NORTH AMERICAN WATER LOSS • 2025

Tapping into Leakage:

Using Water Audit Data for Resilience Planning in the Delaware River Basin

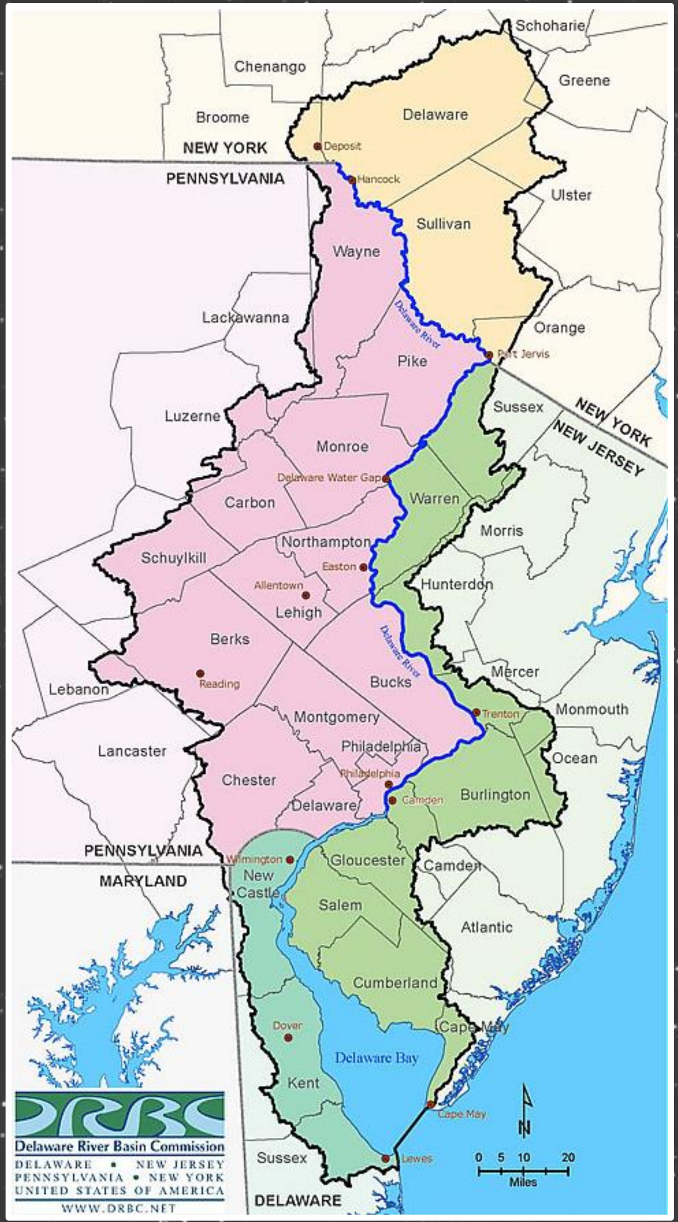
Michael Thompson, P.E.

Wed 12/03/25 (WED03-01) 10:30 AM - 11:00 AM

Michael Thompson received a B.S. in Civil Engineering from Lafayette College, an M.S.C.E. from the University of Notre Dame, and is a licensed professional engineer in Pennsylvania. He spent five years as a consulting engineer in the field of environmental remediation, in 2018 began working for the Delaware River Basin Commission, and is currently a Senior Water Resource Engineer. His work is focused on sustainable water use planning for the Basin, which includes but is not limited to hydrology, groundwater and surface water availability modelling, withdrawal data analysis, as well as water audits and water loss conservation.

Basin highlights…

- 330 miles long
- interstate boundary
- un-dammed
- 13,539 square miles
- 8.6 million people live here
- ½ of New York City's water supply
- 6.4 billion gallons/day withdrawn
- $21B in economic value
- Cools 101 TWh of energy in 2023



Delaware River Basin
13,500 square miles
8.6 million people

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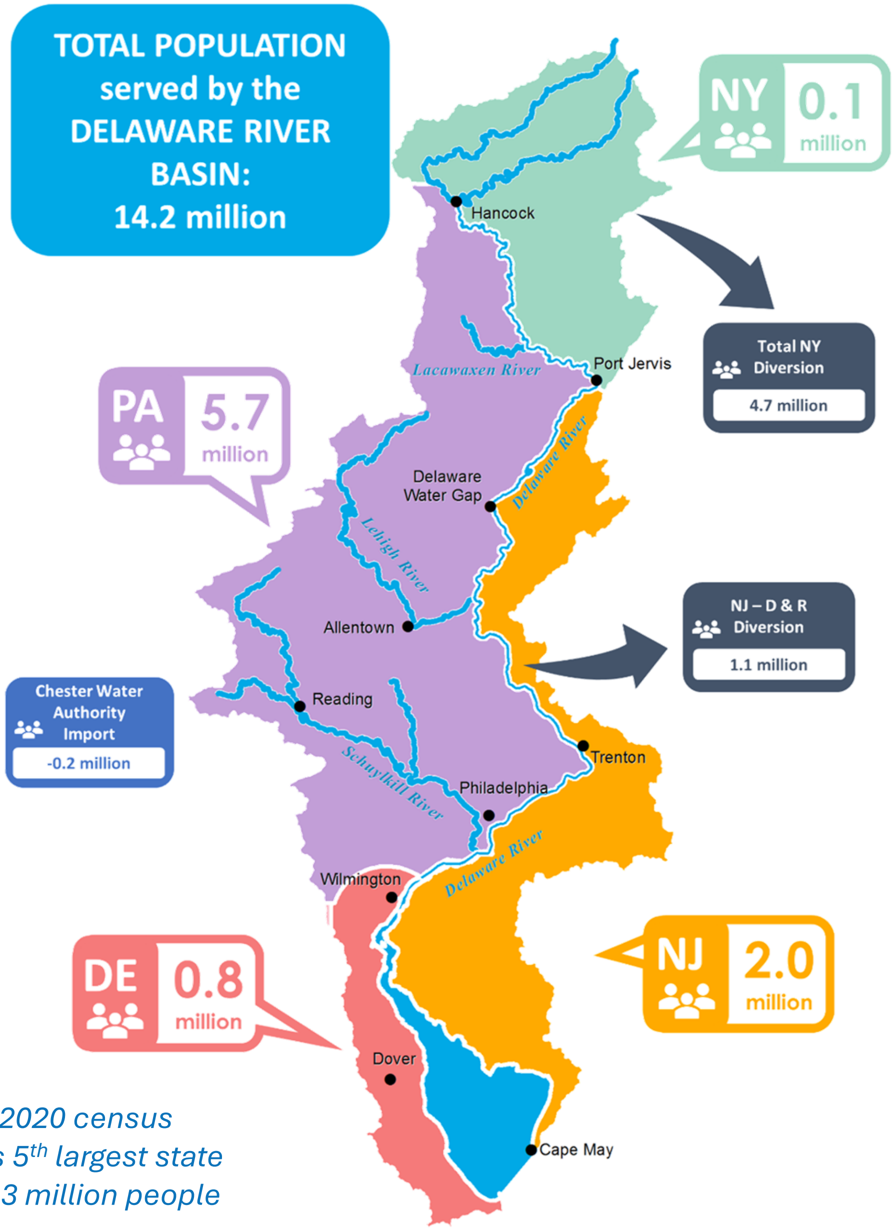
Over 14 million people rely on the Delaware River Basin for drinking water



For reference, the US 2020 census reported the country's 5th largest state population as about 13 million people (Pennsylvania).

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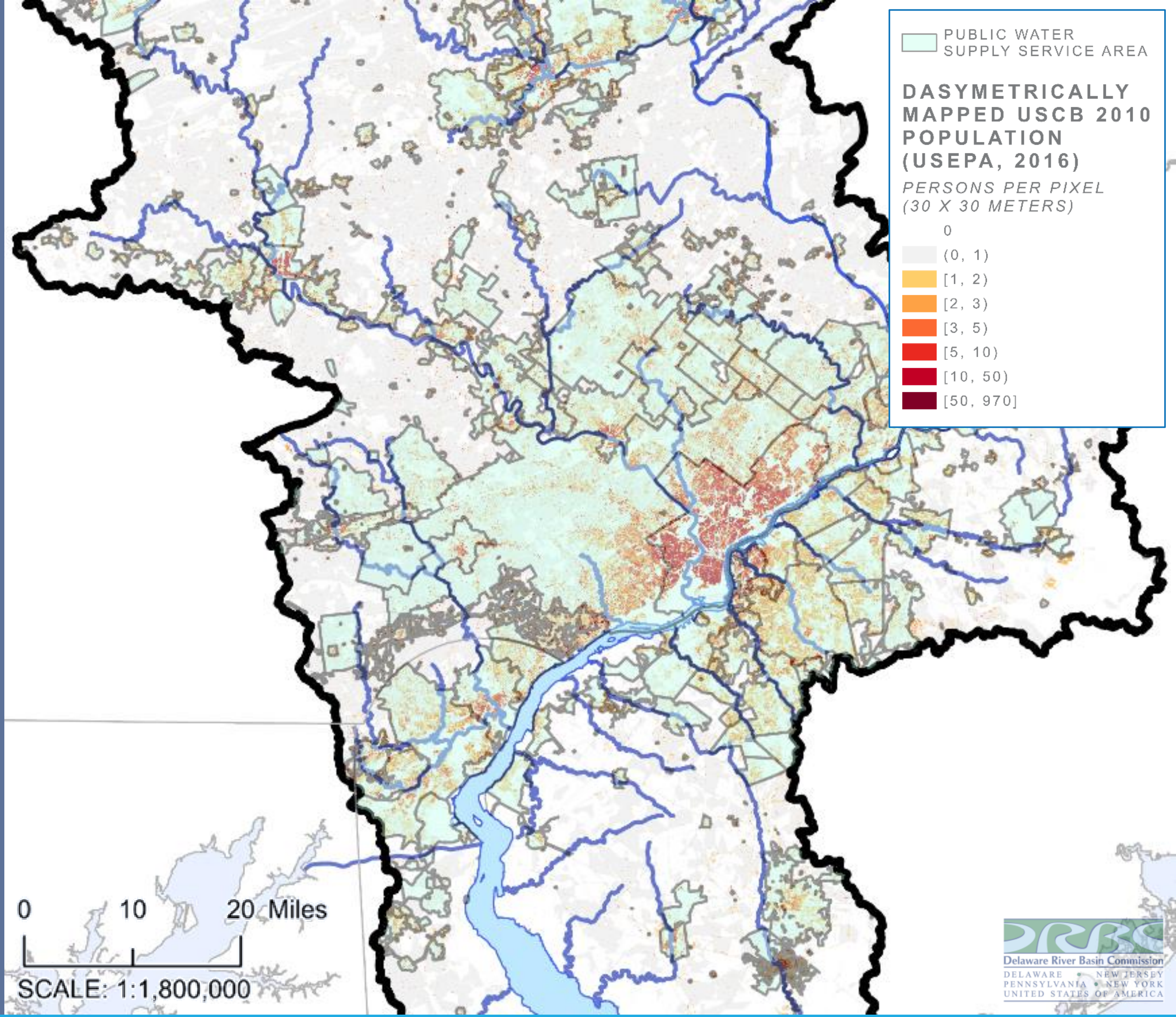
Most people in the Basin rely on public water supply

8.629 million people live in Delaware River Basin (2020 Census)

7.366 million people live inside public water supply service areas

~ 85% of the population



The DRBC "Water Audit Program" applies to around 300 water systems

29,000 miles of water main (enough to circle the Earth)

2.5 million service connections (active and inactive)

The regulation is to submit a report, not to meet a target loss rate

2000
International Water Association publishes research standardizing methods to quantify water loss

2006
DRBC staff participate on the American Water Works Association (AWWA) Water Loss Control Committee (WLCC) and help publish the first AWWA Free Water Audit Software (FWAS)

2007-2009
DRBC undergoes rulemaking process
Adopted Res 2009-1 to amend the Water Code
Applies to systems which:
"distribute water supplies in excess of an average of 100,000 gallons per day (gpd) during any 30-day period"

2013
The first mandatory water audits are due for CY2012

“A Comprehensive Assessment of the Delaware River Basin Commission’s Water Audit Program (2012-2021)”

DRBC audit program

Visit the website:

https://www.nj.gov/drbc/programs/supply/water-audit-program.html

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DRBC Report No: 2023-7

Prepared by Michael Y. Thompson, Sara C. Sayed, and Chad E. Pindar

Authorization

This work is being conducted in accordance with Article 3 Section 3.6(c) of the Delaware River Basin Compact (PL 87-328, 75 Stat. 688). More specifically, the project is outlined in Section 2.2.1.3 (Water Supply Management: Conservation, Special Area Management, and Permitting) of the DRBC Water Resources Program FY2024-2026 (DRBC, 2023).

Acknowledgements

First and foremost, the authors express gratitude to all utilities and staff who have been completing the AWWA Free Water Audit Software reports over the past decade. Thank you for your coordination year after year, and for working with DRBC to get the best data feasible. As the adage goes, you cannot manage what you do not measure – and because of your efforts, it is possible to perform analyses such as this to help plan for a sustainable future.

The authors express their gratitude to: Allan Lambert and Kate Stanton-Davies (Water Loss Research & Analysis Ltd) for sharing valuable knowledge of the industry's history, reviewing the draft report, and for assistance related to their ongoing research on System Correction Factors; to George Kunkel (Kunkel Water Efficiency Consulting) and Gary Trachtman (Arcadis US, AWWA WLCC) for their discussions on meter testing/accuracy, and for providing valuable insight after reviewing a draft report; and to Margaret Hunter (New Jersey American Water) for her assistance in compiling the additional data needed for the pilot study on System Correction Factors. Additionally, the authors would like to acknowledge the help and expertise of the DRBC Water Management Advisory Committee (WMAC).

Scope and Organization

The purpose of this study is to perform a comprehensive assessment of the ten years of data collected though the Delaware River Basin Commission's water audit program (Delaware River Basin Water Code §2.1.8). A detailed background on water system efficiency is presented, with a specific focus on how the industry has arrived at its current practices (i.e. top-down approaches to water balances with standardized terminology). A review of the most recent year of data (CY2021) summarizes specific metrics measured by the AWWA Free Water Audit Software, followed by assessments of observed trends (2012-2021). Investigations are performed to estimate possible reductions of real water loss (i.e., leakage) across the Delaware River Basin. Multiple recommendations are made at the end of this report to help move the water audit program in the Delaware River Basin from monitoring progress, to promoting progress.

DRBC 2023-7
December 2023

Why is understanding water loss important?

Drought of Record (1961-1967)

Delaware River near Trenton, New Jersey

DRBC Water Code (18 CFR Part 410 §2.400.1)
"The Drought of Record (DOR), which occurred in the period 1961-1967, shall be the basis for determination and planning of dependable Basin water supply."

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I need water now.

SUNDAY, JULY 29, 1962

(shown right) high on Mt. Minsi, overlooking the Gap. Using a Civil Defense pump from Allentown and borrowed hose, the firemen will for the second time pump water half a mile into dry Caledonia Creek, so it will run down into the reservoir and alleviate the critical shortage. (Call-Chronicle photos by Mantz)

SATURDAY, AUGUST 21, 1965

Bristol Daily Courier
The Levittown Times

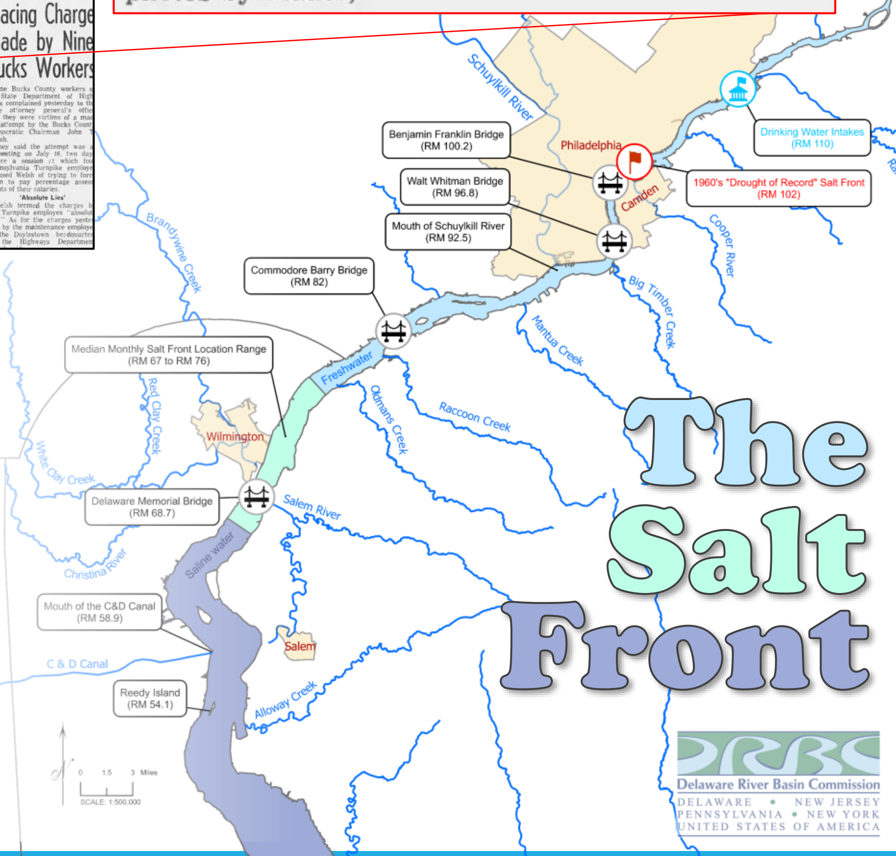
Owned and Published by the Bristol Printing Company
Route 13, Levittown, Pa., Telephone WI 3-1000
(Incorporated May 27, 1914)

Plan Now For Dry Days

With each successive day of drought, the water shortage that is menacing North New Jersey and New York City comes that much closer to Lower Bucks County. It is high time that our municipalities and our residents showed some awareness of this situation.

At present, both Bristol Borough and the Lower Bucks County Joint Municipality among others, rely upon the Delaware River for much of their water. The salt line is creeeping up the river from Delaware Bay and the drought is creeping down from reservoirs diverting what little water is left to other users. The underground water level is dropping each day and soon our reserve supplies, our wells, will be in trouble.

The hour to practice conservation and to clean up pollution is not when the water famine is upon us; it is now. We need objective, intelligent direction on this point and we need complete, individual compliance.



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Data management and review

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What does the dataset look like?

Statistics for the DRBC's Water Audit Program (2012-2024)

Year	First Year	Last Year	Expected	Missing	v4.1	v4.2	v5.0	v6.0	Received	Compliance	Filtered Dataset
2012	305		305	63	3	239			242	79%	197
2013		2	305	44	2	257	2		261	86%	200
2014		2	303	43	1	96	163		260	86%	167
2015			301	35		7	259		266	88%	175
2016			301	11		1	289		290	96%	183
2017	1		302	8			294		294	97%	188
2018	1	5	303	7			296		296	98%	192
2019	5	3	303	18		1	284		285	94%	201
2020	1	2	301	13			150	138	288	96%	207
2021		3	299	6			6	287	293	98%	187
2022		3	296	12			4	280	284	96%	194
2023			293	16			1	276	277	95%	192
2024	1		294	14			1	279	280	95%	204

Filtering Criteria

1. Cannot be backfilled report data
2. Losses >= 0
3. CMI < 25% of Total Water Loss
4. ILI 1 < ILI <20
5. BMAC > 1,000 gal/connection/month

Data backfill example...

YEAR	VOS
2012	121.000
2013	
2014	
2015	
2016	93.230
2017	75.545
2018	82.466
2019	
2020	80.712
2021	94.000

→

YEAR	VOS
2012	121.000
2013	93.230
2014	93.230
2015	93.230
2016	93.230
2017	75.545
2018	82.466
2019	80.712
2020	80.712
2021	94.000

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Comparison (2021)

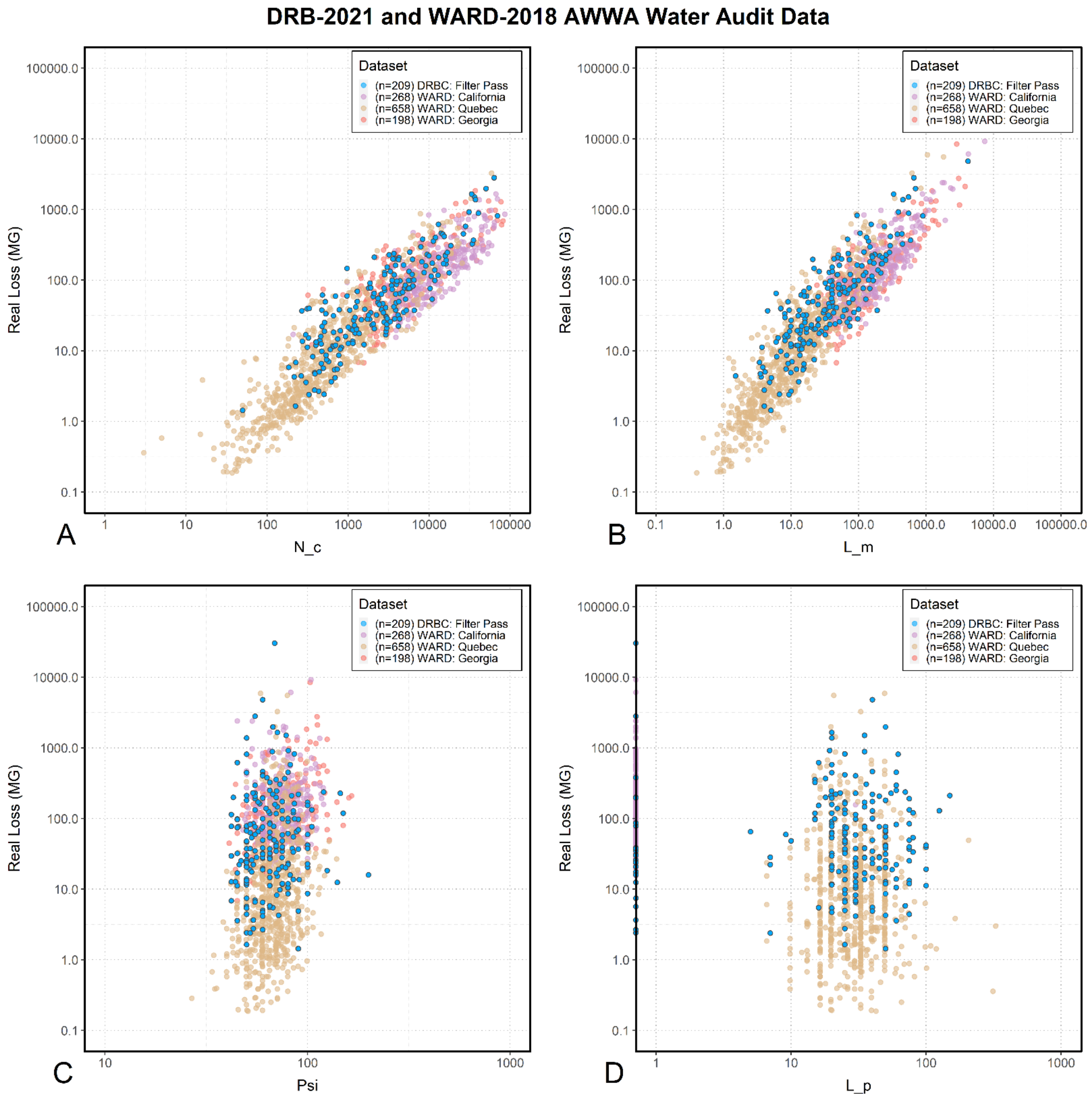
Water Audit Reference Dataset (WARD)

A product compiled by the AWWA Water Loss Control Committee which includes Level 1 validated water audits for calendar year 2018 from 1,124 utilities in:

- Quebec (Canada)
- California
- Georgia

Real Loss on y-axis in all plots

“Filtered” data from the Delaware River Basin aligns with Level 1 validated data fairly well



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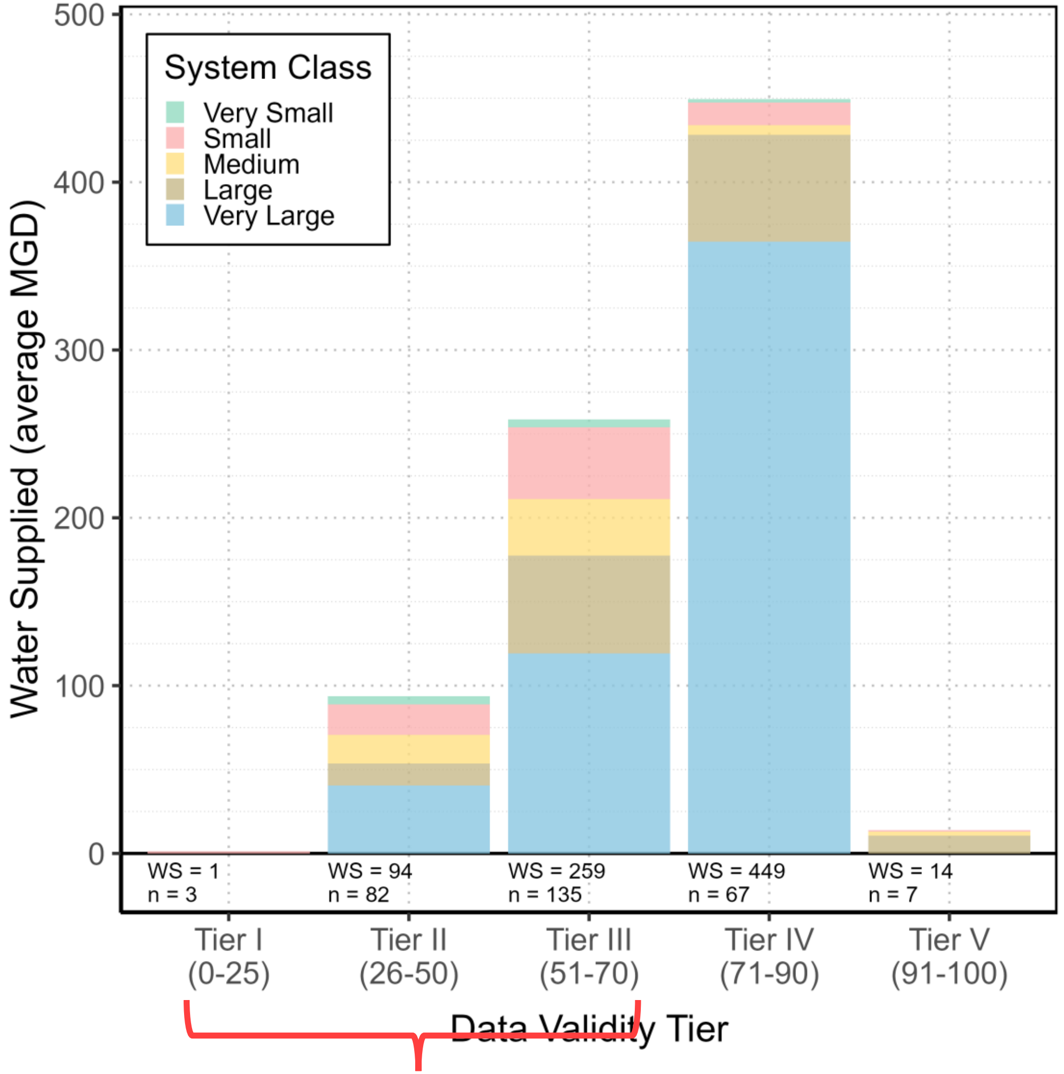
“Are you sure?”

CY2024 data “sureness”



There is room for improvement here…

We can look at the Interactive Data Grading response for…

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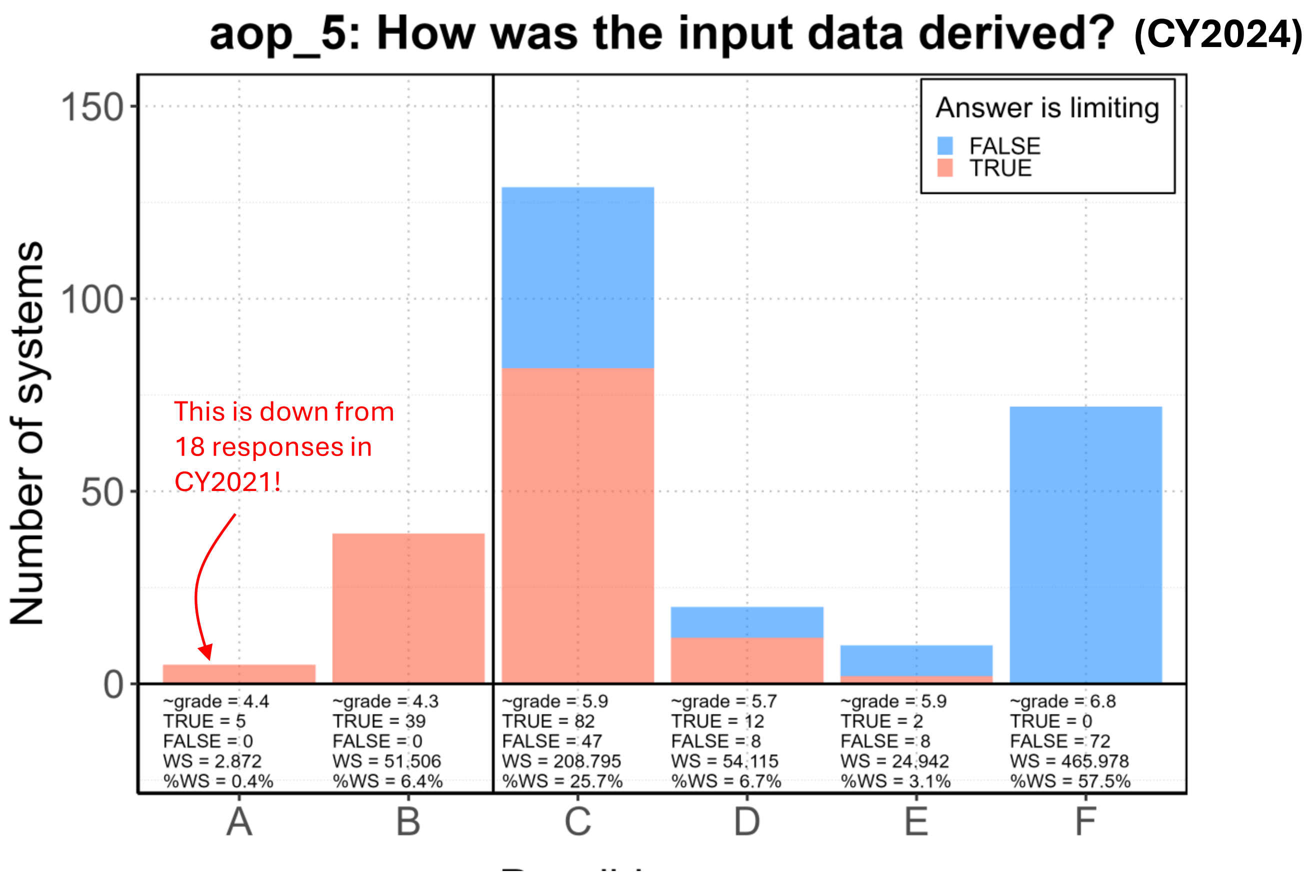
Pressure!



A Guesstimated

B Loose estimate inferred from field measurements but no analysis nor calculations performed

C Calculated from field data as a simple average

D Calculated from field data as a weighted average compliant with methods described in the M36 Manual

E Derived from hydraulic model where model has not been field calibrated in the last 5 years

F Derived from hydraulic model where model has been field calibrated in the last 5 years

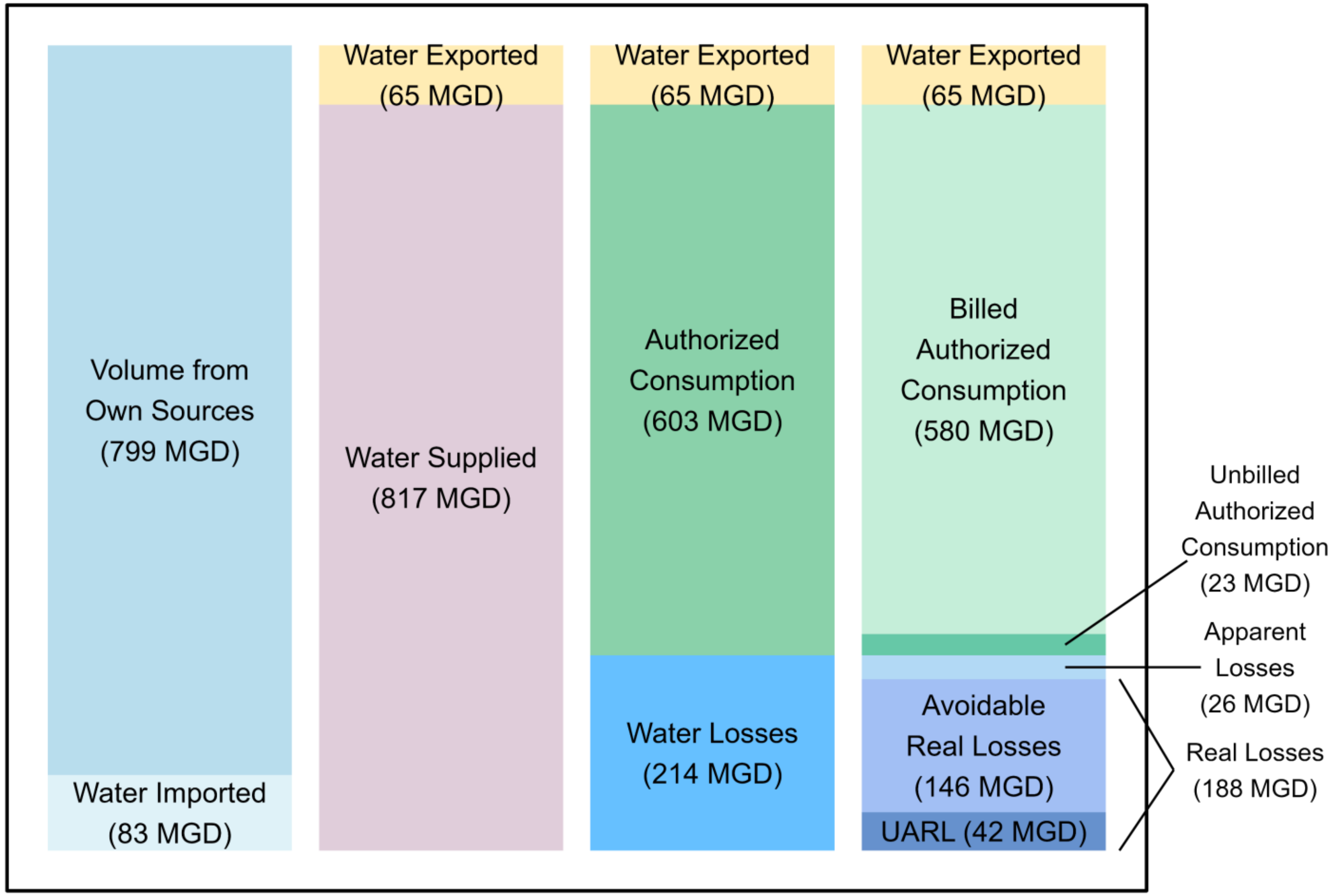
Water Audit Analysis (2024) & Trends (2012-2024)

Basin wide, 2024

- Aggregate data for 294 reports
- Net “Import-Export” = 18 MGD
- Water supplied = 817 MGD

UARL (42 MGD)

- Not all real losses can be resolved
- Addition of UARL to the water balance adds some context to Real Loss volume
- The word “avoidable” used here as the antonym to “unavoidable”, but perhaps there is better terminology …



CY2024 aggregate water balance from 294 reports submitted by systems within the Delaware River Basin. Note that the UARL=42 MGD summation is based on standard UARL calculations performed for all systems regardless of operating pressure or number of connections (if ILI<1, UARL was replaced with the observed real loss value).

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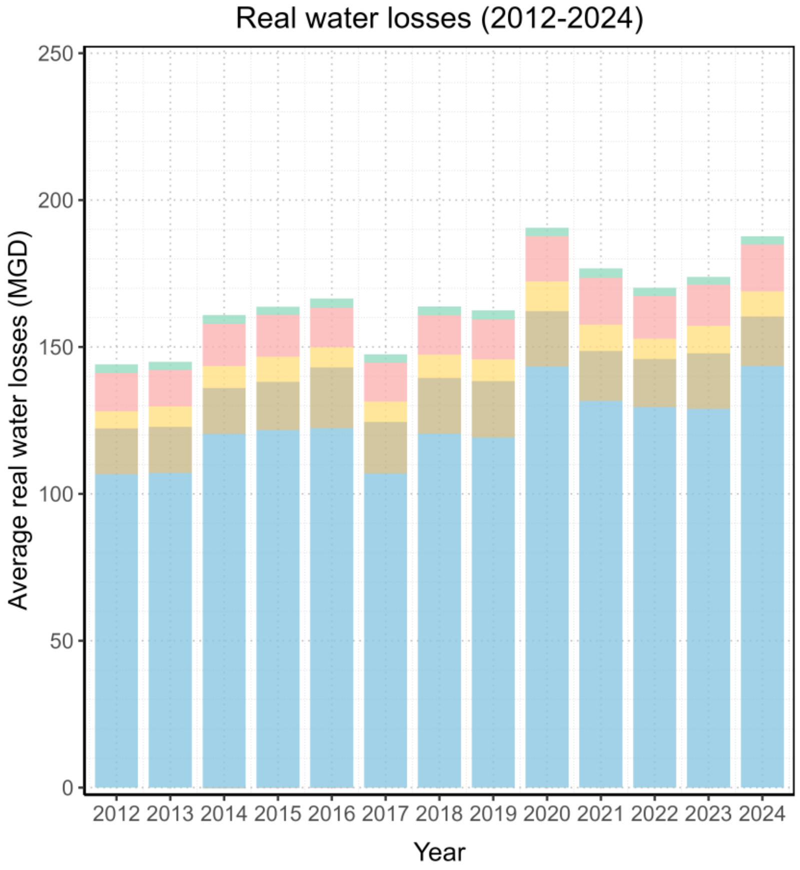
Real losses

Quoting the 2023 report…

"The volume of real losses has remained relatively constant, with increases in the last two years (2020, 2021)."

Looking at data through 2024…

"???"



Class	Max N_c	Count*	
Very Small	1,000	89	Primarily GW
Small	5,000	123	
Medium	10,000	30	
Large	20,000	36	~1/3 rely on SW
Very Large	> 20,000	16	14/16 rely on SW

* The count is the number of systems in each class, based on CY2024 reports

Recall planning objectives related to a repeated DOR:

(1) will the water be there for taking on the day its needed

(2) could mitigating losses today help prevent future shortfalls (if any)

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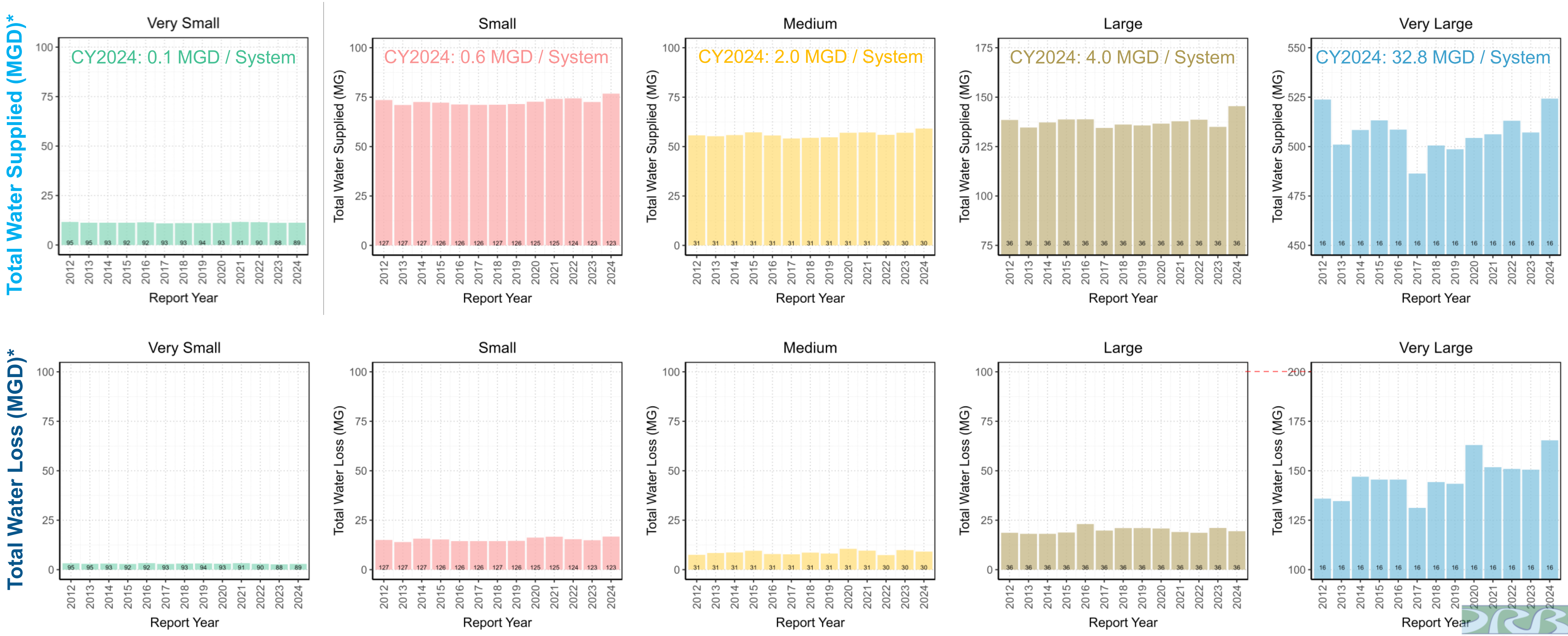
Where to start



** Scales are different, but Δy is the same (100 MG)*

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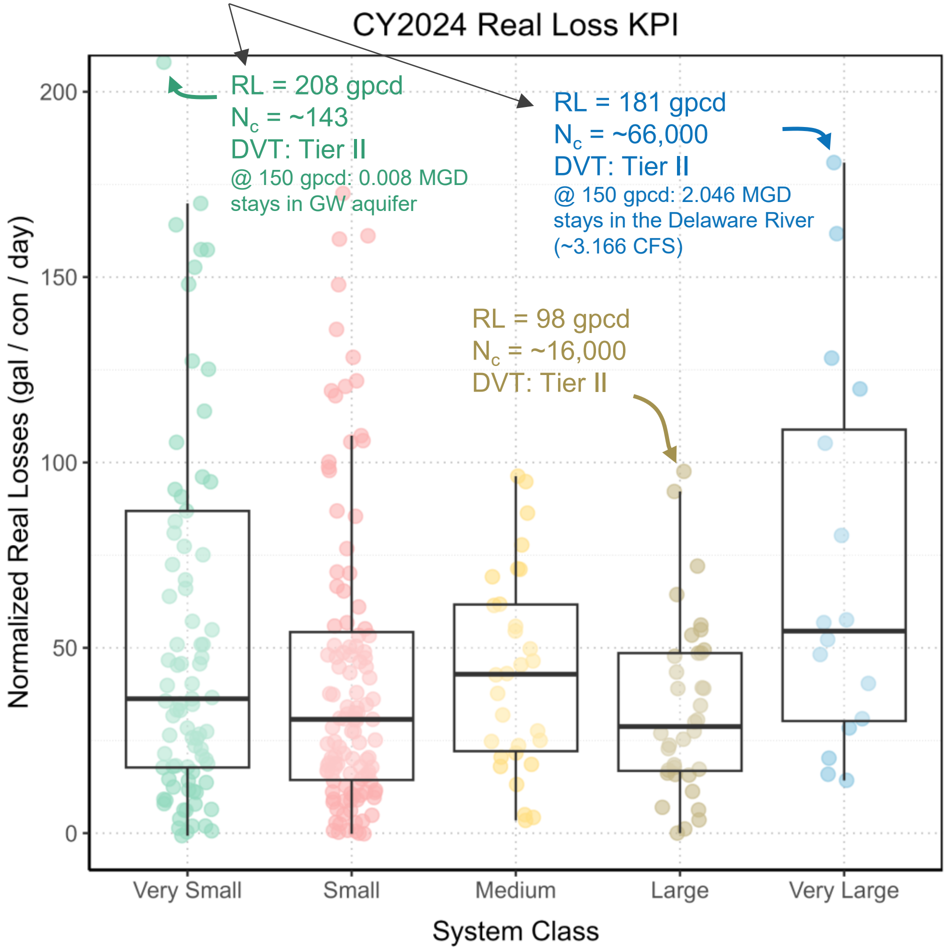
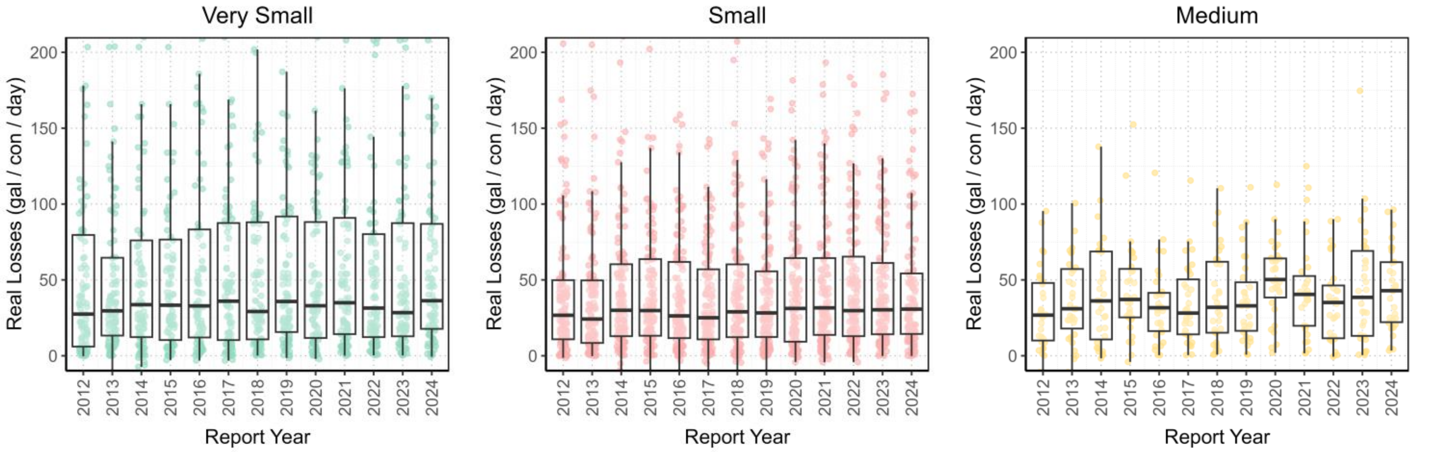
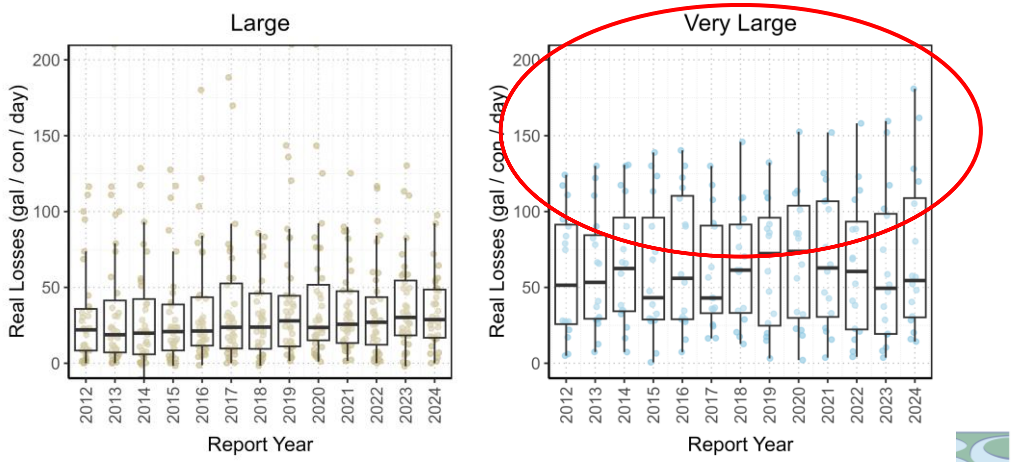
Class	Max N_c
Very Small	1,000
Small	5,000
Medium	10,000
Large	20,000
Very Large	>20,000

Key Performance Indicators

Yes, there are different levels of effort for each system to reach 150 gpcd. This is a hypothetical scenario for illustrative purposes.







[1] Not considering connection density, which may suggest using an alternate KPI of (gal / mi main / day) would be more suitable.

[2] WARD 2018 (FWAS V6 speedometer) 90th percentile is about 115 gpcd

[3] Similar leakage rates ≠ Similar performance (see slide #25)

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Class	Max N_c
Very Small	1,000
Small	5,000
Medium	10,000
Large	20,000
Very Large	>20,000

Some notes to remember…

When it comes to Basin-scale picture:

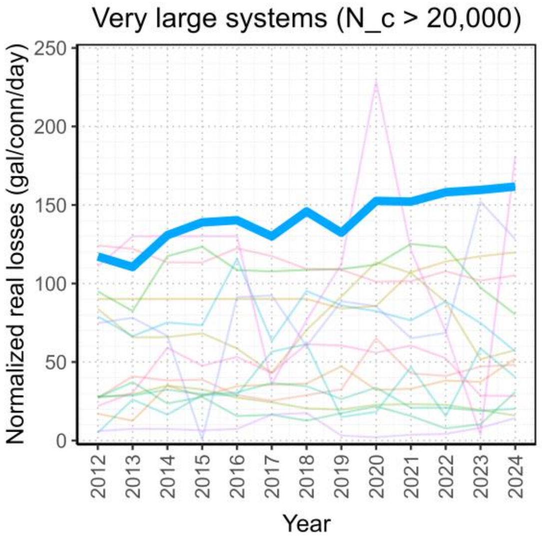
- A few systems can drive volumetric trends
- Who is looking at the data, and what are their goals
- Consider water resource benefit per unit effort

Ultimately…

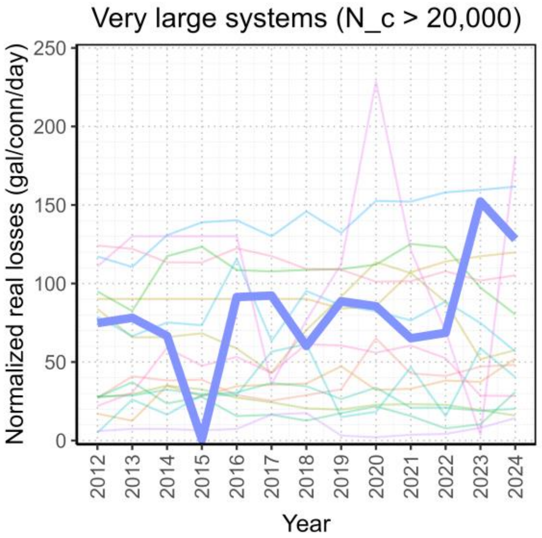
- People = People
- All systems can face drought
- All systems have rate payers → equity

** Scales are different, but Δy is the same (100 MG)*

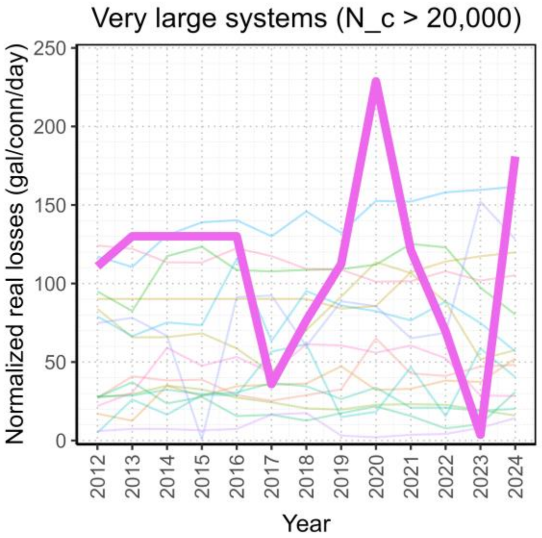
Look at Key Performance Indicators (KPIs)



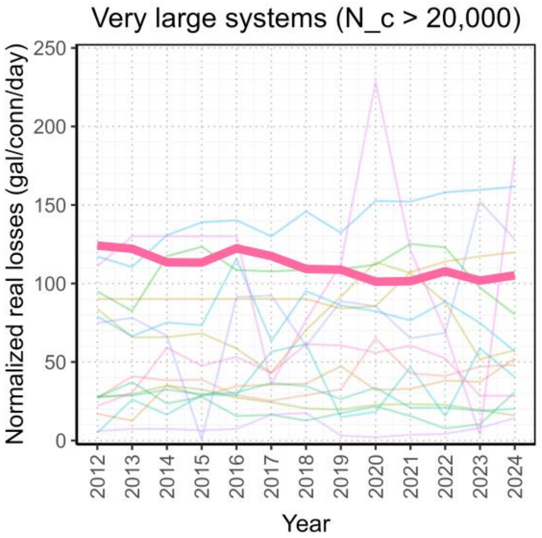
One of the largest systems reporting a steady increase in normalized real losses from about 110→150+ gcd over 13 years



Another system which in the last 2 years has gone from <100 gcd to ~140-150 gcd



An example of a system which has apparently had issues with reporting consistency. Known staff turnovers in recent years



An example system reporting gradual decreases in real loss KPI from about 130 →100 gcd

Urban centers with older infrastructure have unique challenges to overcome

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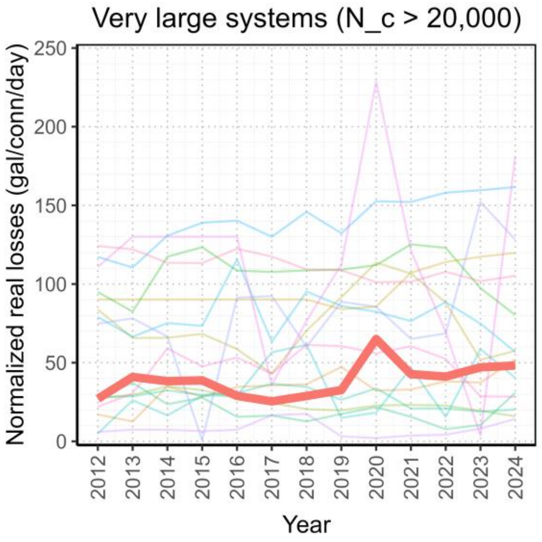
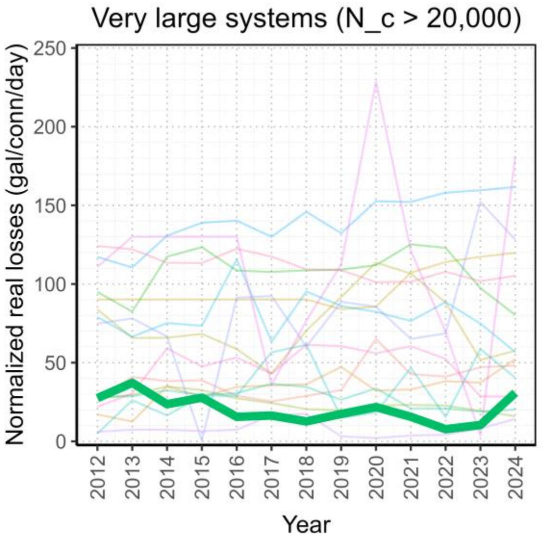
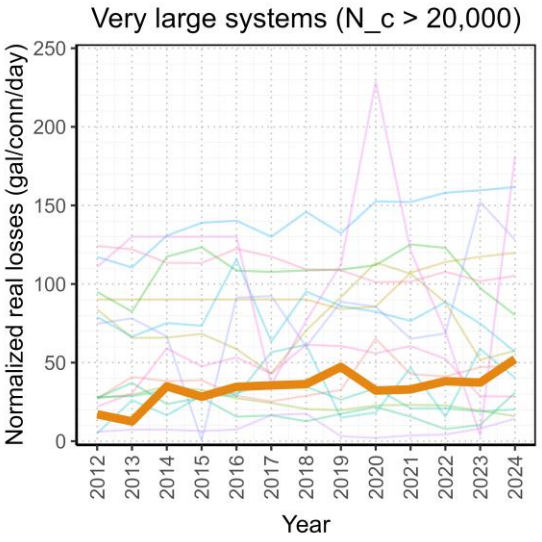
Look at Key Performance Indicators (KPIs)



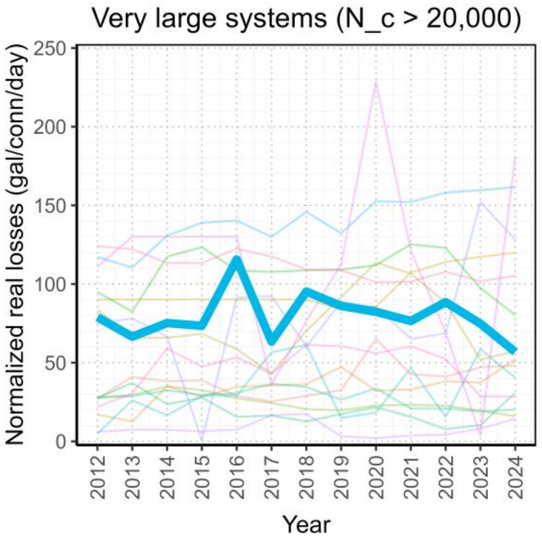
One of the largest privately owned and operated systems reporting *slight* gradual increases in normalized real losses.



Another private system which has helped with conjunctive use to alleviate dependance on groundwater in suburban areas



An example of a private water system which has remained relatively constant at a real loss metric of about 40-50 gcd for 10 years.



A private system operating around 80-90 gcd since 2018, possibly trending down to a reported ~60 gcd in 2024.

Many of these systems serve suburban areas and likely also have newer infrastructure

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Real Loss Reduction Potential (RLRP)

Real Loss Reduction Potential

- Cross-plot: Real Loss vs. UARL (unit rates)
- All above ILI=_ reduce to ILI=_ → water savings
- Economic Level of Leakage (ELL) would greatly improve overall estimates – all systems decreasing to ILI=1 is not realistic
- Similar leakage rates do not necessarily mean similar performance

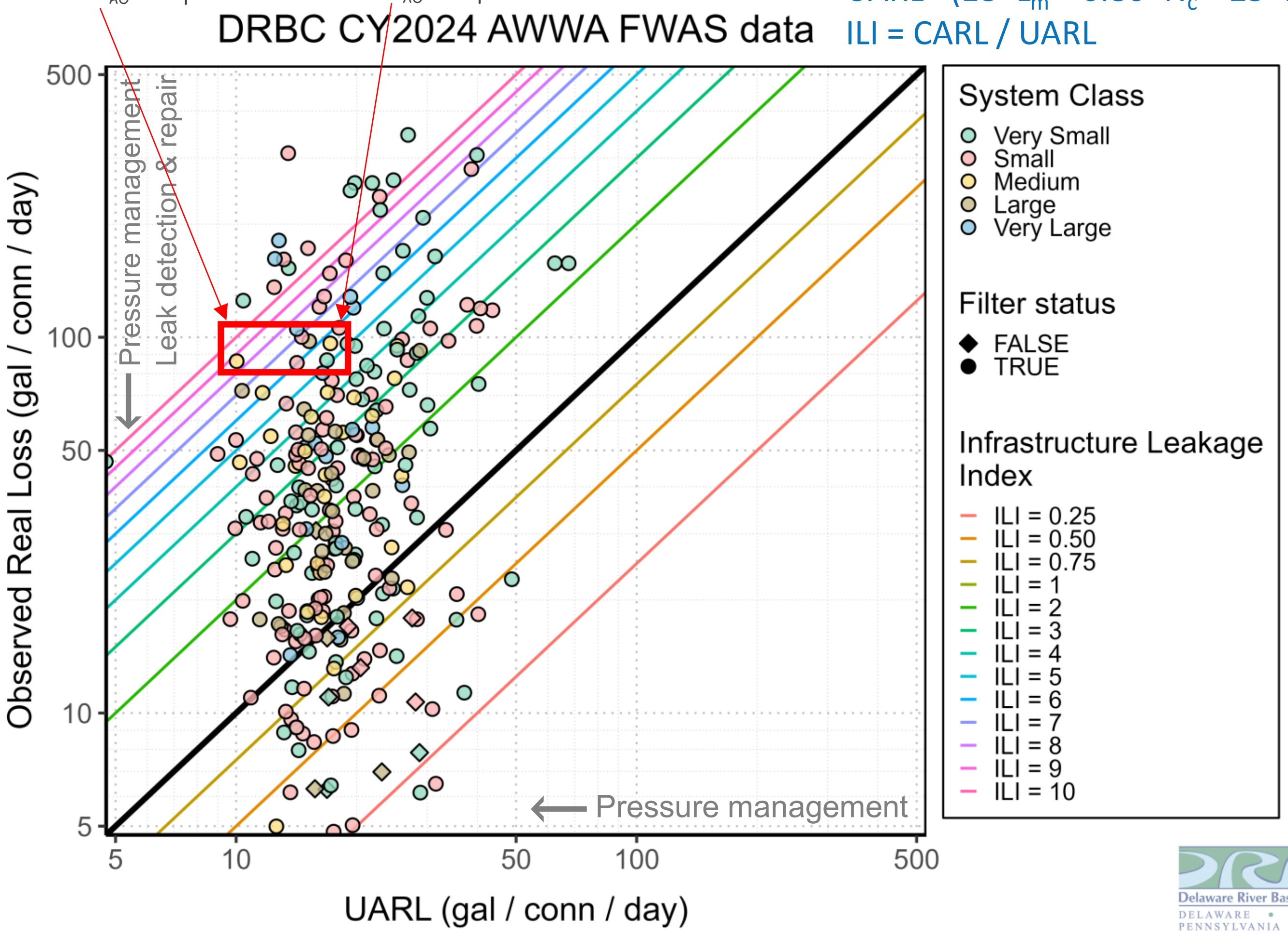
Musing on P_{AO} and ILI

Pressure and leakage are directly related (i.e., orifice equation) – decreases in P_{AO} should be reflected in leakage, adjusting ILI accordingly

Similar leakage rates ≠ similar performance

Medium system #1
Real losses ~86 gcd
ILI~8.6
N_c = 6,616
L_m = 21 mi
L_p = 0 ft.
P_{AO} = 60 psi

Medium system #2
Real losses ~96 gcd
ILI~5.6
N_c = 5,683
L_m = 129 mi
L_p = 60 ft.
P_{AO} = 48 psi

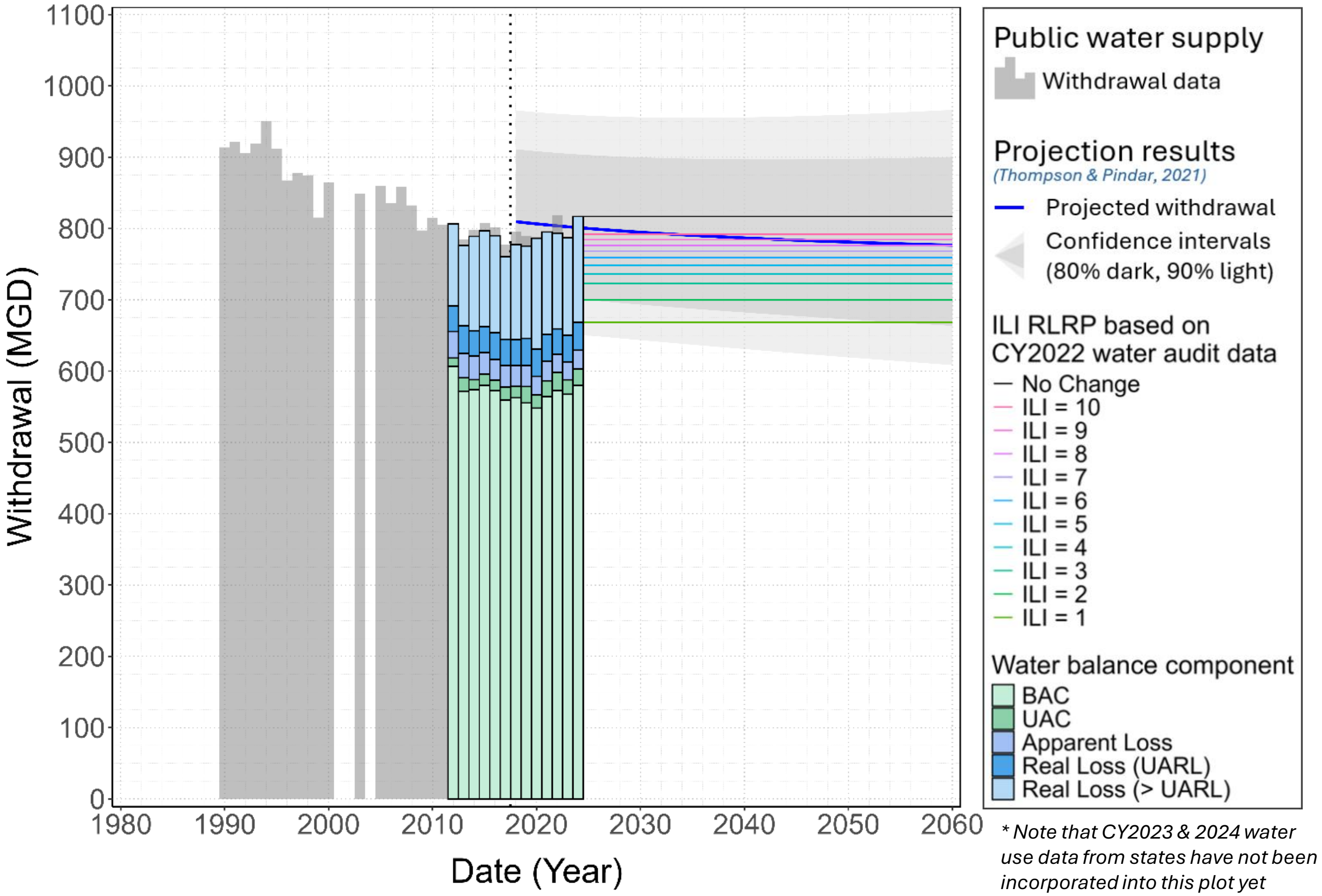


Recall:
UARL =(18*L_m + 0.80*N_c + 25*L_p) * P
ILI = CARL / UARL

RLRP: So what?

> "The decrease in projected withdrawals (based on current operational trends) is equivalent in magnitude to systems above ILI=7 reducing to ILI≈7"

- There is room for improvement e.g. ELL are not included in assessment. ILI=1 not a realistic scenario and ELL analyses may help improve understanding.
- Is it possible the projection may reach an inflection point? Continued population growth outweighs reductions?



** Note that CY2023 & 2024 water use data from states have not been incorporated into this plot yet (grey bars)*

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We never know the Worth of Water, till the Well is dry.

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DRBC website

DRBC audit program

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