

Water and Revenue Losses in Pennsylvania Water Utilities: How Big, How Much and How Do they Compare Nationally?

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PA AWWA Section Annual Loss Conference 2017

Hershey, PA

April 26, 2017

KUNKEL
WATER EFFICIENCY CONSULTING



Natural Resources Defense Council



- Conducting advocacy for improved water audit practices and efficient water loss control operations in drinking water utilities
- Status of State and Regional Agency requirements; see webpage under “Cutting Our Losses” and inter-active map at:
<https://www.nrdc.org/resources/cutting-our-losses>
- Strategic focus on improved practices in PA and NJ

Natural Resources Defense Council



Commissioned studies of PA and NJ water utilities:

- Assess level of losses and cost impacts from utilities that are required to report annual water audit data
- Compare PA utility data with validated data from a North American water audit dataset
- Project the extent of losses and cost impacts for all water utilities in the Commonwealth of PA
- Support informed decision-making by PA regulatory agencies and water utilities about water loss auditing and loss control strategies
- Reports on PA, NJ utilities water audit data available for free download

<https://www.nrdc.org/resources/cutting-our-losses>

Collecting the Data

AWWA Free Water Audit Software Reporting Worksheet (Top Portion)

The Reporting Worksheet is the primary Data Input Worksheet. Input data on this portion of the Reporting Worksheet include::

- Volumes of supply
- Consumption
- Apparent Loss
- Real Loss is calculated
- Data Gradings

AWWA Free Water Audit Software: WAS v5.0
 American Water Works Association.
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Reporting Worksheet

? Click to access definition

+ Click to add a comment

Water Audit Report for: << Please enter system details and contact information on the Instructions tab

Reporting Year:

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

PLEASE CHOOSE REPORTING UNITS FROM THE INSTRUCTIONS SHEET BEFORE ENTERING DATA

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

WATER SUPPLIED

----- Enter grading in column 'E' and 'J' -----

Volume from own sources:	+	?	▼		
Water imported:	+	?	▼		
Water exported:	+	?	▼		

WATER SUPPLIED: 0.000

Master Meter and Supply Error Adjustments

	+	?	▼		
	+	?	▼		
	+	?	▼		

Enter negative % or value for under-registration
Enter positive % or value for over-registration

AUTHORIZED CONSUMPTION

Billed metered:	+	?	▼		
Billed unmetered:	+	?	▼		
Unbilled metered:	+	?	▼		
Unbilled unmetered:	+	?	▼		0.000

Default option selected for Unbilled unmetered - a grading of 5 is applied but not displayed

AUTHORIZED CONSUMPTION: 0.000

Click here: ? for help using option buttons below

	+	?	▼		
	+	?	▼		

Use buttons to select percentage of water supplied OR value

	+	?	▼		
	+	?	▼		

1.25%

	+	?	▼		
	+	?	▼		

0.25%

	+	?	▼		
	+	?	▼		

0.25%

WATER LOSSES (Water Supplied - Authorized Consumption) 0.000

Apparent Losses

Unauthorized consumption:	+	?	▼		
	+	?	▼		

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

Customer metering inaccuracies:	+	?	▼		
Systematic data handling errors:	+	?	▼		

Apparent Losses: 0.000

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: 0.000

WATER LOSSES: 0.000

NON-REVENUE WATER

NON-REVENUE WATER: 0.000

= Water Losses + Unbilled Metered + Unbilled Unmetered

AWWA Free Water Audit Software Reporting Worksheet (Bottom Portion)

Inputs on this portion of the Reporting Worksheet include:

- System Data
- Cost Data
 - System Operating Cost
 - Customer Unit Retail Cost
 - Variable Production Cost
- Data Gradings

SYSTEM DATA

Length of mains:	+	?	7	100.0	miles
Number of active AND inactive service connections:	+	?	6	1,000	
Service connection density:	?			10	conn./mile main
Are customer meters typically located at the curbside or property line?				Yes	(length of service line, beyond the property boundary, that is the responsibility of the utility)
Average length of customer service line:	+	?			
Average length of customer service line has been set to zero and a data grading score of 10 has been applied					
Average operating pressure:	+	?	6	60.0	psi

COST DATA

Total annual cost of operating water system:	+	?	5	\$1,000,000	\$/Year
Customer retail unit cost (applied to Apparent Losses):	+	?	7	\$3.50	\$/1000 gallons (US)
Variable production cost (applied to Real Losses):	+	?	7	\$3,000.00	\$/Million gallons <input type="checkbox"/> Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 60 out of 100 ***

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Volume from own sources

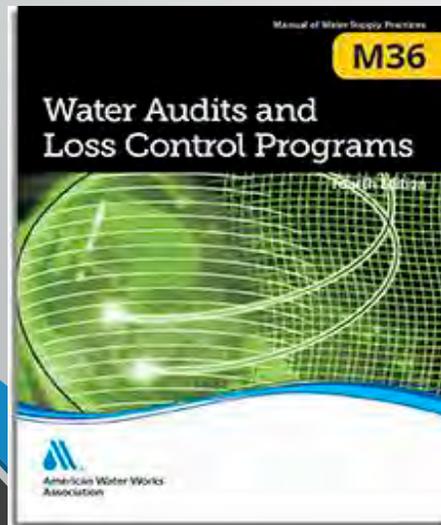
2: Customer metering inaccuracies

3: Total annual cost of operating water system

AWWA Free Water Audit Software Data Grading and Validation

Grading reflects the level of proper management of meters and data

New 4th Edition of
AWWA M36 Manual
provides guidance on
grading all
components entered
into the water audit



AWWA Free Water Audit Software: Reporting Worksheet WAS v5.0
American Water Works Association
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Water Audit Report for: << Please enter system details and contact information on the Instructions tab >>
Reporting Year:

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

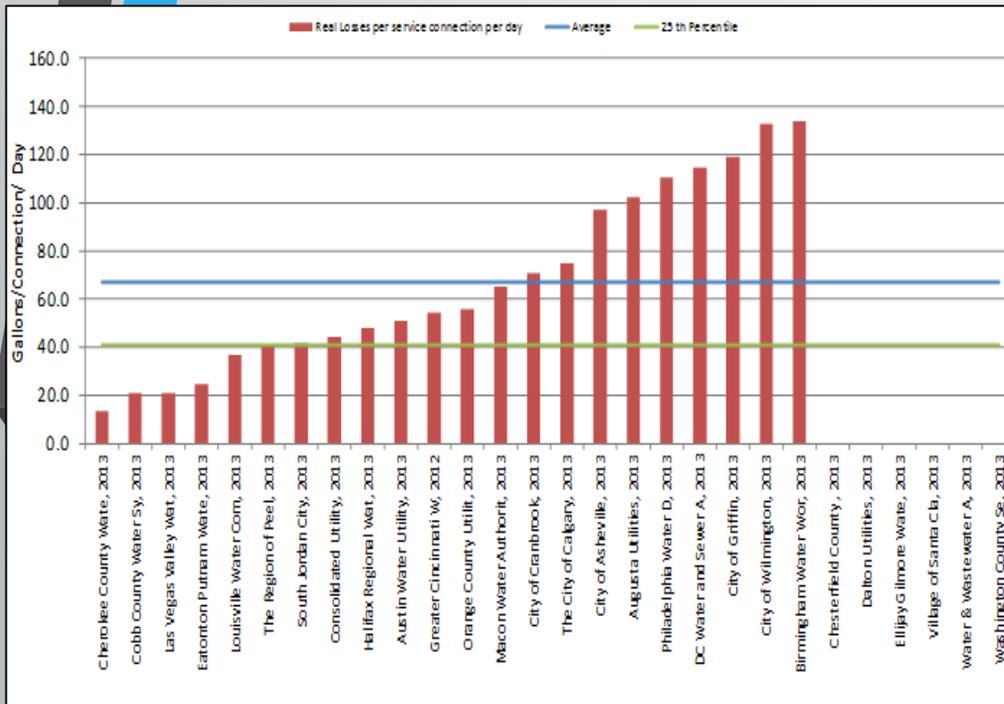
PLEASE CHOOSE REPORTING UNITS FROM THE INSTRUCTIONS SHEET BEFORE ENTERING DATA

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

		Master Meter Error Adjustments	
		Pcnt:	Value:
WATER SUPPLIED	Volume from own sources: <input type="text"/> <input type="text"/>	n/a (not applicable). Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own) 1. Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted. 2. 25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted. 3. Conditions between 2 and 4 4. 50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing or electronic calibration conducted. 5. Conditions between 4 and 6 6. At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy. 7. Conditions between 6 and 8 8. 100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy 9. Conditions between 8 and 10 10. 100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually, with less than 10% found outside of +/- 3% accuracy. Procedures are reviewed by a third party knowledgeable in the M36 methodology.	
	Water imported: <input type="text"/> <input type="text"/>		
	Water exported: <input type="text"/> <input type="text"/>		
WATER SUPPLIED:			
AUTHORIZED CONSUMPTION	Billed metered: <input type="text"/> <input type="text"/>	Enter a positive value, otherwise a default percentage of 1.25% (of billed meters)	
	Billed unmetered: <input type="text"/> <input type="text"/>		
	Unbilled metered: <input type="text"/> <input type="text"/>		
	Unbilled unmetered: <input type="text"/> <input type="text"/>		
AUTHORIZED CONSUMPTION:			
WATER LOSSES (Water Supplied - Authorized Consumption)		0.000	
Apparent Losses			
	Unauthorized consumption: <input type="text"/> <input type="text"/>	0.000	Pcnt: <input type="text"/> <input type="text"/> Value: <input type="text"/>
Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed			
	Customer metering inaccuracies: <input type="text"/> <input type="text"/>	0.000	<input type="text"/> <input type="text"/> <input type="text"/>
	Systematic data handling errors: <input type="text"/> <input type="text"/>	0.000	<input type="text"/> <input type="text"/> <input type="text"/>

AWWA Compiler Software – Easily assembles completed audit reports from multiple water audits into one spreadsheet that generates charts

Charts can reveal notable trends



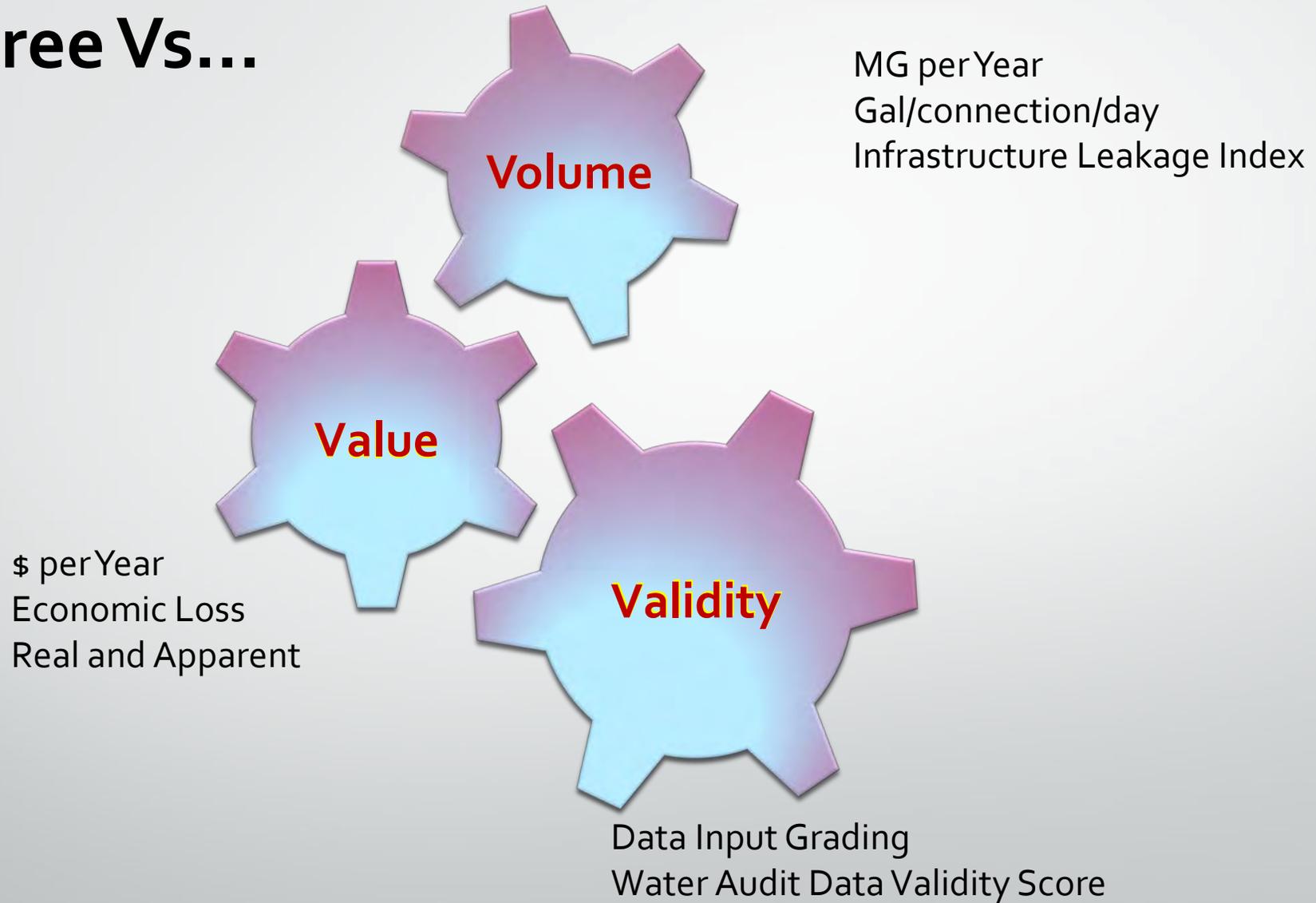
Include on Chart	Run Compiler / View Options Name of City / Utility:	Customer Metering Inaccuracies	Systematic Data Handling Errors	Systematic Data Handling Errors Default Use	Apparent Losses	Real Losses	Water Losses2	Non Revenue Water	Length of Mains	Number of Active and Inactive Service Connection
Yes	City of Asheville	111.220	11.956	Yes	140.844	1,958.789	2,099.633	2,285.180	1236.5	55,256
Yes	Augusta Utilities	202.735	71.603	No	307.087	2,694.886	3,001.973	3,552.620	1213.3	72,235
Yes	Austin Water Utility	828.761	0.001	No	945.924	4,024.607	4,970.531	5,095.921	3707.0	215,960
Yes	Birmingham Water Works Board	557.467	0.001	No	645.000	11,242.159	11,887.159	12,339.569	3941.0	230,018
Yes	The City of Calgary	334.291	82.627	Yes	525.552	8,526.084	9,051.636	9,476.994	3072.7	312,075
Yes	Chesterfield County Rural Water Co., Inc.	6.456	1.598	Yes	9.978	115.171	125.149	130.422	732.0	8,243
Yes	Greater Cincinnati Water Works	308.039	696.500	No	1,096.716	4,873.730	5,970.446	6,972.146	3135.8	246,044
Yes	Consolidated Utility District	17.943	0.300	No	27.152	813.118	840.270	902.268	1301.0	50,510
Yes	City of Cranbrook	0.000	0.000	No	2.798	172.402	175.201	189.193	101.5	6,696
Yes	Cobb County Water System	341.584	16.730	No	404.568	1,347.804	1,752.372	1,764.294	3150.0	178,130
Yes	Dalton Utilities	195.846	15.831	Yes	231.343	1,204.651	1,435.995	1,534.328	1251.0	37,023
Yes	DC Water and Sewer Authority	527.700	1789.500	No	2,449.800	5,621.951	8,071.751	8,748.651	1350.0	134,284
Yes	Ellijay Gilmore Water & Sewer Authority	11.638	1.000	No	15.169	218.215	233.384	283.102	227.0	5,527
Yes	Eatonton Putnam Water and Sewer Authority	2.281	0.511	Yes	5.792	74.506	80.298	101.609	145.0	8,350
Yes	City of Griffin	18.795	1.798	Yes	23.769	510.230	533.999	551.539	212.7	11,733
Yes	Halifax Regional Water Commission	129.981	0.264	No	158.629	1,504.514	1,663.143	1,763.626	1017.2	85,957
Yes	Las Vegas Valley Water District	2638.000	100.000	No	2,998.997	3,025.078	6,024.075	6,030.775	4515.0	397,526
Yes	Louisville Water Company	973.100	150.000	No	1,123.200	4,123.662	5,246.862	7,839.099	4156.0	306,079
Yes	Macon Water Authority	119.744	6.252	No	132.247	1,551.136	1,683.383	1,779.733	1400.0	65,200
Yes	Orange County Utilities Department	104.165	32.920	No	191.107	1,841.418	2,032.525	2,144.747	1745.5	90,402
Yes	Philadelphia Water Department	1490.200	3579.300	No	7,495.000	21,267.500	28,762.500	30,721.500	3178.0	527,205
Yes	The Region of Peel	725.152	1.321	No	855.072	4,717.505	5,572.577	6,079.497	2793.9	315,617
Yes	Village of Santa Clara	1.254	0.250	No	1.740	20.613	22.353	24.947	25.0	752
Yes	South Jordan City	63.709	9.664	Yes	84.822	289.389	374.211	714.143	333.0	19,074
Yes	City of Wilmington	171.726	500.000	No	701.726	1,832.707	2,534.433	2,631.175	410.0	37,751
Yes	Water & Wastewater Authority of Wilson County	5.228	0.020	No	6.170	58.944	65.114	66.494	326.5	7,052
Yes	Washington County Service Authority	14.449	3.485	Yes	24.269	1,047.489	1,071.758	1,139.856	852.5	22,500
Yes	Cherokee County Water & Sewerage Authority	87.701	4.162	Yes	103.643	310.021	413.664	549.551	1234.2	62,708

Water Audit Data Quality Characterization

- There are five categories of data quality which are defined here:
 - **Self-reported** – data and accompanying data quality grading has been compiled into a completed AWWA water audit report, but has not been subject to any in-depth review
 - **Filtered** – One or more completed audit reports have been checked for technical plausibility by employing simple screening criteria, such as losses are less than zero.
- Data validation consists of in-depth review of the data sources and practices of the water utility
 - **Level 1 validated** - focuses primarily on the suitability of the data gradings assigned to the various inputs, with scrutiny on the data inputs to flag gross or egregious errors
 - **level 2 validated** - in-depth investigation of various input data and information of one or more components of the water audit. This is still largely a desk-top activity.
 - **level 3 validated** - Bottom-up review and investigation into a single component or sub-component that collects new or additional data at a field/source level, and provides detailed analysis

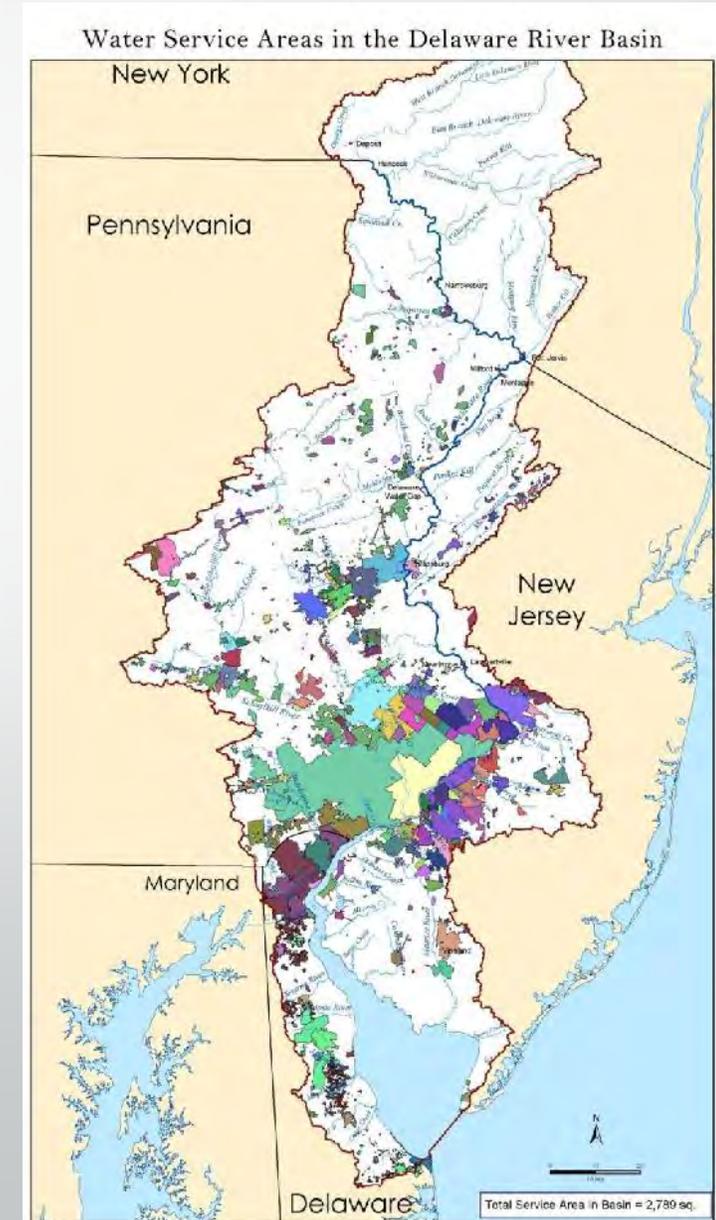
How to Assess Water Loss and Its Impacts?

Three Vs...



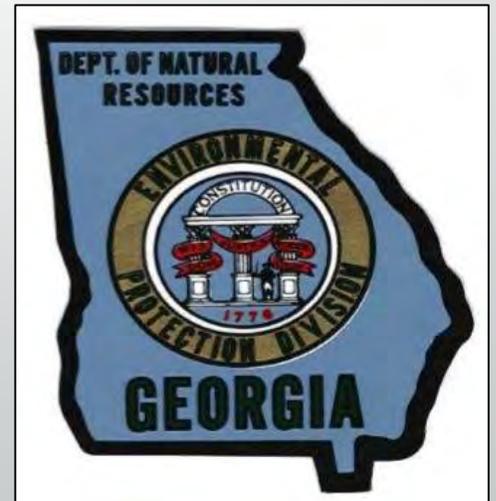
Pennsylvania Water Audit Data Collection

- Delaware River Basin Commission
 - Water Audit collected since 2012
 - Applies to all utilities in the Delaware River Basin
 - Data is *filtered* by DRBC Staff
 - High level data analysis is conducted by DRBC Staff and compiled in a summary report
- PA Public Utility Commission
 - Since 2009
 - Applies to privately held water companies
 - Data is publicly available in *self-reported* form on PUC website
- Combined filtered PUC/DRBC dataset includes **155 utilities** for data from 2013
- No water audit requirement exists for many water utilities in PA



North American Water Audit Dataset

- AWWA – National Water Loss Control Committee
 - Water Audit Data Initiative (WADI)
 - WADI data from 2013 for 20 water utilities used in this analysis
- State of Georgia
 - Data collection required by Water Stewardship Act (2009)
 - First state to require extensive training for water utilities and Level 1 data validation
 - data from 2013 for 226 water utilities used in this analysis
- WADI and GA data were combined to assemble a master dataset of validated water audit data for 246 utilities
 - Data units were converted as needed for consistent volume and cost comparisons



Placing a Cost Value on Water Losses

- Apparent Losses: Customer losses from:
 - Customer Metering Inaccuracies
 - Unauthorized Consumption
 - Systematic Data Handling Error in Customer Billing Systems
 - These losses are valued at the price of revenue billed to the customer: the Customer Retail Unit Cost (CRUC)
- Real Losses: leakage and storage tank overflows
 - In Pennsylvania and most places, these losses are valued at the Variable Production Costs (VPC), or cost to produce the next million gallons of supplied water
 - For water systems that import supplied water, the VPC = Imported water unit cost
 - In areas where source water resources are stressed and/or the ability to meet future water demands is questionable, then it is appropriate to value real losses at the CRUC

Comparing PA Water Utilities with the North American Dataset

- How do PA Utilities stack up against systems across the USA and Canada?
- Remember:
 - The North American data has been Level 1 Validated
 - The PA data has not been validated

Data Validity Score (DVS)

Measure of “trustworthiness” of the data

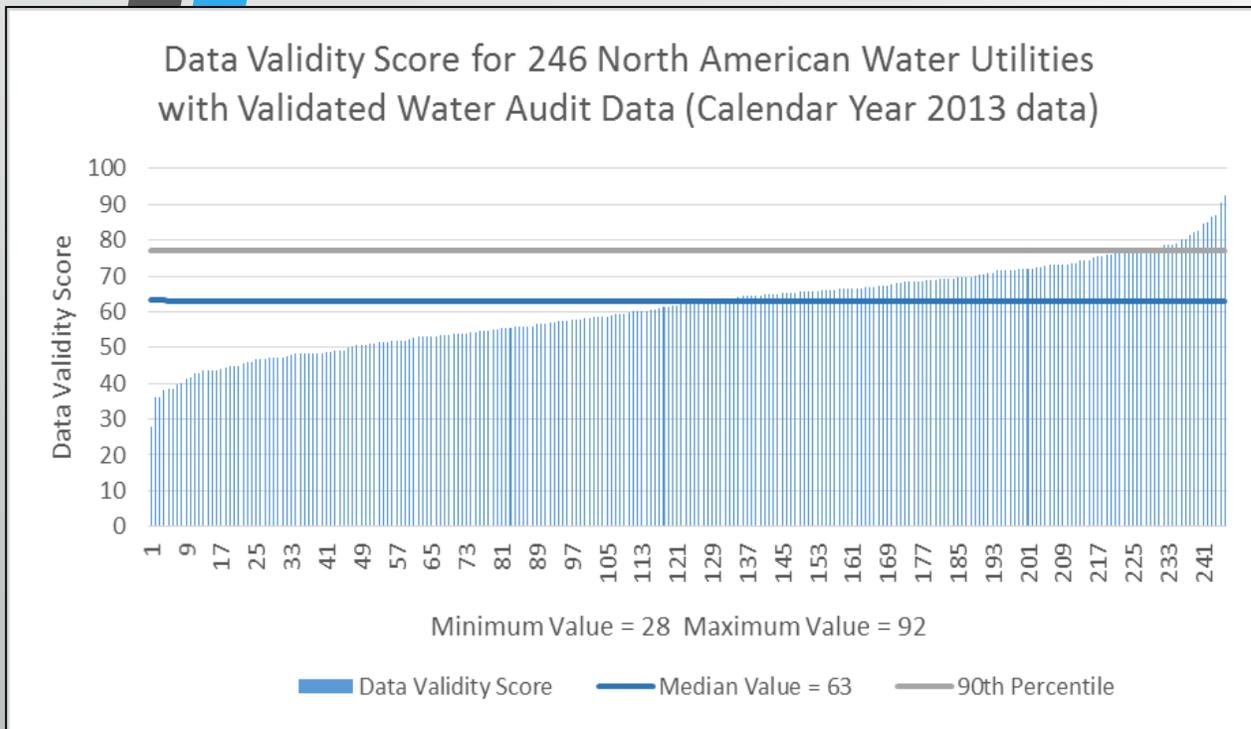


Figure 1 Data Validity Score (DVS) for NA Dataset

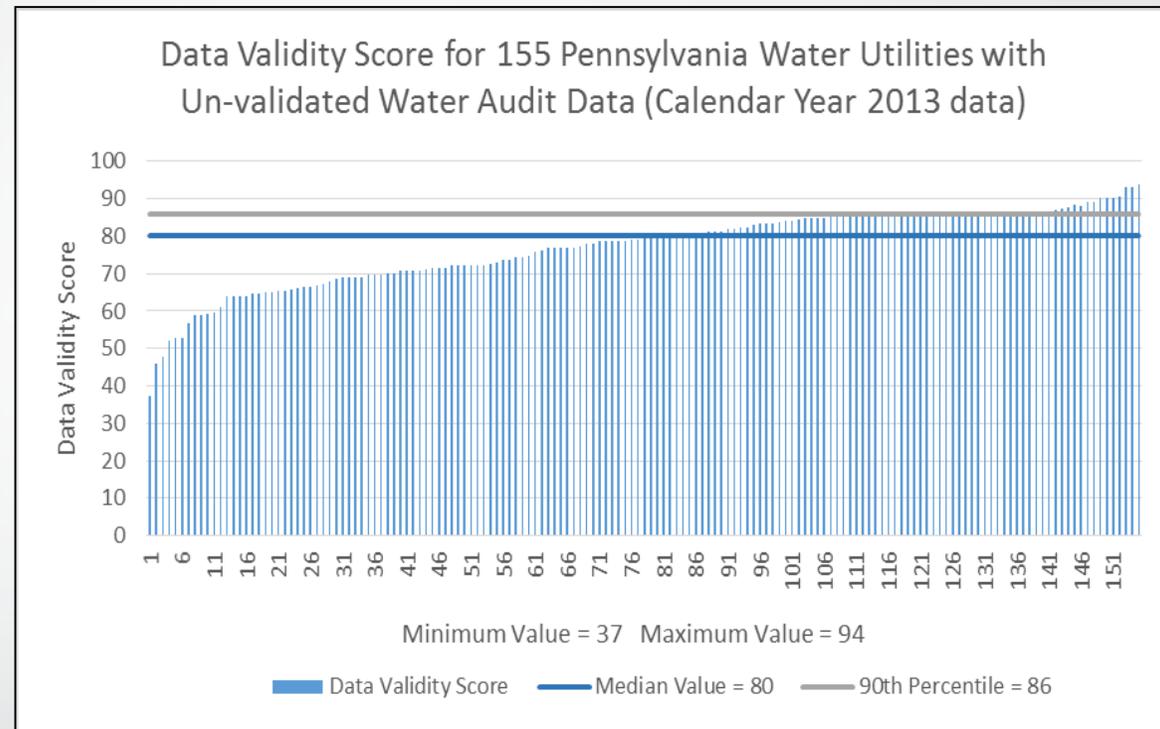


Figure 2 Data Validity Score (DVS) for PA Dataset

Median Data Validity Score (DVS)

North American Dataset – 63 PA Dataset – 80

Is the PA data of higher quality than the NA data, or are PA utilities simply giving themselves better grades?

Apparent Loss Rates, gal/service connection/day

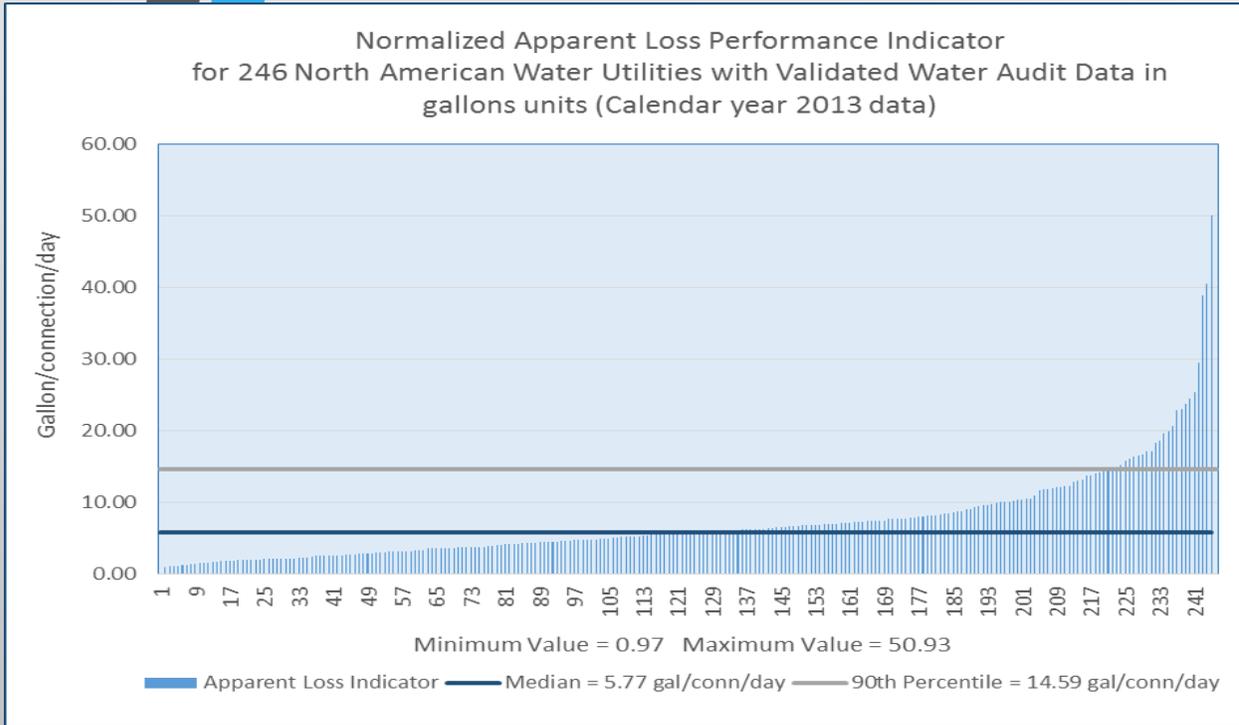


Figure 3 Normalized Apparent Losses for NA Dataset

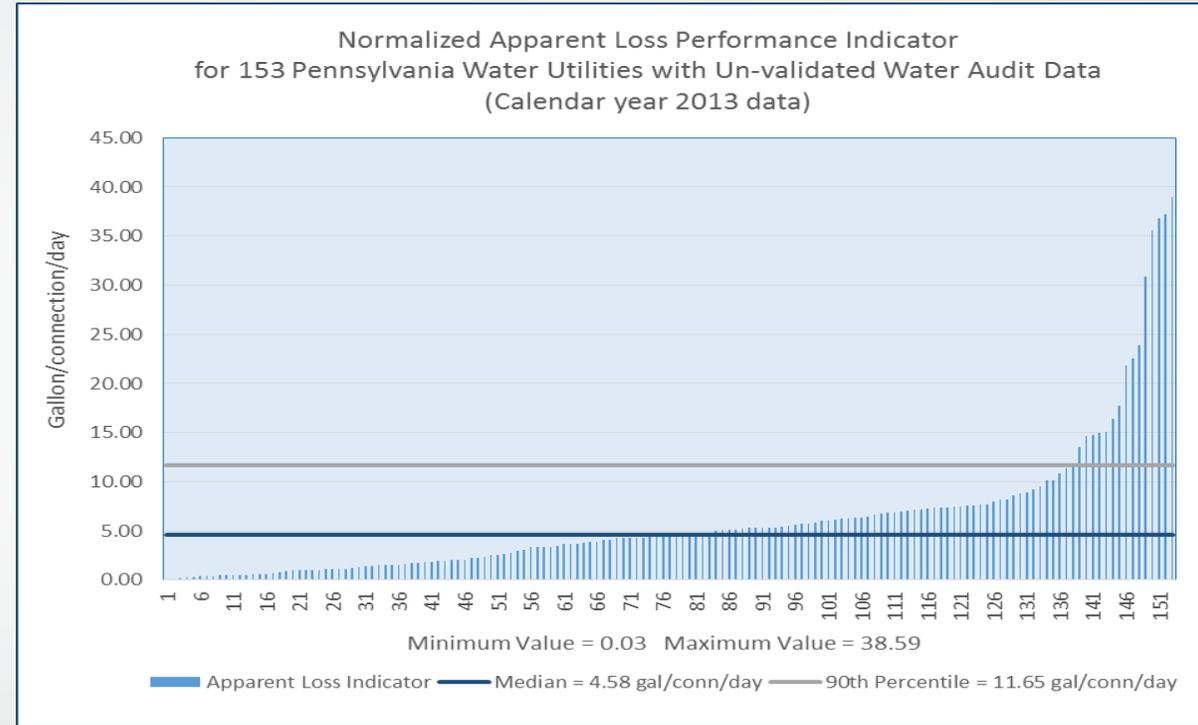


Figure 4 Normalized Apparent Losses for PA Dataset

Median Values of Normalized Apparent Loss Rates

North American Dataset – 5.77 gal/conn/day PA Dataset – 4.58 gal/conn/day

Do PA utilities have lower apparent losses than other utilities?

Customer Retail Unit Cost, dollars per 1,000 gallons

Customer Retail Unit Cost, \$ (US) per 1,000 gallons, for 246 North American Water Utilities with Validated Water Audit Data (Calendar Year 2013 data)

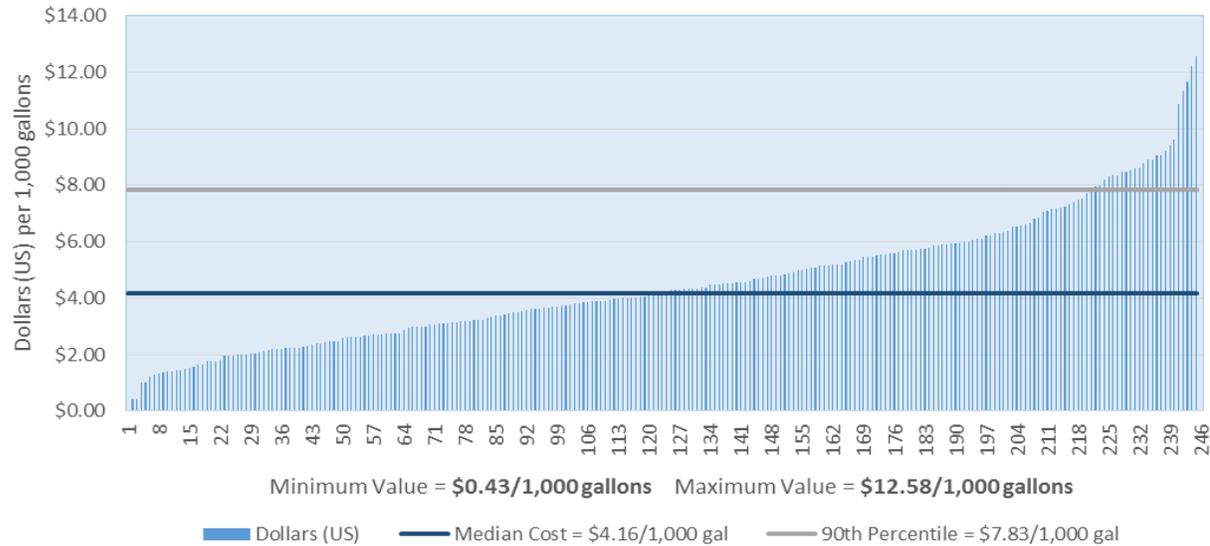


Figure 5 CRUC rate for NA Dataset

Customer Retail Unit Cost, \$ (US) per 1,000 gallons, for 151 Pennsylvania Water Utilities with Un-validated Water Audit Data (Calendar Year 2013 data)

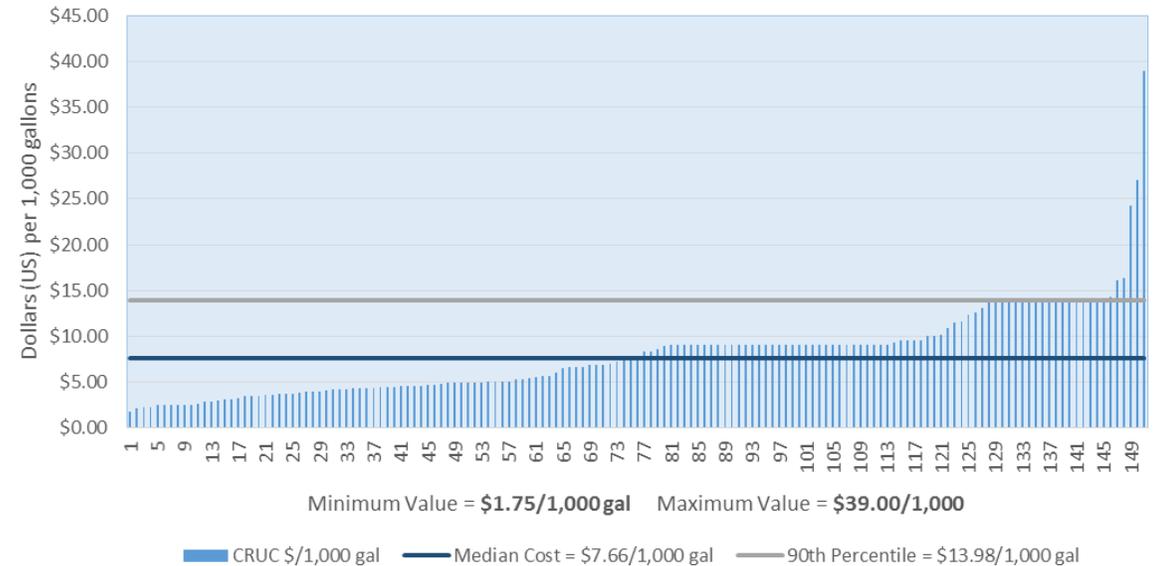


Figure 6 CRUC rate for PA Dataset

Median Values of Customer Retail Unit Cost Rate

North American Dataset – \$4.16/1,000 gal PA Dataset – \$7.66/1,000 gal

PA utilities appear to charge notably more than other utilities.

Real Loss Rates (Leakage and Tank Overflows)

(gallons/service connection/day)

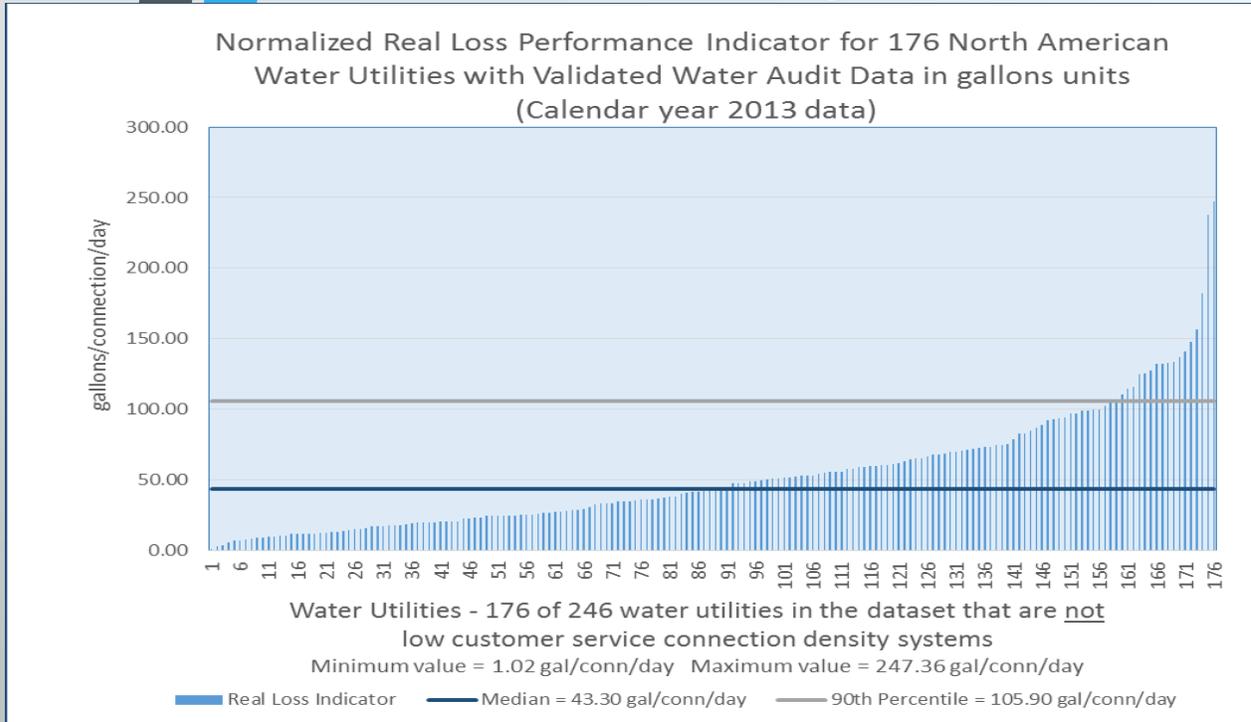


Figure 7 Normalized Real Losses for NA Dataset

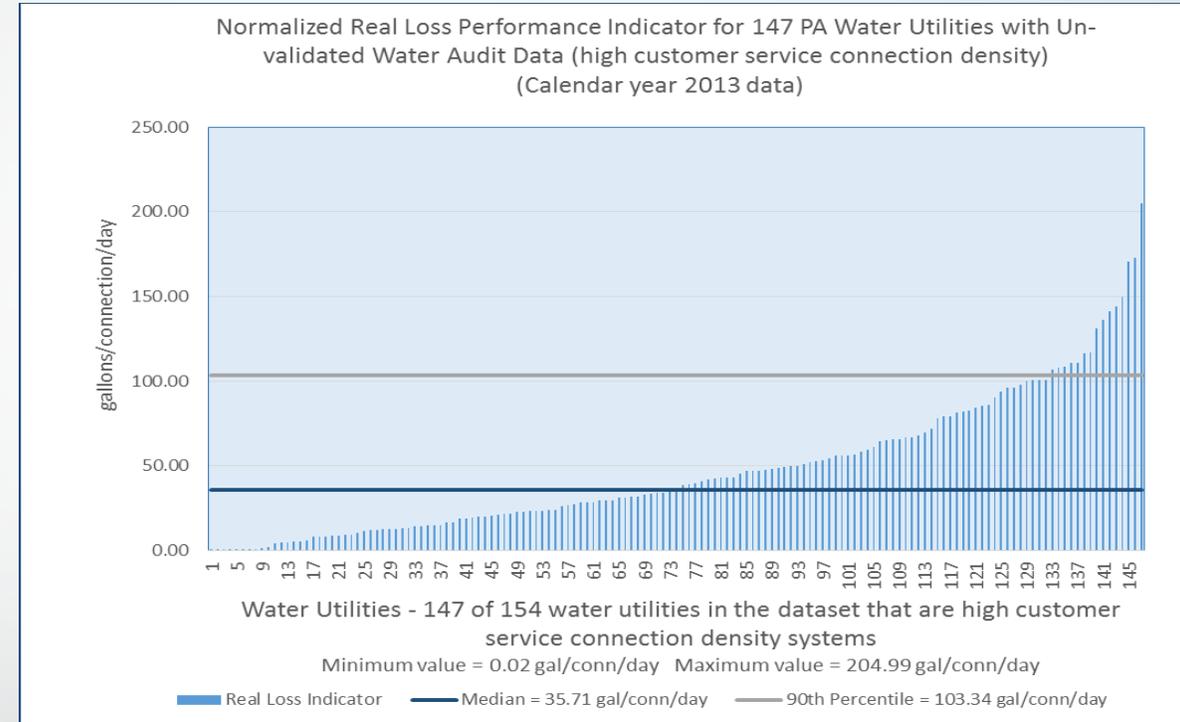


Figure 8 Normalized Real Losses for PA Dataset

Median Values of Normalized Real Loss Rate
 North American Dataset – 43.30 gal/conn/day PA Dataset – 35.71 gal/conn/day
Do PA utilities leak less than NA water utilities?

Variable Production Cost, (dollars per million gallons)

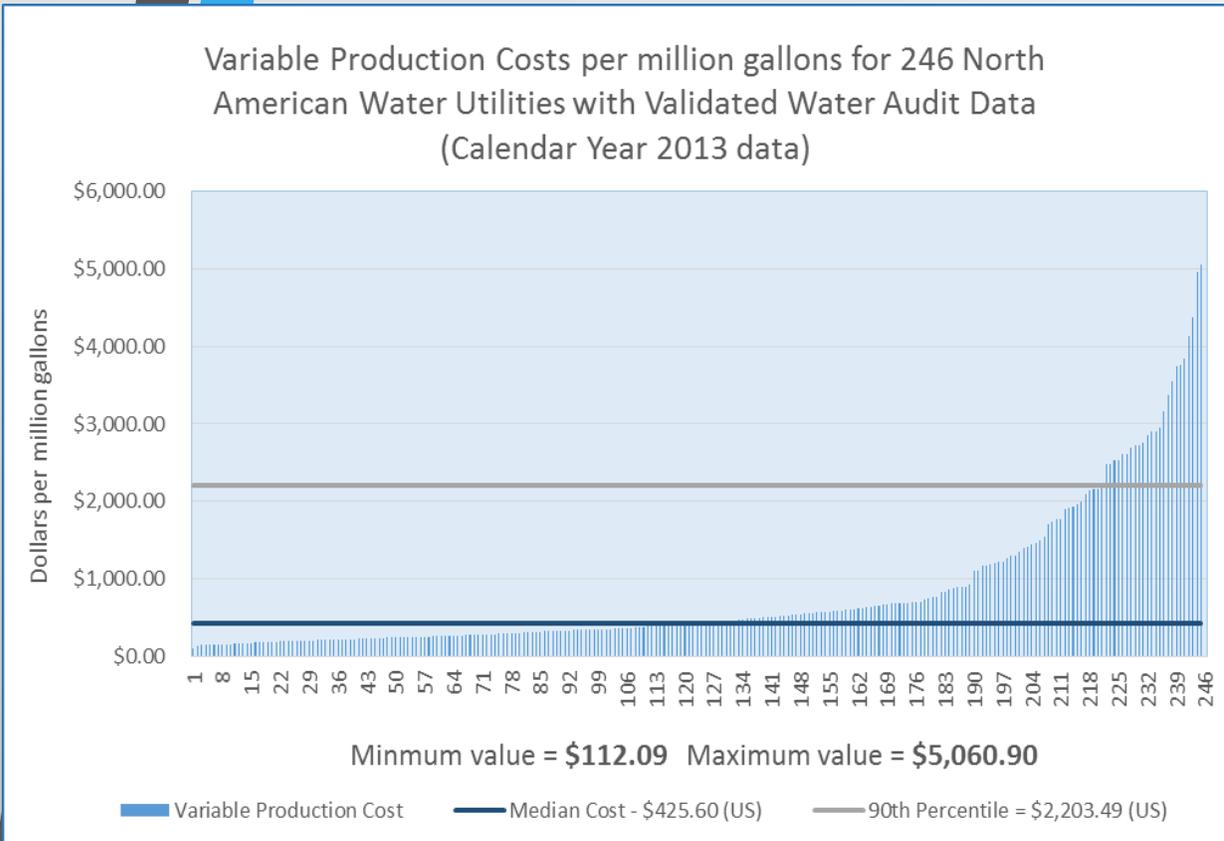


Figure 9 VPC rate for NA Dataset

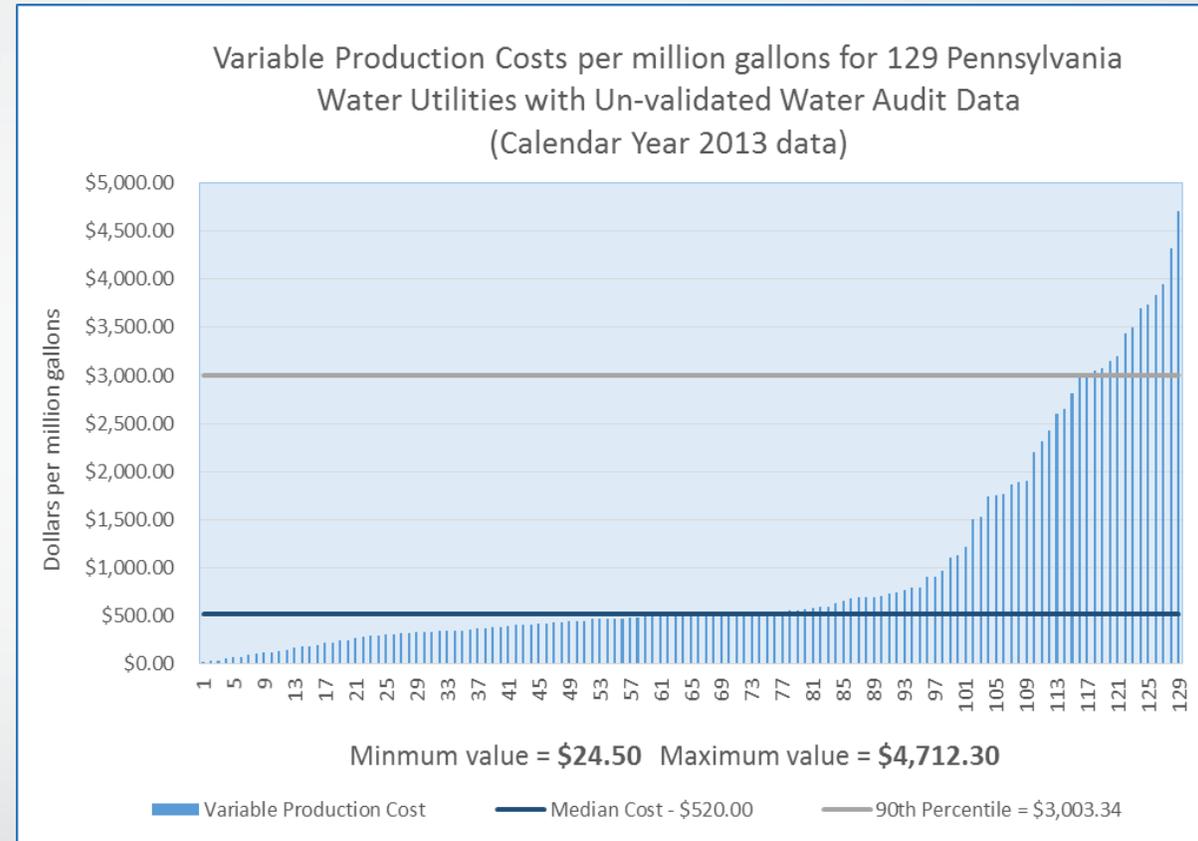


Figure 10 VPC rate for PA Dataset

Median Values of Variable Production Cost (VPC) Rate

North American Dataset – \$425.60/million gal PA Dataset – \$520.00/million gal

Drinking water appears to be more costly to produce in PA than across NA

Average System Pressure

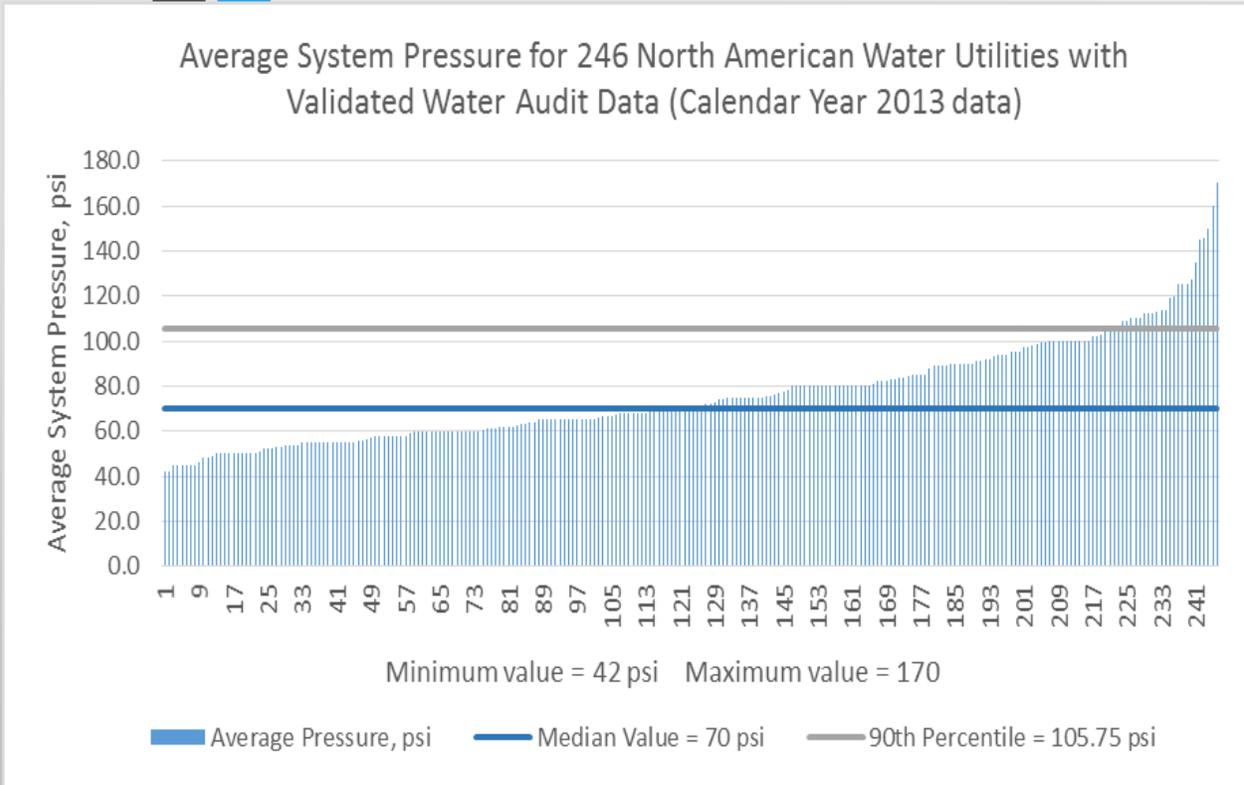


Figure 11 Average Pressure for the NA Dataset

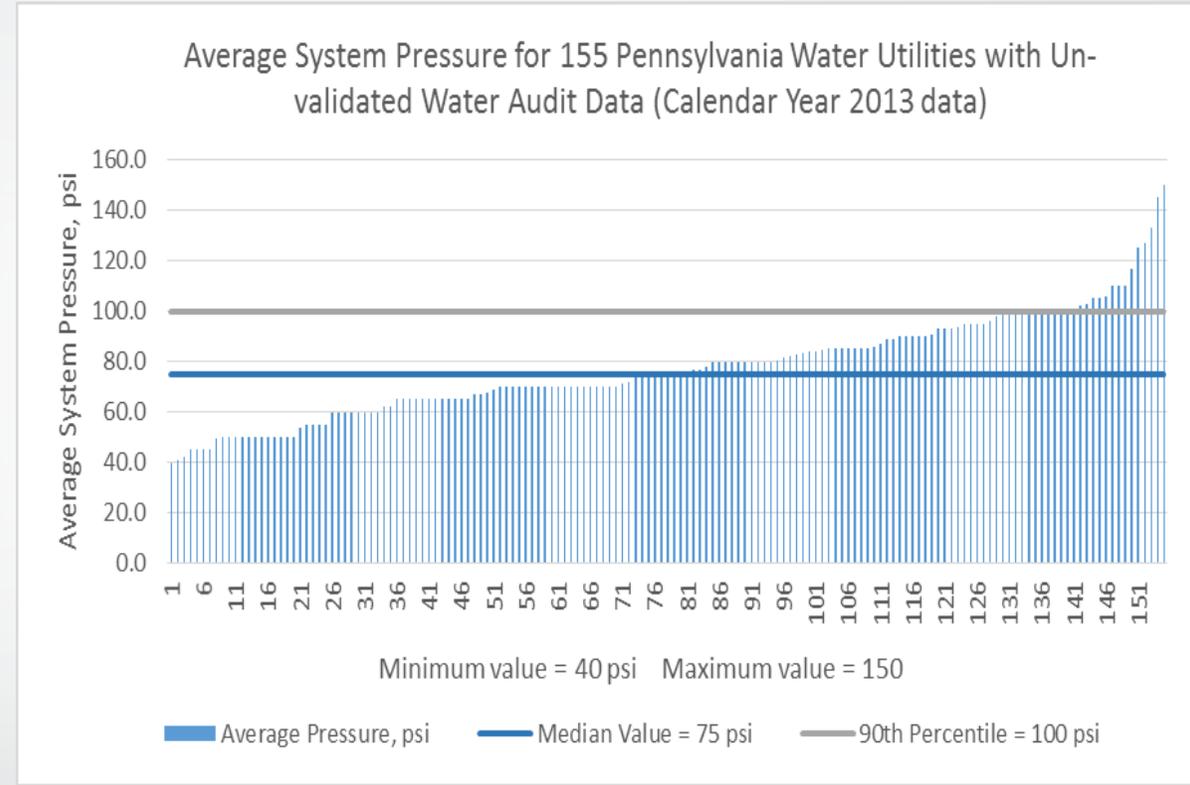


Figure 12 Average Pressure for the PA Dataset

Median Values of Average System Pressure

North American Dataset – 70 psi PA Dataset – 75 psi

Average system pressures in PA are similar to utilities across NA

Assembling Projections for Losses and Costs for all Pennsylvania Water Utilities

Devising a “loss cost rate indicator”

- Apparent loss rate (gal/conn/day) x CRUC (\$/1,000 gal) x units conversion factor gives a measure in ***\$/connection/day***
- Real loss rate (gal/conn/day) x VPC (\$/million gal) x units conversion factor gives a measure in ***\$/connection/day***
- Utilities with a relatively high loss cost rate have a combination of high loss volume and high production and/or retail costs; these systems could benefit most significantly from improved loss control efforts
- Losses for systems with loss cost rates above the median of the dataset were taken to have losses that could be economically recovered

Findings: Assessment of 155 Audited PA Water Utilities

Water Audit Data and Estimated Economically Recoverable Amounts

Component	Value
Apparent Losses Volume	11,220 mg (30.7 mgd)
Apparent Losses Value	\$92.50 million
Apparent Losses – Estimated Economically Recoverable Volume	8,461 mg (23.2 mgd)
Apparent Losses – Estimated Economically Recoverable Value	\$67.03 million
Real Losses Volume	56,203 mg (154 mgd)
Real Losses Value	\$23.40 million
Real Losses – Estimated Economically Recoverable Volume	17,888 mg (49 mgd)
Real Losses – Estimated Economically Recoverable Value	\$10.71 million

By volume, real losses are 5 times greater than apparent losses, but, by cost, apparent loss costs are 4 times greater than real loss costs

Findings: Projections of Statewide Losses & Potential Savings

Water Audit Data and Estimation Economically Recoverable Amounts

Component	Value
Apparent Losses Volume – statewide	23,842 mg (65.3 mgd)
Apparent Losses Value – statewide	\$196.50 million
Apparent Losses – Estimated Economically Recoverable Volume – statewide	17,968 mg (49.2 mgd)
Apparent Losses – Estimated Economically Recoverable Value – statewide	\$138 million
Real Losses Volume – statewide	119,313 mg (327 mgd)
Real Losses Value – statewide	\$49.7 million
Real Losses – Estimated Economically Recoverable Volume – statewide	37,988 mg (104.1 mgd)
Real Losses – Estimated Economically Recoverable Value - statewide	\$19.8 million

SUMMARY

- Using standardized water audits, PA utilities were compared with North American utilities
- This study found lower reported loss levels in PA utilities, as well as higher costs, but:
 - PA data is not validated, but was compared to a validated NA dataset: **validation is important!**
- Data for 155 PA utilities reveals significant water and revenue losses. Projections of recoverable losses for all PA water utilities suggest:
 - *17.9 billion gal/year (49 mgd) of apparent losses, costing almost \$138 million annually in missing revenue*
 - *38 billion gal/year (104 mgd) of real losses, costing \$19.8 million annually in excessive production and purchased water costs*
- Greater reporting consistency can be achieved if PA DEP and the Susquehanna River Basin Commission (SRBC) adopt the AWWA Water Audit methodology for annual reporting of water loss, as DRBC and PA PUC have done.

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