Smart Management for Small Water Systems

Water Loss Auditing:
Navigating AWWA's Infrastructure Leakage Index

January 15, 2019

www.efcnetwork.org

EFCN environmental finance center network

NADO National Association of Development Organizations

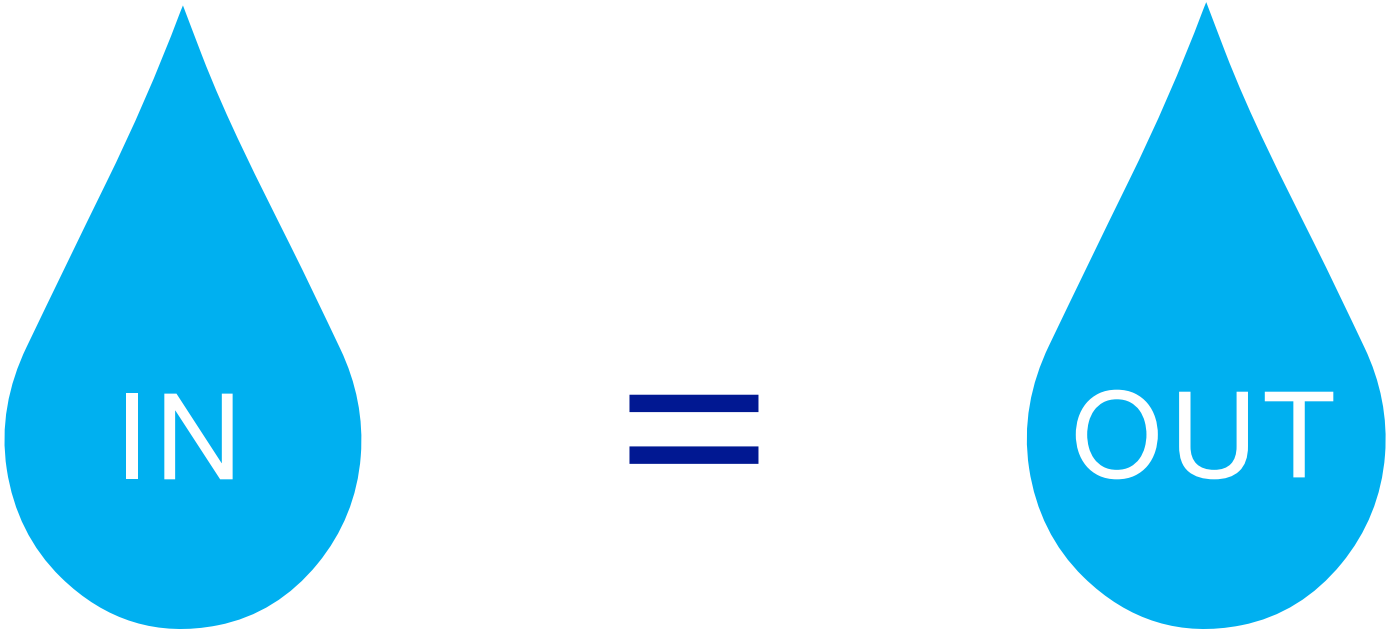
GFOA Government Finance Officers Association

This program is made possible under a cooperative agreement with the U.S. EPA.

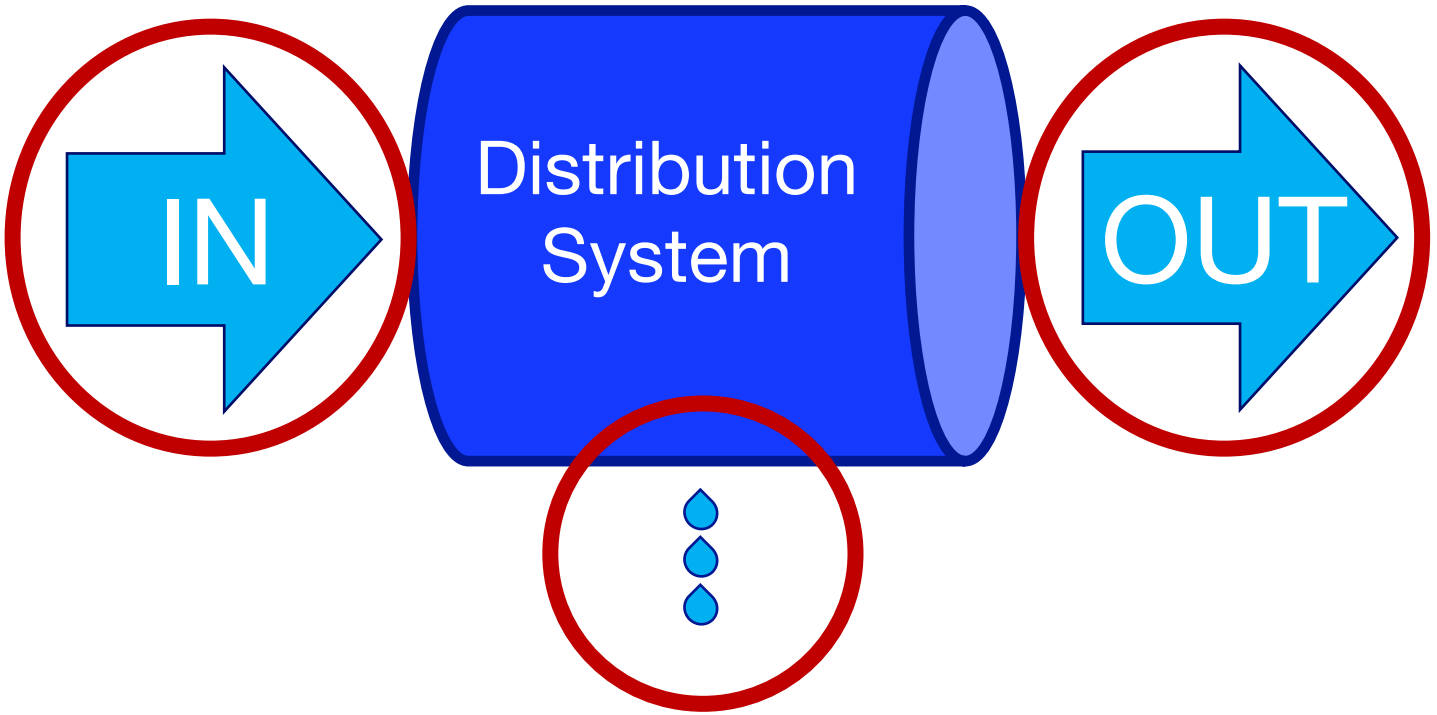
Water Auditing

Some background and a quick review

It’s based on the concept of a water balance…



The software helps us estimate:

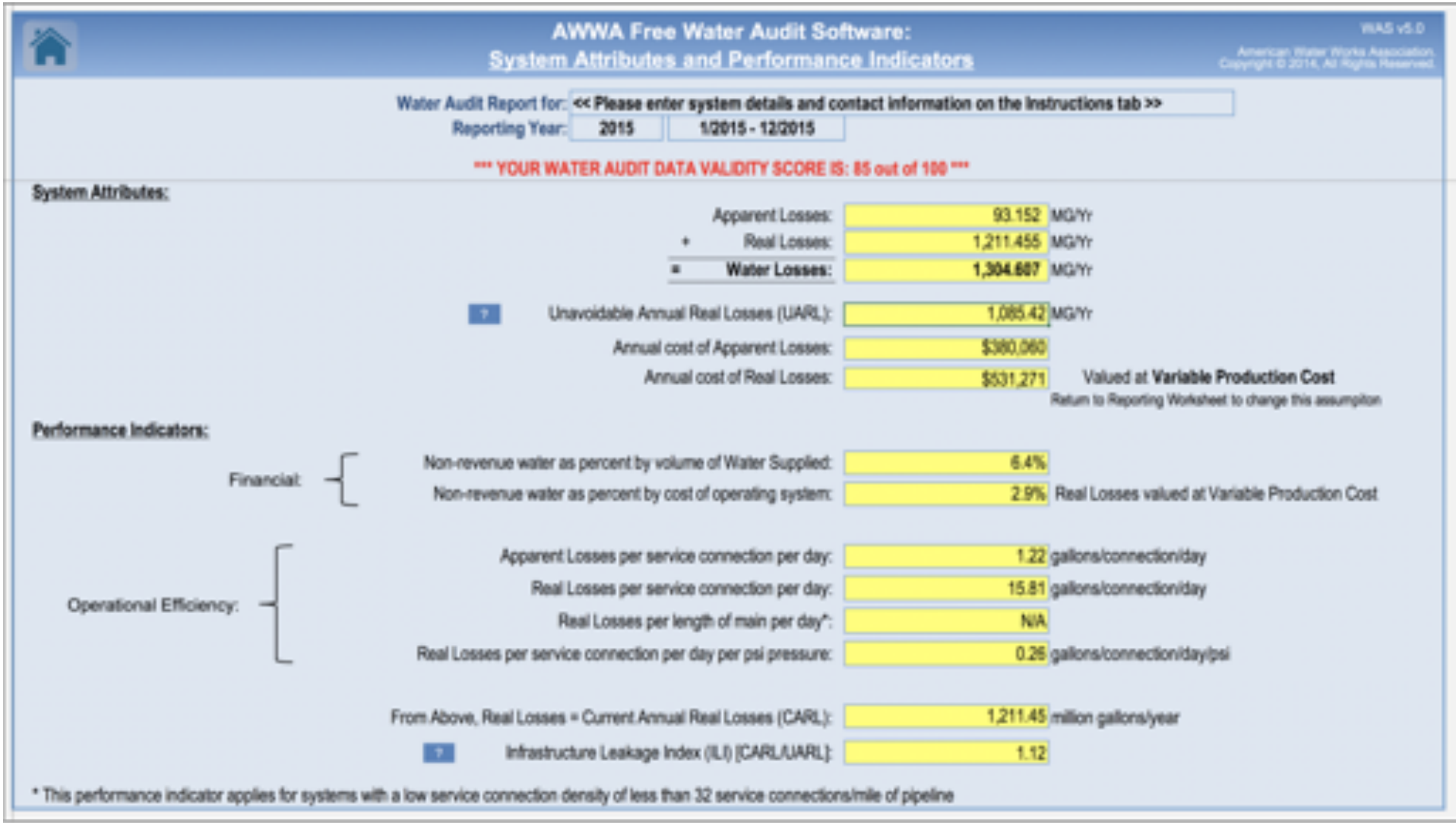


Audit accuracy depends on data

- Positive input error leads to greater calculated ”Real Loss”
- Negative input error leads to lower calculated ”Real Loss” (possibly even negative loss – which is physically impossible)


STAEDTLER
ENTER


“Trust, but verify”



AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0
American Water Works Association
Copyright © 2014, All Rights Reserved

Water Audit Report for: << Please enter system details and contact information on the Instructions tab >>
Reporting Year: 2015 1/2015 - 12/2015

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 85 out of 100 ***

System Attributes:

	Apparent Losses:	93.152	MG/Yr
+	Real Losses:	1,211.455	MG/Yr
=	Water Losses:	1,304.607	MG/Yr
?	Unavoidable Annual Real Losses (UARL):	1,085.42	MG/Yr
	Annual cost of Apparent Losses:	$380,060	
	Annual cost of Real Losses:	$531,271	Valued at Variable Production Cost

Return to Reporting Worksheet to change this assumption

Performance Indicators:

Financial:	Non-revenue water as percent by volume of Water Supplied:	6.4%	
	Non-revenue water as percent by cost of operating system:	2.9%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	1.22	gallons/connection/day
	Real Losses per service connection per day:	15.81	gallons/connection/day
	Real Losses per length of main per day*:	N/A	
	Real Losses per service connection per day per psi pressure:	0.26	gallons/connection/day/psi
	From Above, Real Losses = Current Annual Real Losses (CARL):	1,211.45	million gallons/year
?	Infrastructure Leakage Index (ILI) [CARL/UARL]:	1.12	

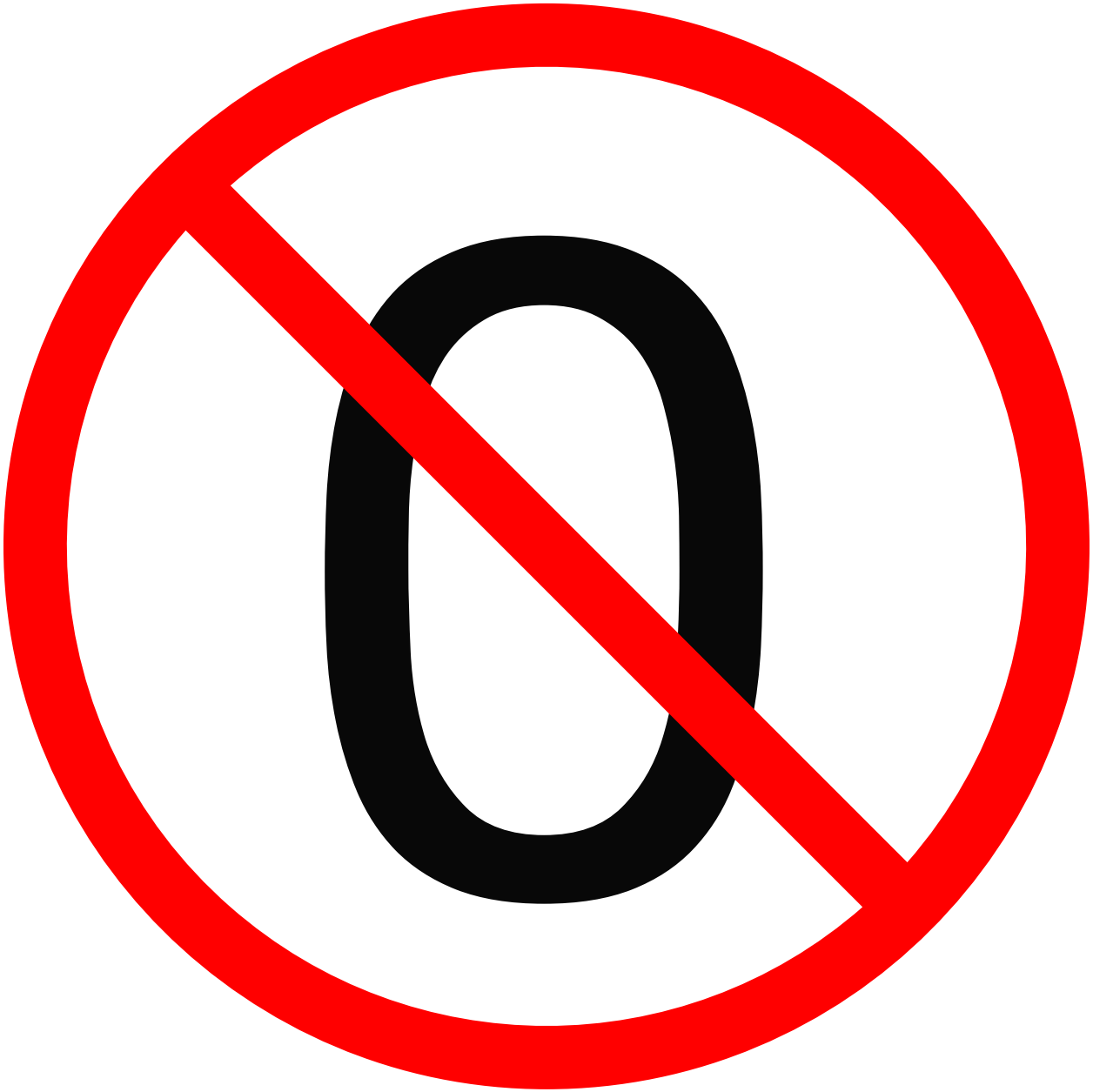
* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

Typical Ranges:

Losses per connection: 20-200 GPD

Losses per mile of main: 400-4000 GPD

ILI: 2-10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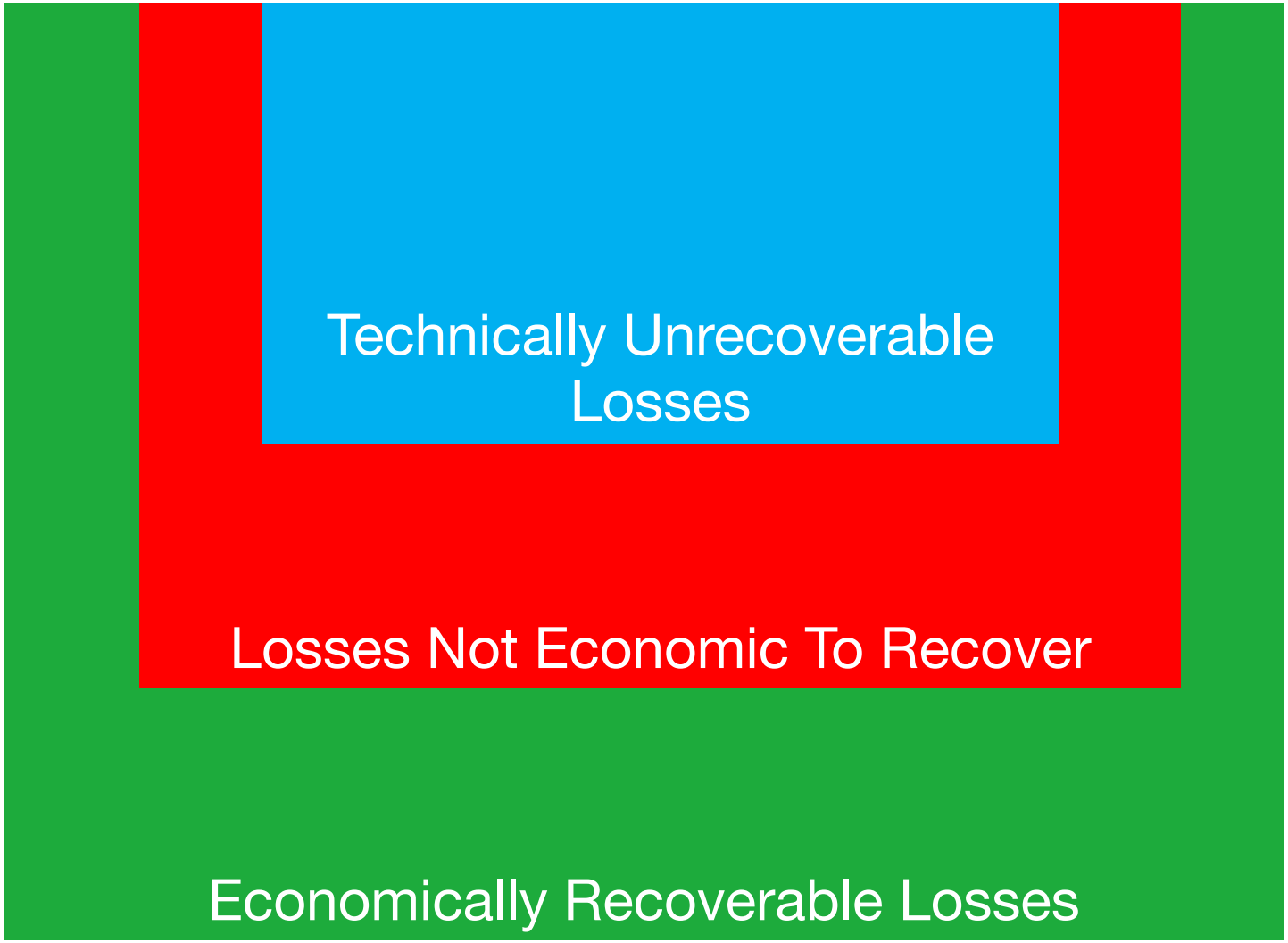
Current Annual Real Loss



Leakage Control Methods:

1 – active leakage control

2 – optimizing repair activities

3 – pressure management

4 – system rehabilitation and renewal


22

Economic Leakage Level

There is a breakpoint where the cost of reducing real losses exceeds the value of of the recoveries.

In other words, you don't want to spend $20 to save $10 unless there are non-monetary reasons to.

Leakage Control Methods:

1 – active leakage control

2 – optimizing repair activities

3 – pressure management

4 – system rehabilitation and renewal

Words of Wisdom

"There is no single 'silver bullet' to leakage control. Water utilities need to have an ample 'toolbox' of leakage control tools and know when to use each tool in the right amount."

George Kunkel, AWWA M36 Manual Chair


Audits help you focus

End of Review

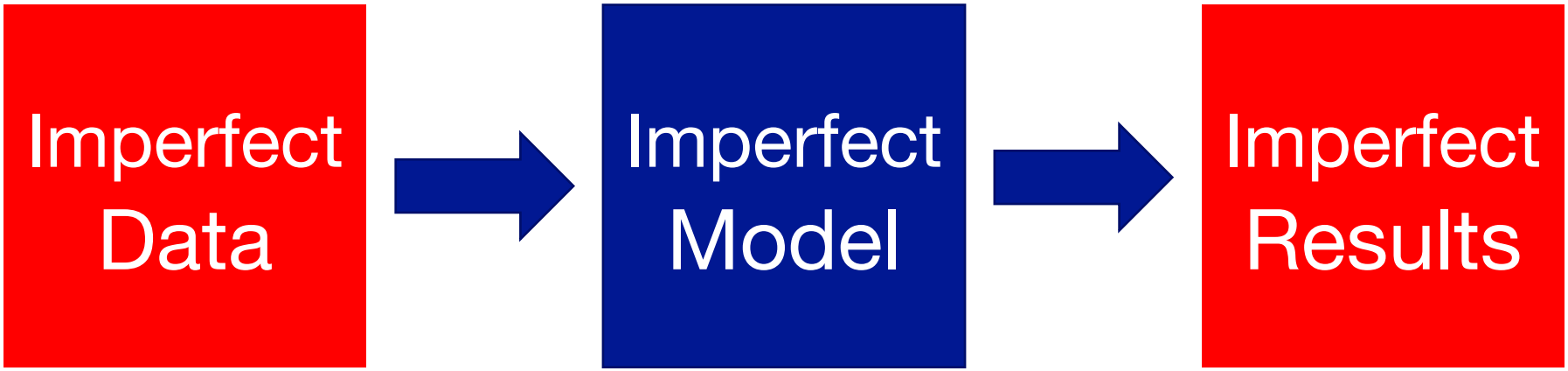

Let’s
look at
the
ILI!

All models are wrong, some models are useful.

~ George E.P. Box (a famous British statistician)

What we wish for:

A typical first time audit:



Imperfect, but still useful

Infrastructure Leakage Index

What is it? What is it for?

Touted as the “best indicator **for comparisons among systems** … best applied only after sufficient water audit data validity is achieved and all justifiable pressure management is complete.”

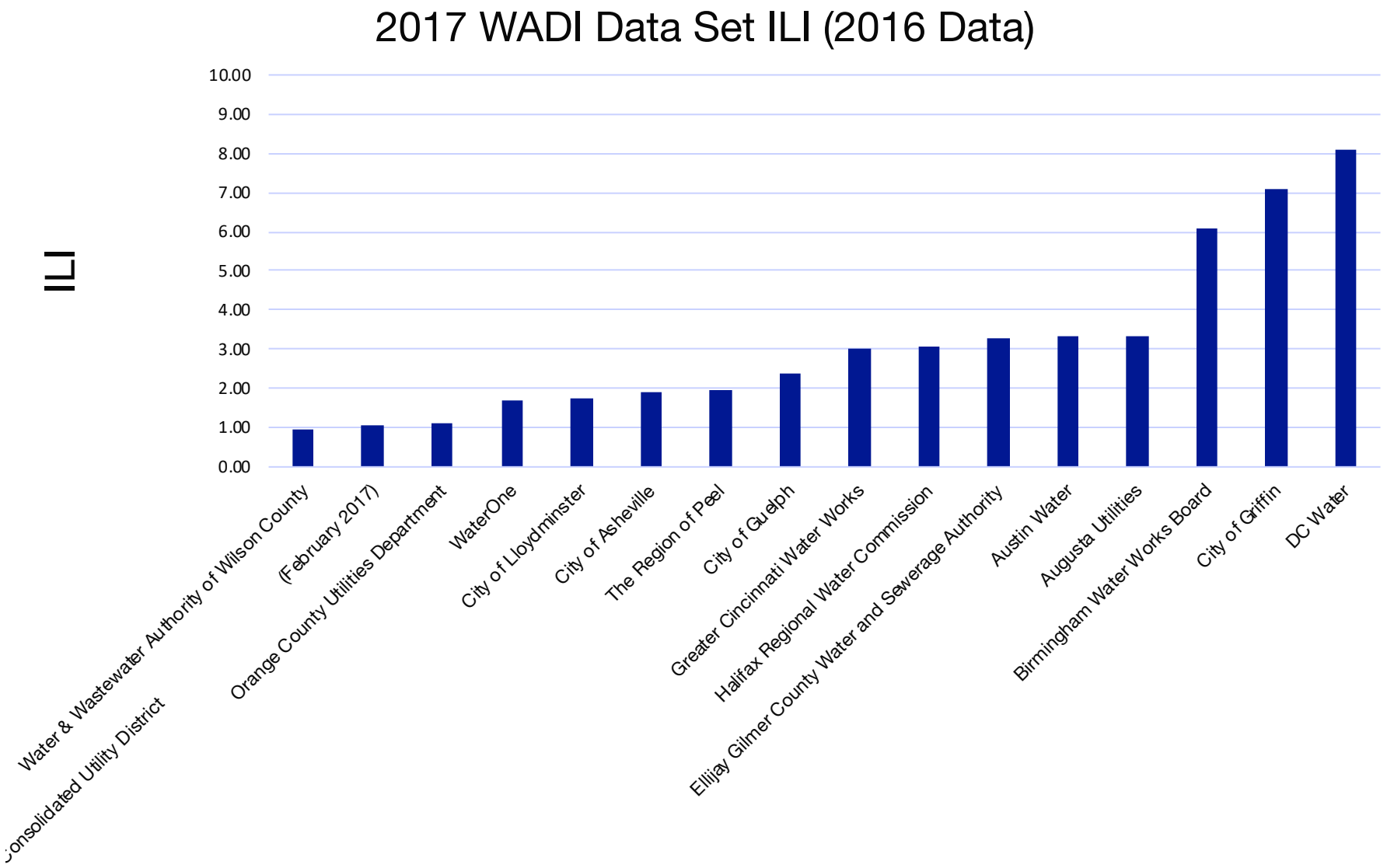
M36 Manual 4th ed. Table 3-24


980E
KOMATSU

$$ILI = \frac{CARL}{UARL}$$

The ILI "magic number":

Some typical ILIs:



Current
Annual
Real
Loss

Real Loss volume calculated by the audit.

Small metering errors can lead to large error margins of NRW components – they show up as real loss (or lack thereof).

The CARL will not categorize your losses.

Unavoidable
Annual
Real
Loss

Definition:

"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*."

M36 Manual 4th ed. Table 3-24

OR

"A theoretical reference value representing the technical low limit of leakage that could be achieved *in a system that is well managed and in good condition, at a given average pressure level*."

M36 Manual 4th ed. Page 102

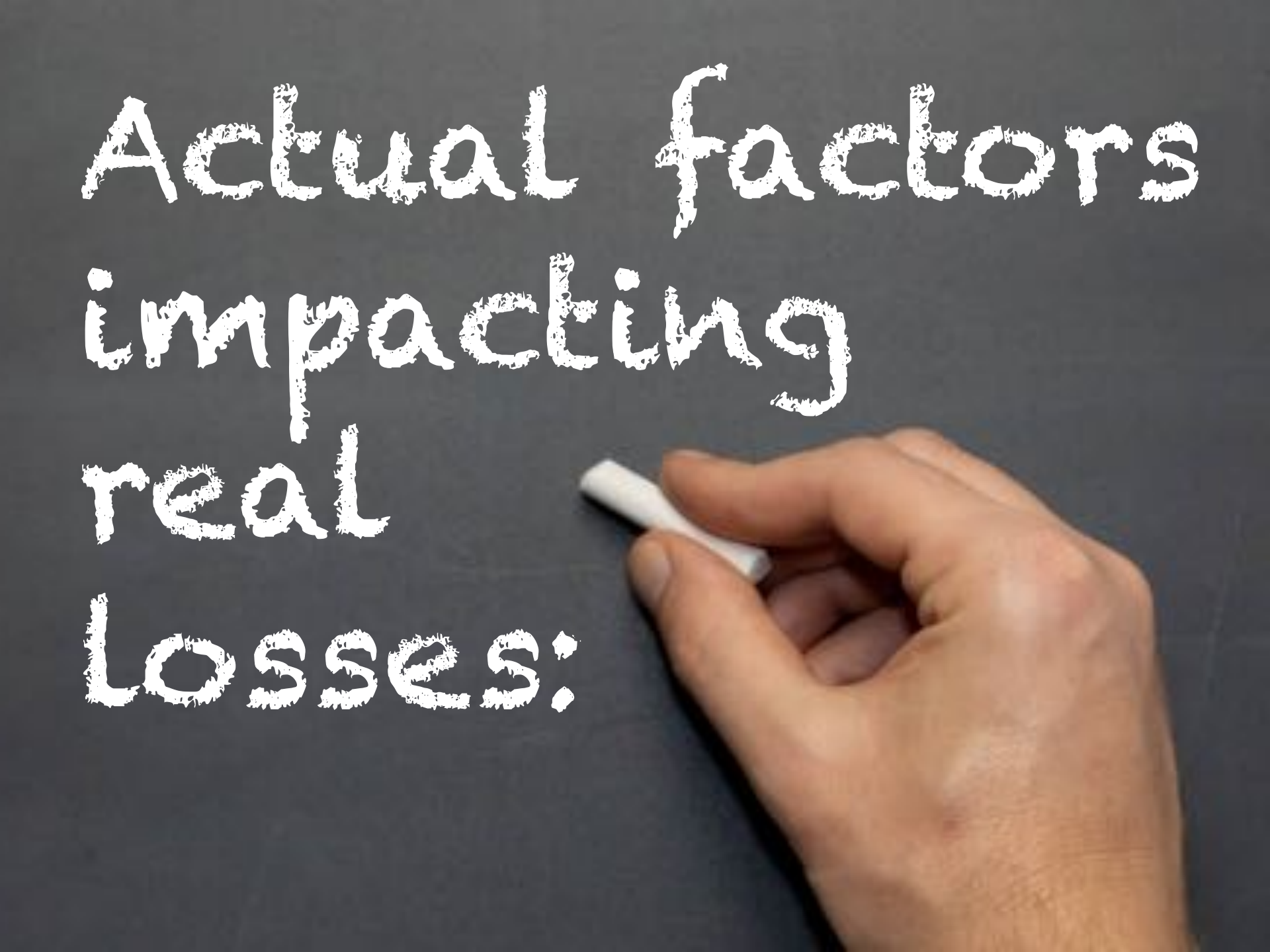
“Theoretical low limit of leakage”

It’s a theoretical reference value.

It does not refer to specific types of losses.

But, it is based on specific types of losses.

Actual factors impacting real losses:




Soil Type...

Materials...


Weather...
10
20
30
40
°C
20
0
20
40
°F

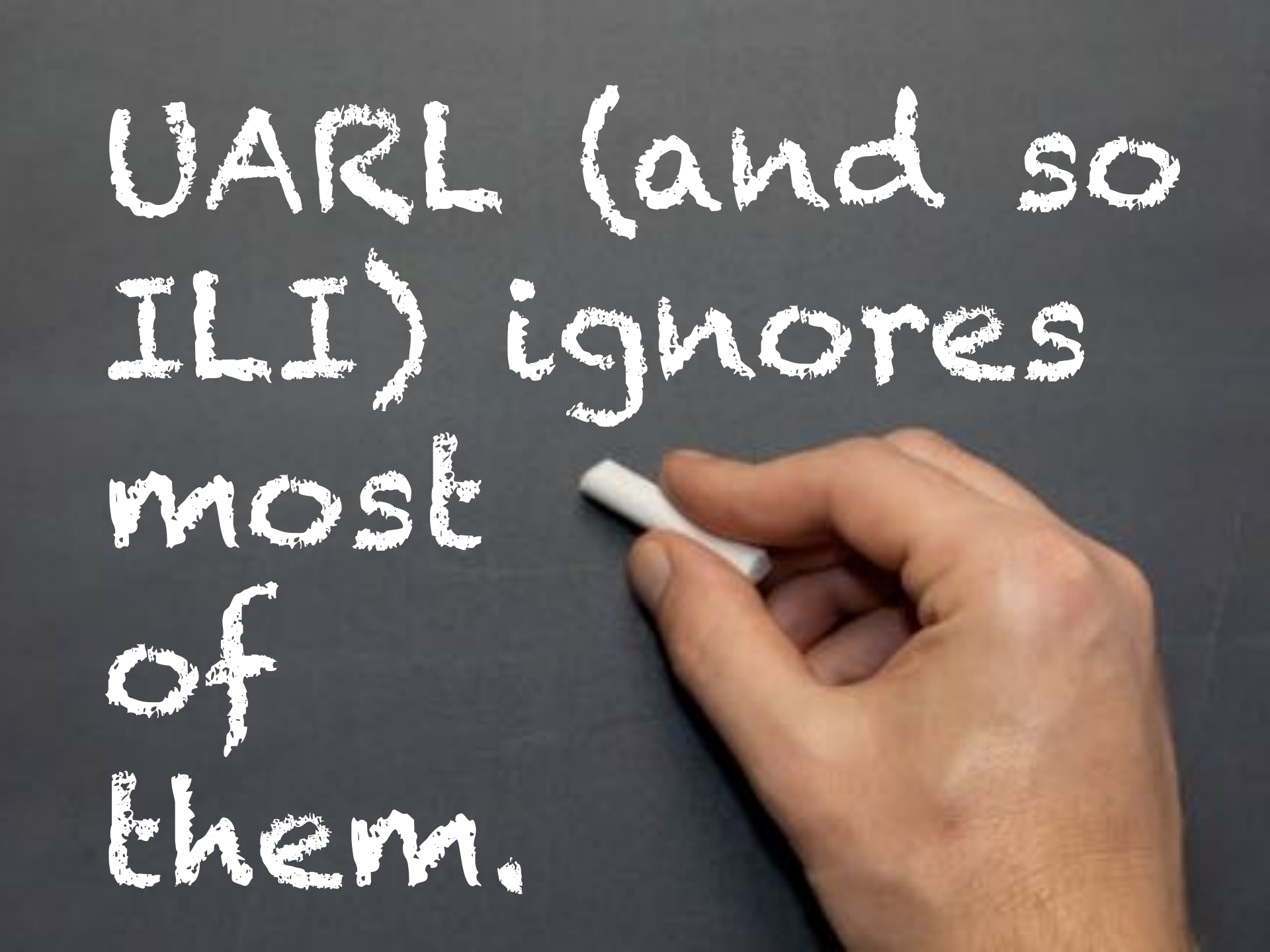
Installation


Break
Frequency

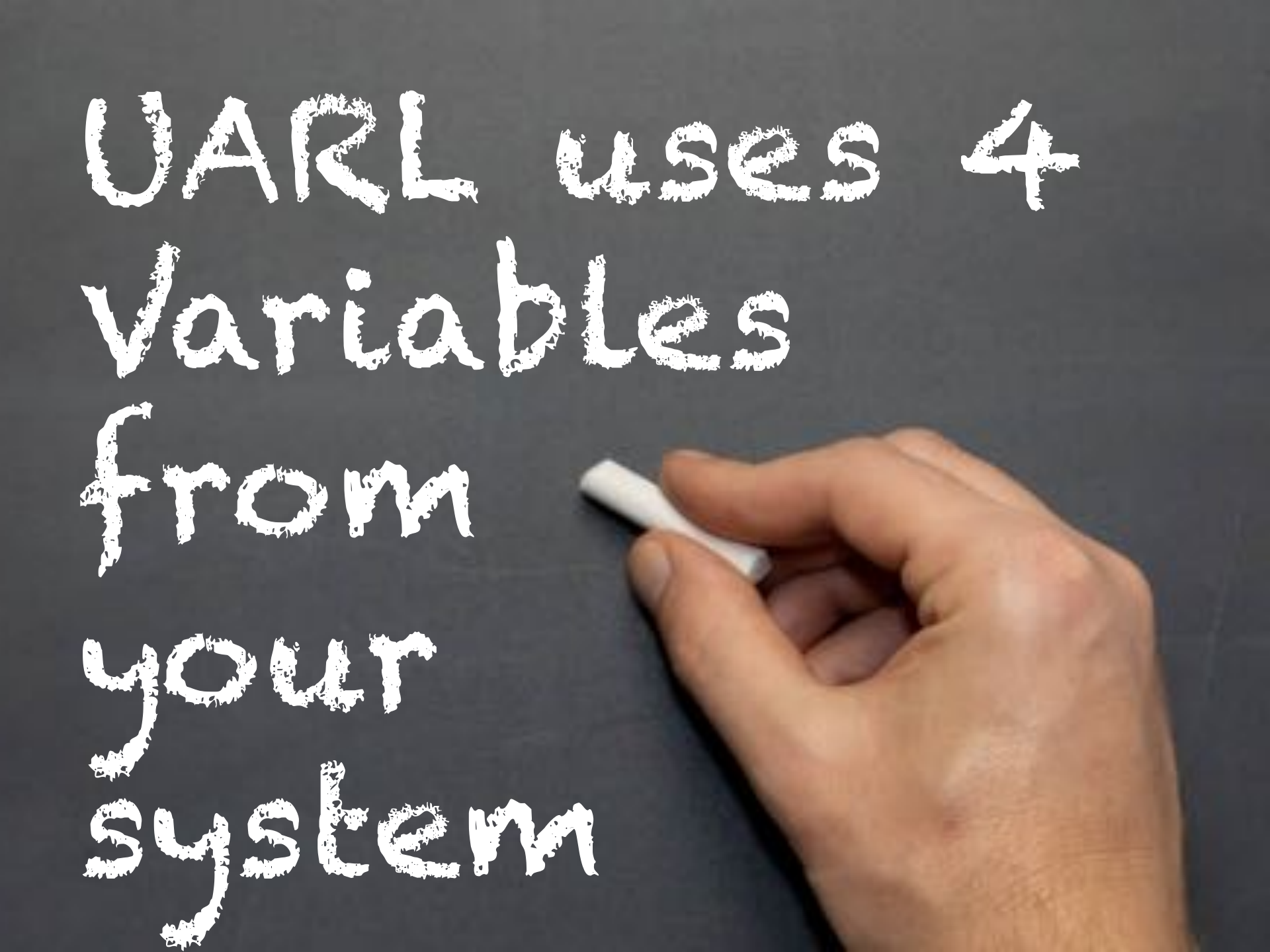
Flow rates

Time:
Discovery
Repair

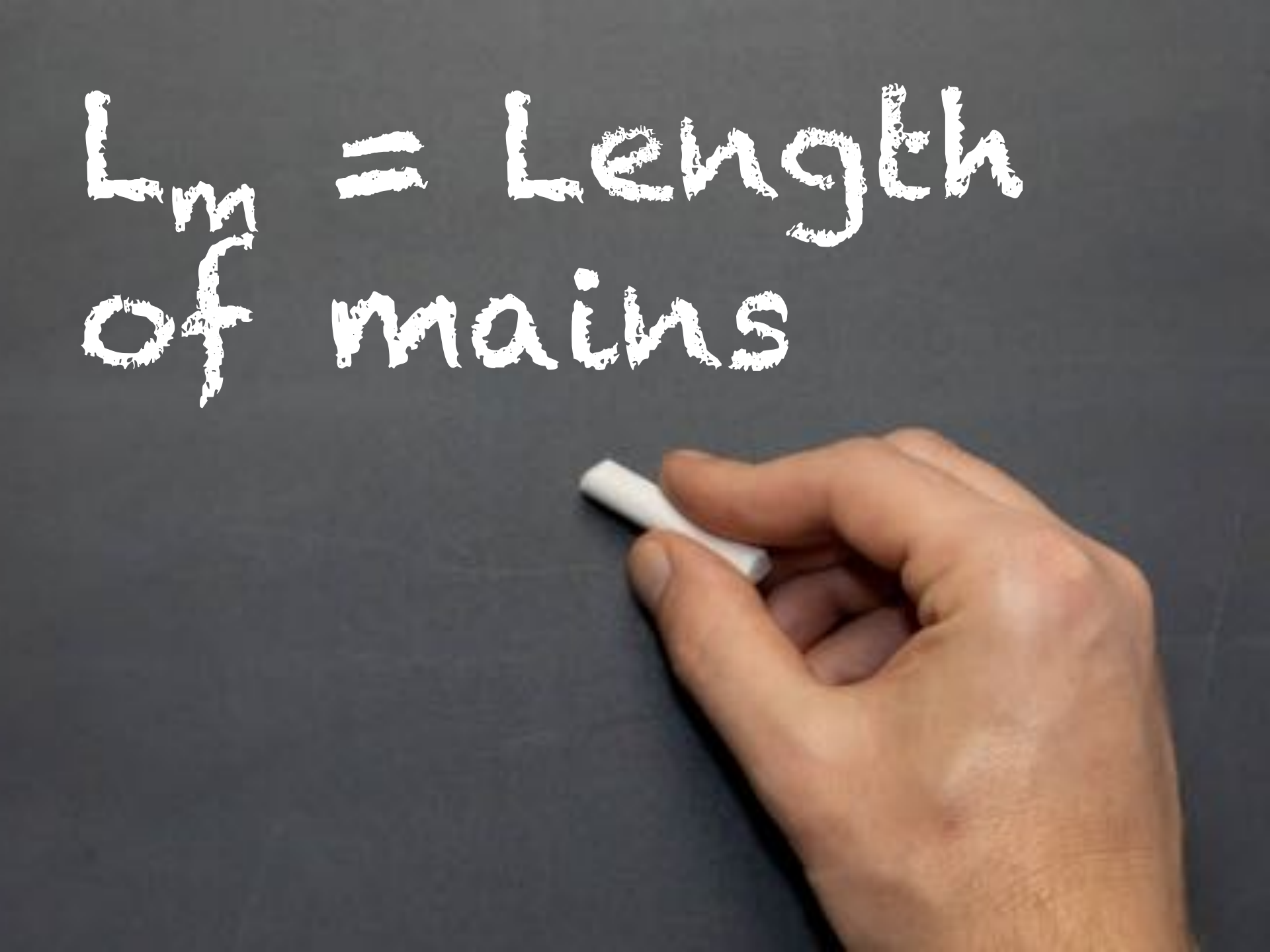
etcetera ...


URL (and so
IRI) ignores
most
of
them.

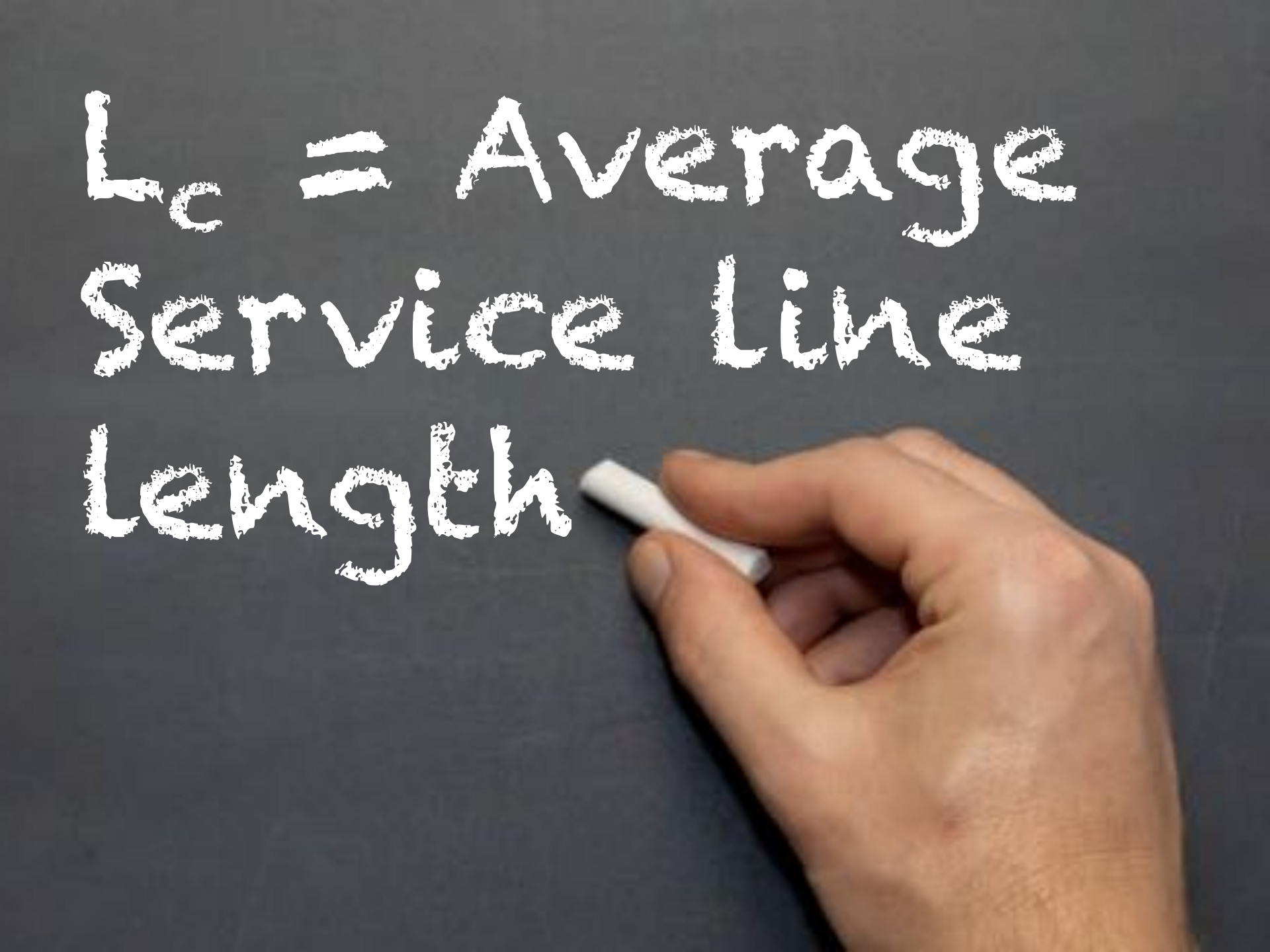
UARL uses 4 Variables from your system



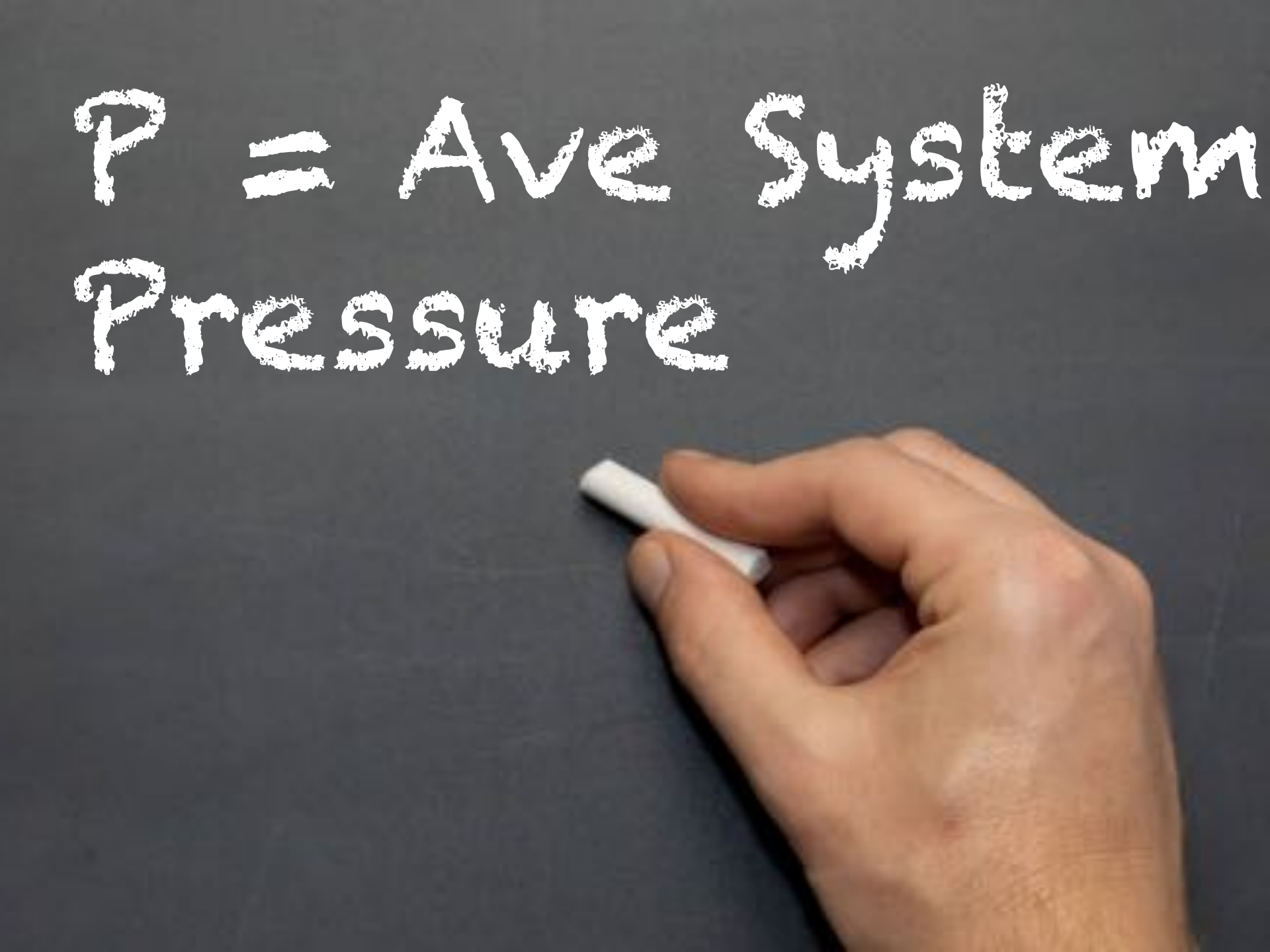
L_m = Length of mains



N_c = Number of connections


L_c = Average
Service Line
Length

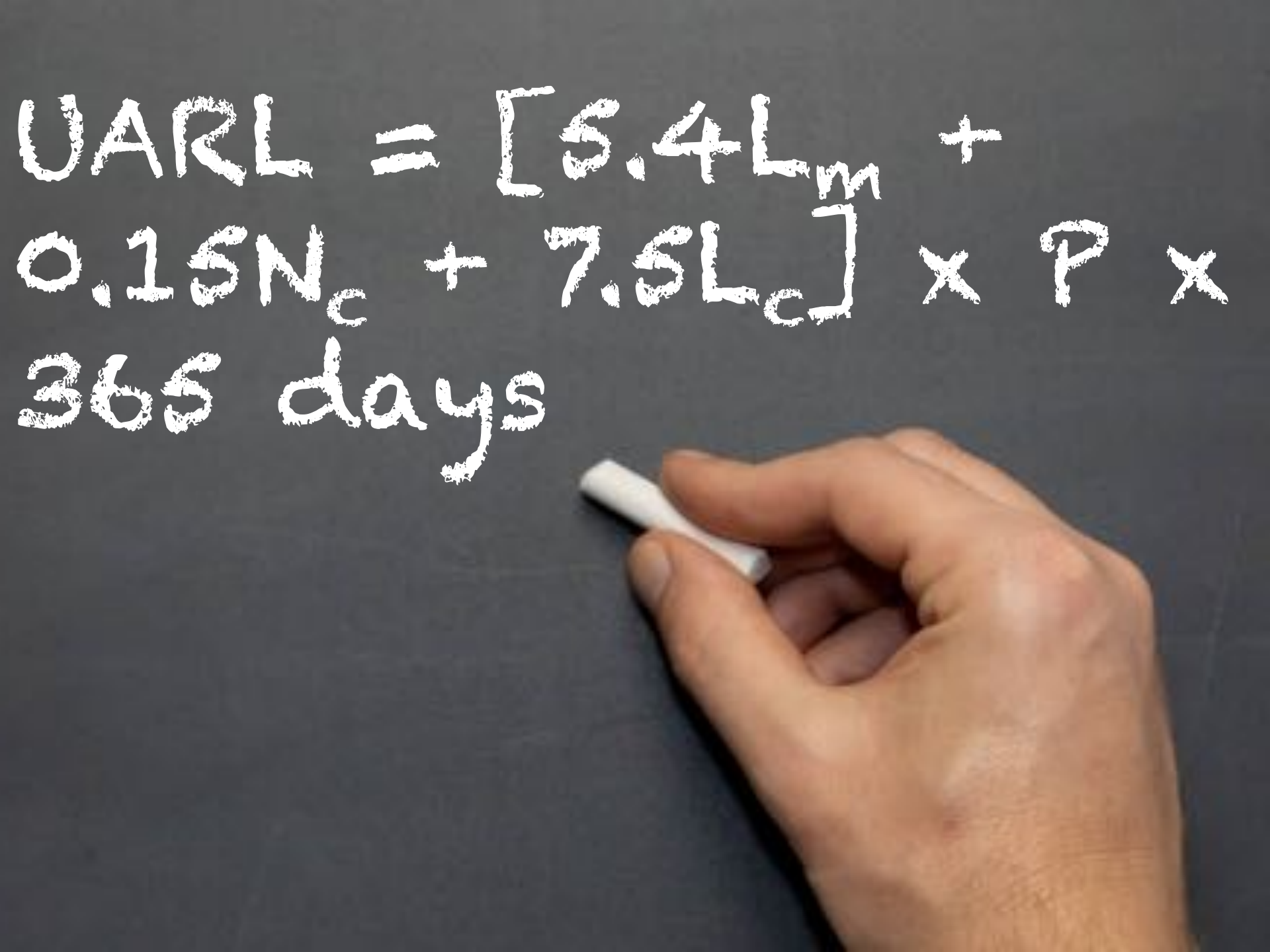
P = Ave System Pressure

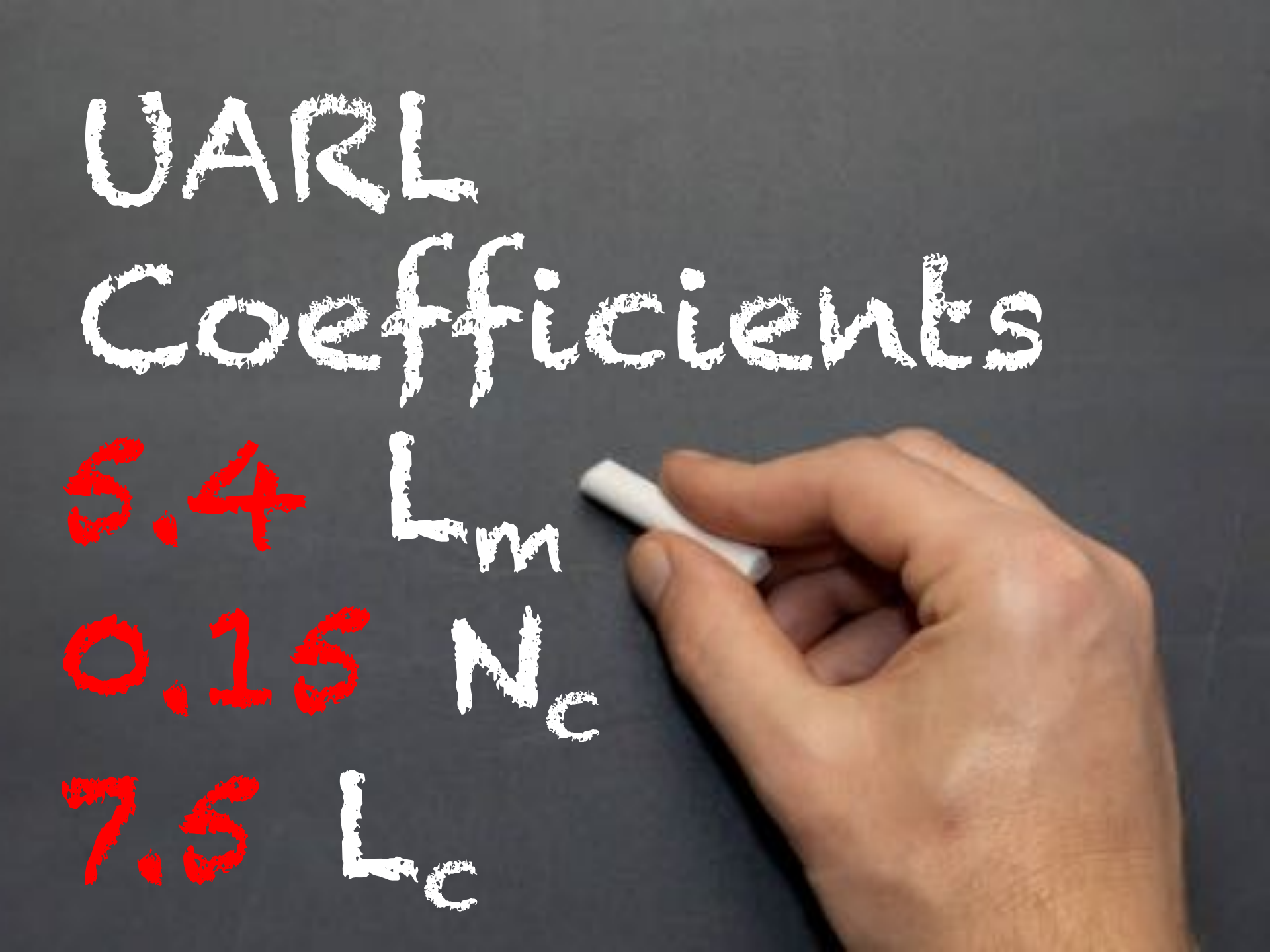


Requirements

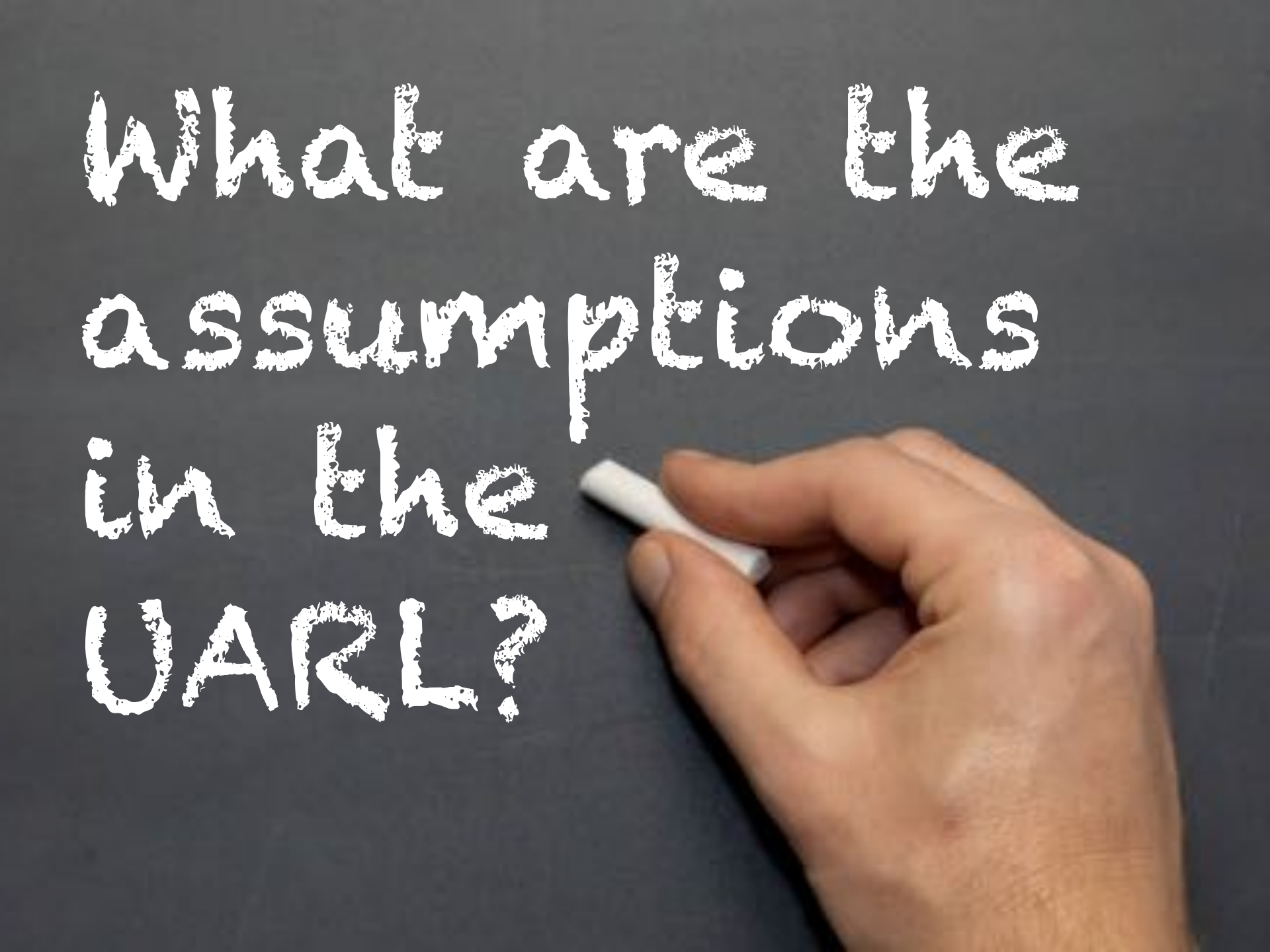

35 psi, 3000
connections

$$UARL = [5.4L_m + 0.15N_c + 7.5L_c] \times P \times 365 \text{ days}$$




UARL
Coefficients
5.4 L_m
0.15 N_c
7.5 L_c

What are these based on?


What are the assumptions in the URL?

Main Line Breaks

Service Line Breaks

Background Leakage

Component values of the UARL Calculation at 70 PSI

Infrastructure Component	Background (undetectable) Leakage	Reported Leaks and Breaks	Unreported Leaks and Breaks
Mains or Pipelines	8.5 gal/mi/hr	0.2 breaks/mi/year at 50 gmp for 3 days duration	0.01 breaks/mi/year at 25 gpm for 50 days' duration
Service connections, main to curb stop	0.33 gal/service connection/hr	2.25 leaks/1000 service connections at 7 gpm for 8 days duration	0.75 leaks/1000 service connections at 7 gpm for 100 days duration
Service connections, curb stop to meter or property line (for 50 ft ave. length)	0.13 gal/service connection/hr	1.5 leaks/1000 service connections for 9 days duration	0.50 leaks/1000 connections at 7 gpm for 101 days duration

Components Annualized at 70 PSI

Infrastructure Component	Background (undetectable) Leakage	Reported Leaks and Breaks	Unreported Leaks and Breaks
Mains or Pipelines	74,460 gal/mi/year	43,200 gal/mi/year	25,200 gal/mi/year
Service connections, main to curb stop	2891 gal/conn/year	181 gal/conn/year	756 gal/conn/year
Service connections, curb stop to meter or property line (for 50 ft ave. length)	1139 gal/service connection/year	136 gal/service connection/year	509 gal/service connection/year

Issues with the UARL and ILI

Disclaimer

What follows is based on published articles, our observations at the SWEFC and my own research.

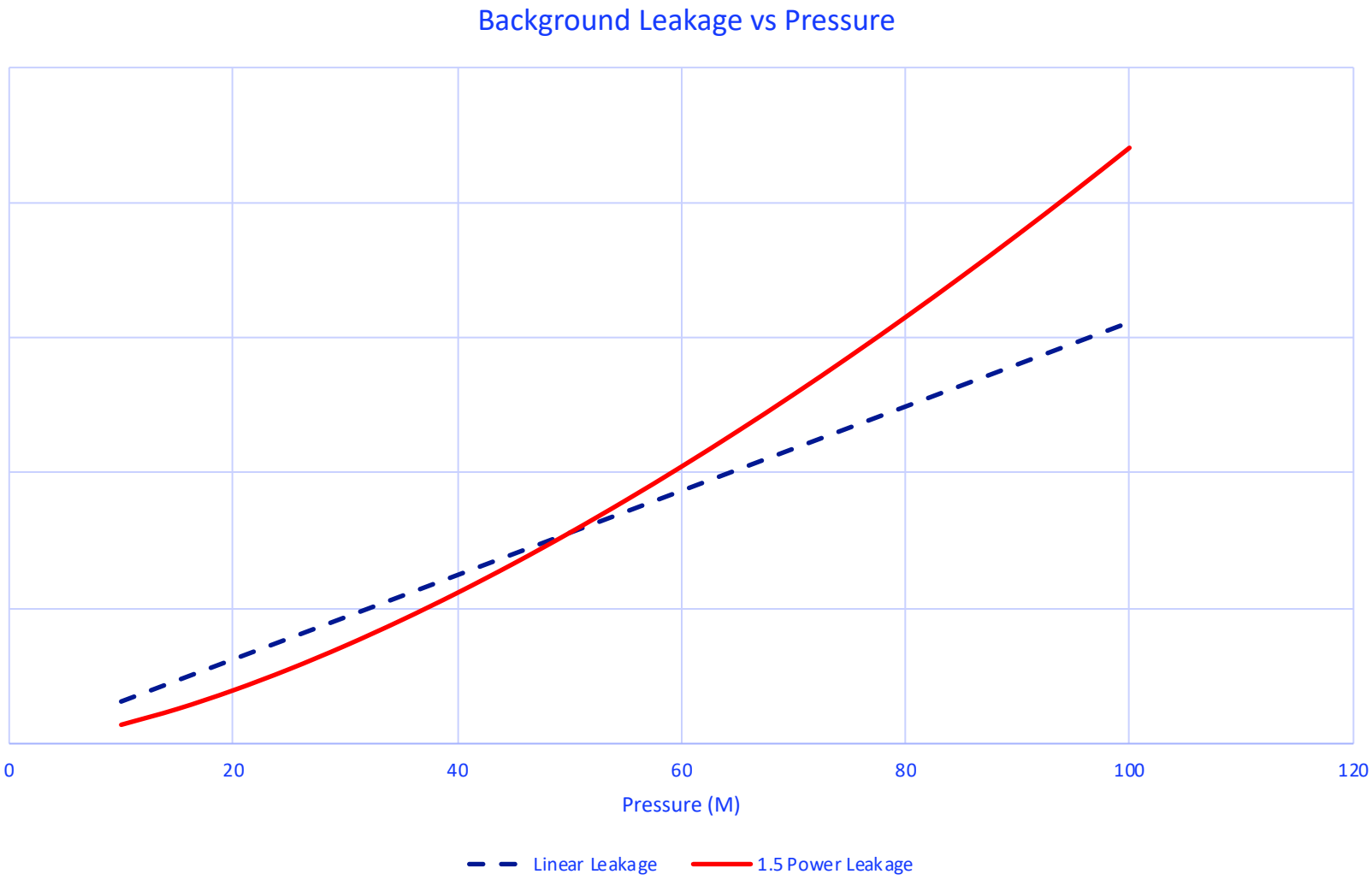
Pressure

We know there’s a relationship between pressure and leakage

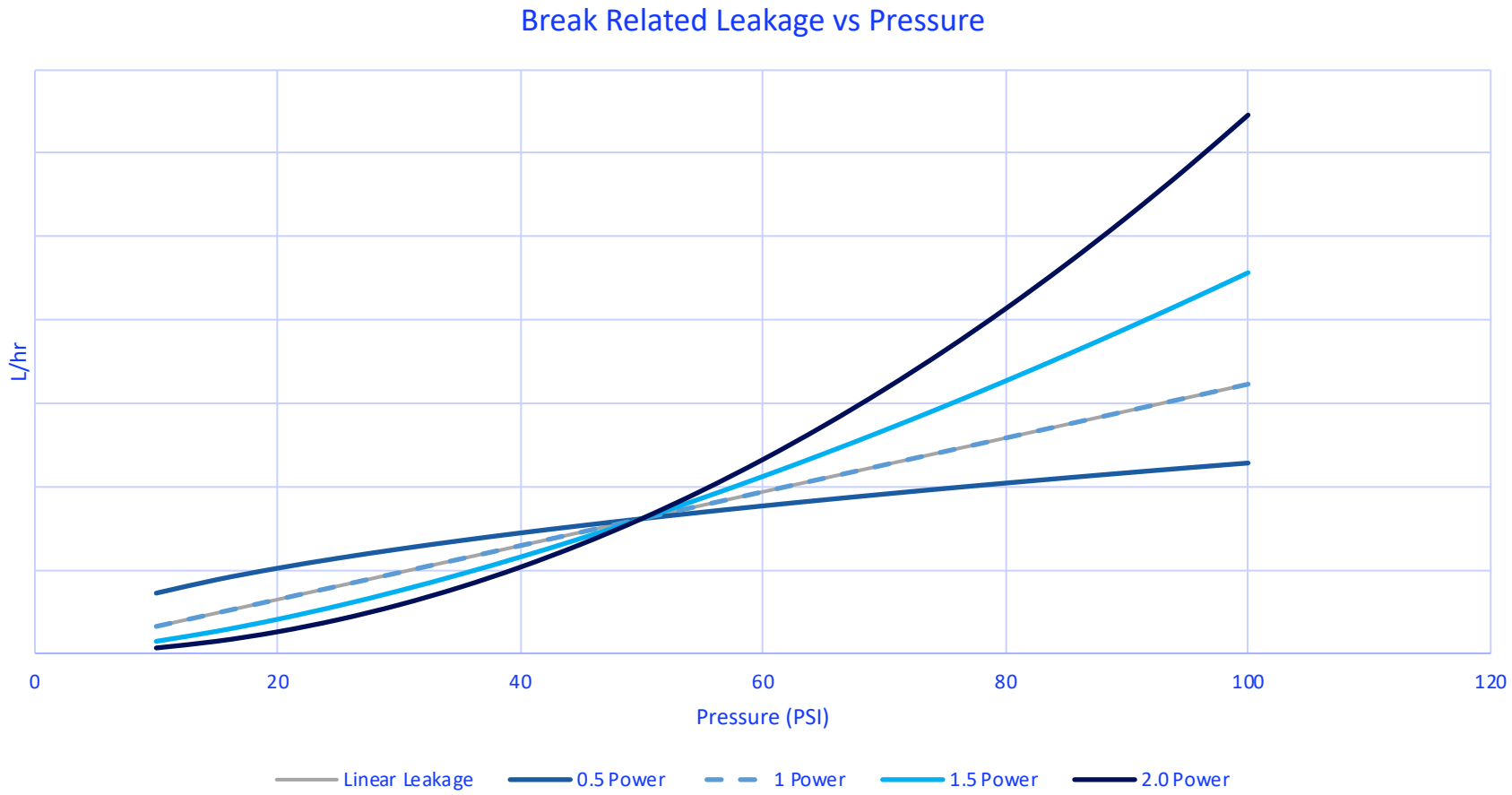
Source: George Kunkel Jr.

Source: George Kunkel Jr.

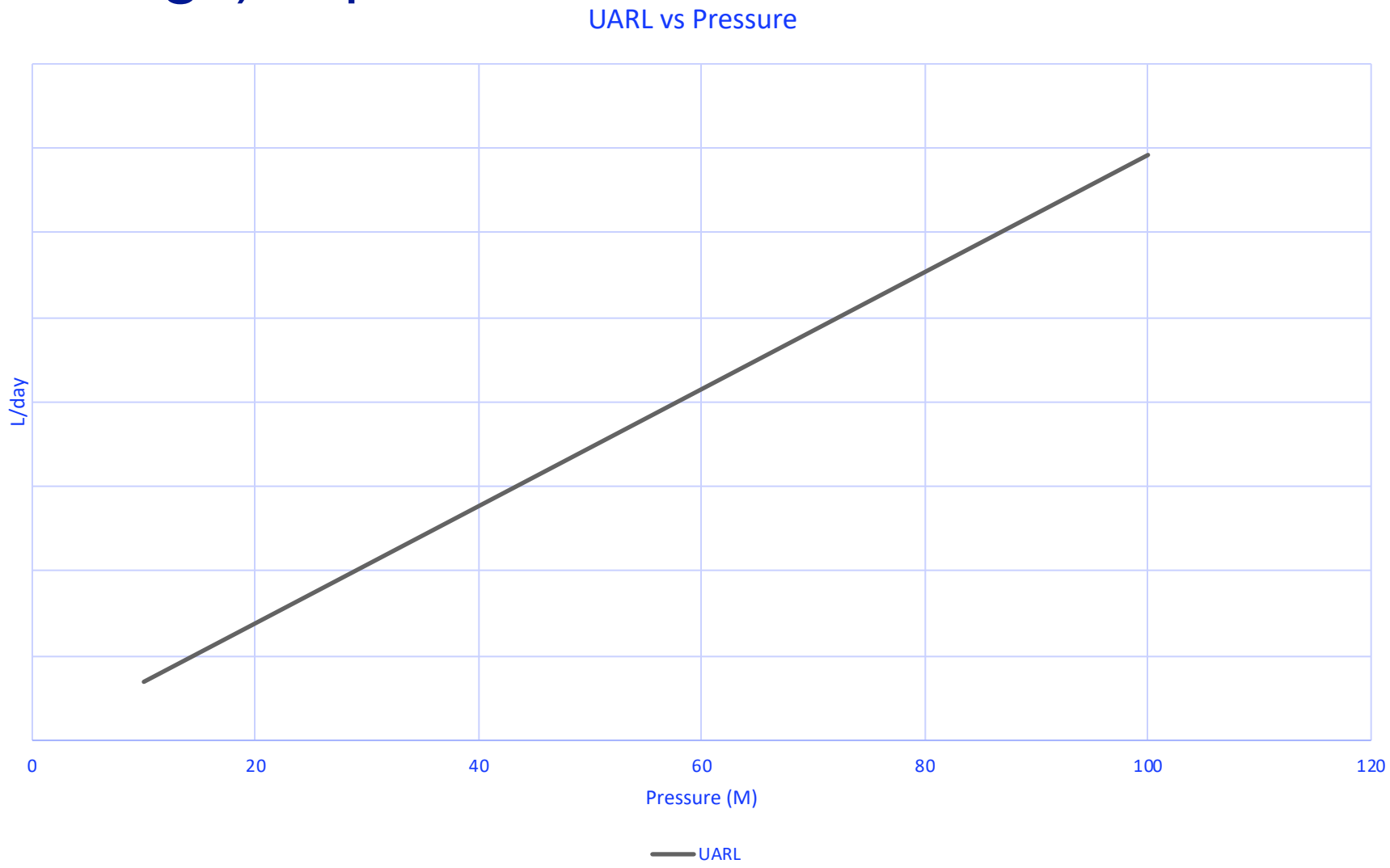
But, background leakage typically varies with pressure to the power of 1.5



And pipe burst leakage can vary with pressure to the power of 0.5, to 1.5or more depending on material and type of leak.



UARL (made up of background and break leakage) is presented as a linear formula



Impact of pressure reduction on ILI

Hypothetical System:

Lm = 3339.4 miles of main
Nc = 209,977 connections,
Lc = 0 (meters at the curb)
P = 60 PSI (average system operating pressure)

$$UARL = [(5.4Lm + 0.15Nc + 7.5Lc) * P] * 365\ d$$

$$= [(5.4 * 3339.4 + 0.15 * 209977 + 7.5) * 60\ psi] * 365\ d$$

$$= 1085\ MG$$

ILI Calculation at 60 PSI

$$\frac{\text{CARL}}{\text{UARL}} = \frac{2422\ \text{MG}}{1085\ \text{MG}} = 2.23$$

15% Real Loss Reduction Goal:

What if, over time our goal is reducing losses by 15%?

Hypothetically by:

Reducing Average System Pressure by 10 PSI

Improving leak repair response time

Conducting some leak detection

Revised ILI Calculation at 50 PSI

$$\frac{\text{CARL}}{\text{UARL}} = \frac{2059\ \text{MG}}{904\ \text{MG}} = 2.28$$

Wait, the ILI went up?!?!

Reduced real losses through pressure management may increase your ILI.

That’s ok.
Volume
matters
more.

Data Validity and Confidence Intervals

Systems new to auditing tend to over-score their data validity

UARL +/- 15%?

CARL +/- 20%?

ILI as a range of e.g. +/- 20%

1.78 2.23 2.68

If your data isn’t good, the metrics aren’t reliable

Break Frequency

0.2 breaks/mile/yr?

or

0.02 breaks/mile/yr

25% unreported service leaks

5% unreported main breaks

Hypothetical system (Based on WADI data):

Data grade: 86

5817 connections

237 miles of mains

Connection density = 25 conn/ mile

Pressure = 95 PSI

CARL: 246.423

Standard Break Rate	Custom Break Rate
0.2 breaks /mile	0.074 breaks /mile*
UARL =74.71 (MG)	UARL =61.21 (MG)
ILI = 3.3	ILI = 4

18% difference in UARL by changing **1 factor**

*Note: Albuquerque's break rate is less than half of that

If the underlying assumptions are inappropriate the standard formula may also be inappropriate

Allan Lambert has developed an Excel spreadsheet that you can use to develop a system specific UARL using assumptions specific to your system. (Contact Mr. Lambert via www.Leakssuite.com)

My take …

Based on our observations and my research …

The ILI is NOT shorthand for your audit grade

- It's **not** how you track real loss reduction.
- Don't look at it in a vacuum. It's one of several performance indicators that should be reviewed in context

The ILI is ok for basic benchmarking: comparing different systems with different characteristics

Assuming the underlying assumptions are valid for your system and your data is good.

I think the ILI has limited value to an individual utility just starting the auditing process – it's a "reality check"

Work on your data

I do not think the standard ILI formula is accurate enough to legislate on in the US

ILI is not useful for process benchmarking or developing specific loss control strategies

Seriously, don’t use ILI for process benchmarking: particularly if pressure management is part of your strategy

Dig Deeper

2014 WRF Component Analysis Tool 4372

http://www.waterrf.org/resources/Pages/PublicWebTools-Detail.aspx?ItemID=27

Collect break data

Calibrate meters

Improve processes

Things you can track, even if the ILI doesn't apply to you.

Real water loss from year to year

Actual water production year over year

Reduction in breaks year over year

Response and repair time year over year

Hours spent on repairs

Repair cost savings

And many others…..

A Quick Poll

Smart Management for Small Water Systems

Thank you for participating today. We hope to see you at a future workshop!

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