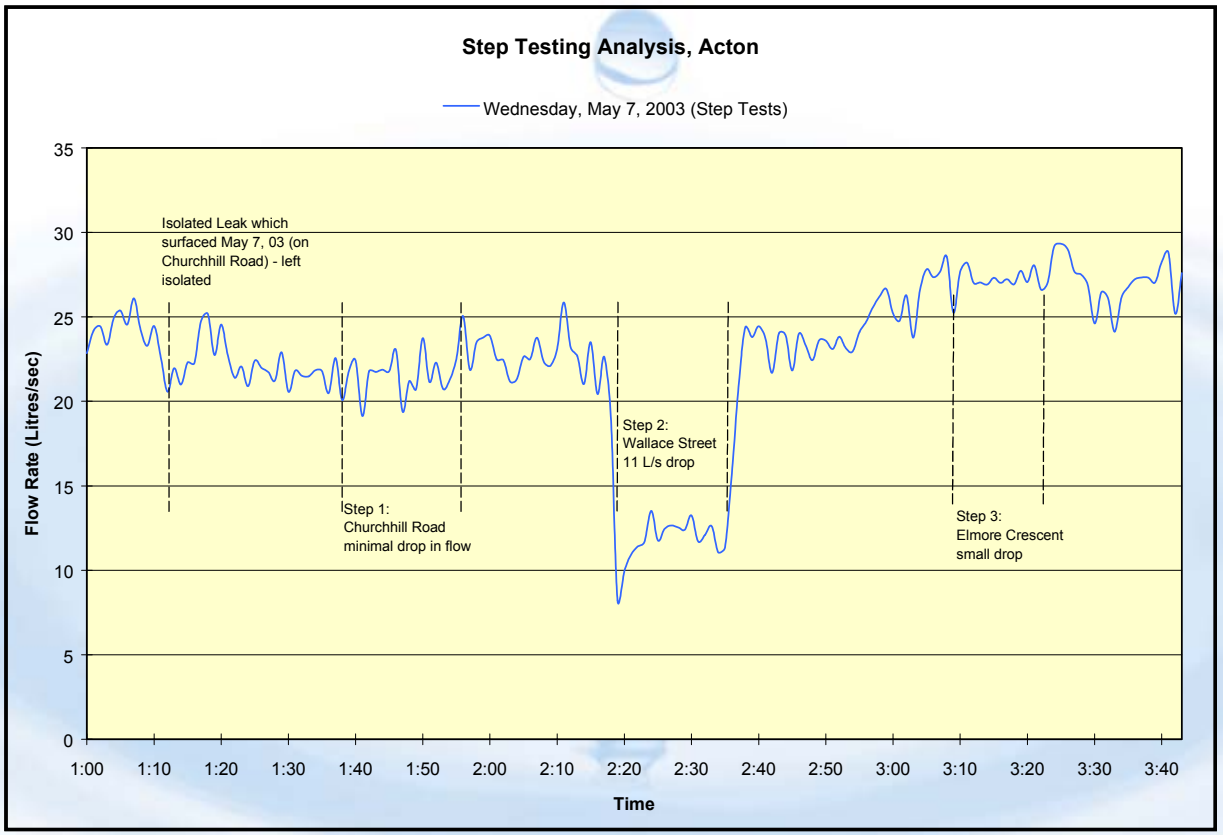
Leak Detection Survey

- Step testing completed on same night as profile to minimize disruption on system.
- Step testing revealed one large leak and several other potential leaks.
- In total, 6 leaks were located and repaired.
- 4 main leaks & 2 hydrant leaks.

Assessing Water Loss

Leak Detection Survey



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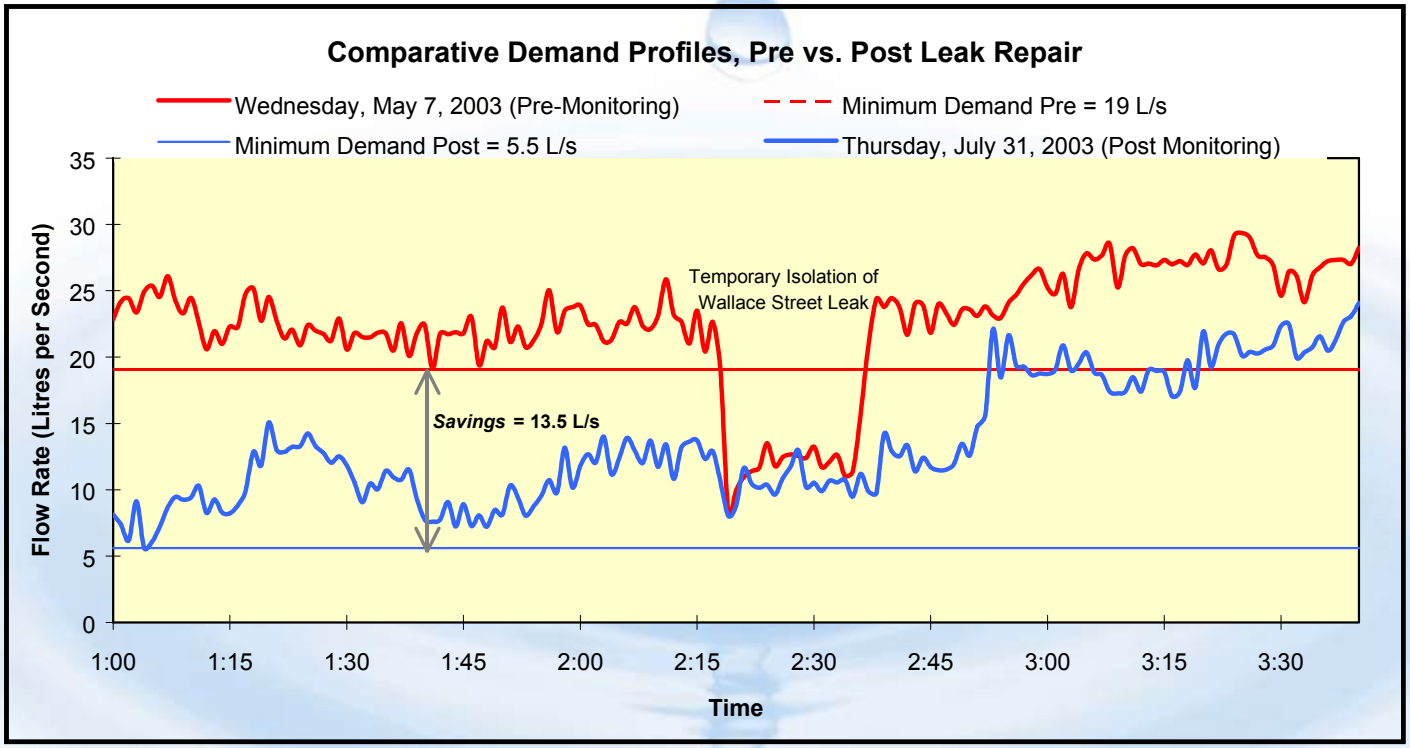
Leak Detection Survey



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Leak Detection Survey

- Wallace Street Leak = 11 l/s.
- Total Leakage = 13.5 l/s.
- 1,165,000 L/day savings.
- Approximately 27% of AADD.
- Reduced the losses from 673 L/con/day to 151 l/con/day.

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Leak Detection Survey

- Cost Benefit Analysis:
  - Total Cost of Program = $9,300
  - Total Water Savings = 1,165 m3/day
  - Assumed production cost of $0.03 per m3
  - Water Savings = $12,757 per year
  - Benefit to Cost Ratio = 1.37
  - Based on water savings alone – not including additional capacity or development charges.

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Assessing Water Loss

Recommendations

- **STEP 1 :** Complete an IWA Water Audit:
  - Determine both Apparent and Real Losses of Non-Revenue Water.
  - Use 95% Confidence Intervals (FastCalc Software)
  - Determine appropriate PI for your system and calculate the value.
  - Compare value for the PI for your system to the minimum values.

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Assessing Water Loss

Recommendations

- **STEP 2** : Determine Cost NRW
  - Determine both the cost of Apparent (at retail) and Real (at production) Losses.
  - Factor in the cost of new supply.
  - Look at revenue from Development Charges.

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Assessing Water Loss

Recommendations

- **STEP 3 :** Initiate NRW Reduction Program:
  - Reduction of Apparent Losses may include meter testing, change out, sizing. Review of meter reading and billing procedures. Review non-metered uses.
  - Reduction of Real Losses should include a DMA leakage survey and evaluation & implementation of a pressure management scheme.
  - Maintenance programs to ensure a low level of NRW should also be considered.

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Thank you – Questions?

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