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REPORT ON THE EVALUATION OF WATER AUDIT DATA FOR NEW JERSEY WATER UTILITIES

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1. INTRODUCTION

This report assesses data collected from those water utilities in the State of New Jersey (NJ) that are required to report water audit data in a standard format to the Delaware River Basin Commission (DRBC). This report is a companion report to a similar assessment that was conducted for water audit data from Pennsylvania (PA) water utilities.[1]

Non-revenue water (NRW) consists of real (leakage) losses and apparent (revenue) losses, and occurs in all drinking water utilities to varying degrees. For many years, water industry efforts to assess and control losses, primarily using "unaccounted-for" water (UAW) terminology, were simplistic and ineffective. Concerted work by the American Water Works Association (AWWA) and International Water Association (IWA) since 2000 has produced a rational methodology to assess and characterize losses and their impacts. Additionally, a host of innovative technologies has been developed to economically control losses. Significant work has since created many useful tools based upon the AWWA methodology for auditing water supplies and many newer methods and technologies for controlling losses. These best practices are defined in the leading AWWA M36 guidance manual *Water Audits and Loss Control Programs*, 4th ed. (2016) with data collected using the AWWA Free Water Audit Software, v5.0 (2014), and the AWWA Compiler Software, v5.0 (2014).

In the United States, a number of state and regional water agencies have grasped these methods and tools and have implemented new regulations that require water utilities to audit and report water supply and loss volumes. At this time AWWA water audit data must be reported to DRBC by PA, NJ, New York (NY), and Delaware (DE) water utilities that exist within the Delaware River Basin. In NJ there are no requirements for water utilities to report water audit data in the AWWA format to the NJ Department of Environmental Protection, or (for investor-owned utilities, or IOU) to the NJ Board of Public Utilities.[2] These two agencies have in place very cursory reporting requirements for water audit data, which are based primarily in the dated, UAW method. Thus, the majority of water utilities in NJ are not required to report water audit data in the AWWA format. Inconsistent reporting processes therefore exist in NJ, with a number utilities required to submit water audit data in the AWWA format to DRBC, while the remaining water utilities must report such data primarily in the UAW format to the other two regulatory agencies in the state.

[1] Kunkel Water Efficiency Consulting, *Report on the Evaluation of Water Audit Data for Pennsylvania Water Utilities*, November 2016.
[2] NJDEP does mention the AWWA Water Audit Method in its report "Water Conservation and Drought or Water Supply Emergency Management Plan Report for Public Water Supply Systems", and notes that this limited reporting can optionally be submitted as information in addition to the unaccounted-for water submittal.

This report discusses the results of work conducted by Kunkel Water Efficiency Consulting (KWEC) to analyze water audit data collected using the AWWA Water Audit Free Water Audit Software from NJ water utilities and compare it to AWWA water audit data collected and validated by knowledgeable water auditors in a standardized manner. All data was collected for calendar year 2013, the most recent year for which data was available for all of the datasets.

The report provides a general assessment of the water audit data collected from NJ utilities by DRBC and compares this data with datasets of validated water audit data from the State of Georgia and the AWWA Water Audit Data Initiative (WADI). This work was conducted under four parts, including:

1. An evaluation of the quality of data used in water audits reported to DRBC and the accuracy of utilities' data validity scores.
2. An evaluation of DRBC-regulated utilities' reported performance with respect to each component of non-revenue water, in comparison to reported performance of utilities in the validated datasets.
3. An evaluation of DRBC-regulated NJ utilities' reported performance with respect to system pressure levels and other factors influencing water loss, in comparison to reported performance of utilities in the other validated datasets.
4. Development of estimates of potentially recoverable losses (water, revenue) in DRBC-regulated NJ utilities and the extrapolation of these estimates to loss levels and recoverable water and revenue statewide.

A summary of the findings of these assessments is listed in Tables 1 and 2.

Table 1 Summary of Findings: Evaluation of 2013 Water Audit Data Reported by New Jersey Water Utilities in the Delaware River Basin

Parameter	Value
Apparent losses reported	790 mg (2.1 mgd)
Estimated economically recoverable apparent losses	287.7 mg (0.79 mgd)
Estimated recoverable annual revenue from economically recoverable apparent losses	$1,244,507
Real losses reported	5,421 mg (14.8 mgd)
Estimated economically recoverable real losses	2,241 mg (6.14 mgd)
Estimated annual production cost savings from economically recoverable real losses	$2,311,531

Table 2 Estimates of Statewide Losses and Potential Savings

Parameter	Value
Apparent loss estimate	6,898 mg (18.9 mgd)
Estimated economically recoverable apparent losses	2,515.2 mg (6.9 mgd)
Estimated recoverable annual revenue from economically recoverable apparent losses	$12,576,000
Real losses estimate	47,383 mg (129.8 mgd)
Estimated economically recoverable real losses	19,591 mg (53.7 mgd)
Estimated annual production cost savings from economically recoverable real losses	$10,128,500

2. ANALYSIS COMPARING WATER AUDIT DATA OF NEW JERSEY WATER UTILITIES WITH THE COMBINED AWWA WADI/STATE OF GEORGIA DATASET

The primary work of this study was to provide a general assessment and comparison of the water audit data collected by NJ water utilities (**NJ Dataset**) vs. data from water utilities across North American (**NA Dataset**). The water audit data of the NJ Dataset was gathered by the Delaware River Basin Commission (DRBC) and has not been validated. The NA Dataset was collected by the State of Georgia Department of Natural Resources – Environmental Protection Division and the AWWA Water Audit Data Initiative (WADI). All data was submitted in the AWWA Free Water Audit Software and is from calendar year 2013 (the most recent year of published data from GA). The charts presented herein are in US customary units and in US dollars. Units for customer retail rate are in $/1,000 gallons rather than $/1,000 cubic feet, for consistency among the water utilities in the datasets.

An initial assessment of the data and performance indicators of NJ utilities was conducted in order to identify any data that exists outside of reasonably expected range of value. This process is considered a data "filtering" exercise. DRBC Staff routinely does provide a filtering quality control function for the utilities reporting water audit data; however, this analysis identified a small portion of additional data that needed to be filtered from the dataset, as described below. The 2013 DRBC dataset included 89 water audits from NJ water utilities. Water audits that were excluded from further analysis are listed below:

1. Merchantville – two water audits (duplicates) from 2012, as well as a valid water audit for 2013, existed in the DRBC dataset. The two 2012 water audits were excluded.
2. Water audits for 5 utilities were listed twice in the DRBC dataset and the duplicates were excluded (Millville, Woodbury, Mantua Twp., Vineland, and Westville)
3. Water audits from 6 utilities were excluded due to irrational/omitted data, including:

a. Incorrect volumetric units of measure (data was 1×10^6 too high), including Washington Twp. MUA and Haddon Township Water Department

b. No volumetric data was entered for the water audit for the Township of Allamuchy

c. Negative water losses existed for two water audits: Medford Township and Andover Borough

d. Virtually zero authorized consumption was entered, and 100% NRW by volume was calculated for Fairview Manor – Cumberland County; a small system with only 320 customer service connections. This systems also reported a Total Annual Cost of Operating the Water System of only $15,000 for the year of 2013.

A total of 13 (15%) water audits were excluded from the group of 89 NJ systems included in the DRBC dataset, leaving 76 water audits that were included in the analysis. For analysis of specific parameters, additional water utilities were deleted due to the existence of questionable data for the specific parameter included in the specific analysis.

Data presentations (charts) show values from the utilities in the datasets, but the utilities are anonymized. Median values of the utility data are shown, along with 90th percentile values (the level at which 10% of the values are higher). Average values are not shown since averages can differ notably from the median if extreme values exist in the data. The median is a better indicator of central tendency in this data.

Four small systems failed to report a value for Customer Retail Unit Cost (CRUC). All of these systems may supply housing developments, or grouped communities of homes or resort properties, which likely do not bill customers based upon water consumption. Instead property owners in these communities may pay for water through a periodic fixed fee included in a community owners fee, or similar charge. It is positive to note that all utilities in the NJ Dataset reported the key values of Volume from Own Sources/Water Imported, Authorized Consumption, and Total Cost of Operating the Water System.

As a final observation, it is noted that 24 of 76 NJ utilities (32%) report a very low (0.100 mg) or zero value of Systematic Data Handling Error, which illustrates that water utilities do not have a strong understanding of the meaning of this component, and, perhaps, are not very engaged with their customer billing operations. The current version 5.0 of the AWWA Free Water Audit Software includes the option of entering a default quantity for this component, so utilities should now be better populating this field. A default value was not available for the utilities in 2013, when Version 4.2 of the AWWA Software was in use, and the subject data was collected.

Several miscellaneous data errors also occurred in the data and reflected data quality issues. These are discussed under the specific data presentations in which they occurred in the discussion that follows.

The analysis work included four sub-components (Parts 1-4) and findings for each are presented below.

Part 1: Data Validity

Figure 1 plots the Data Validity Score (DVS) from the AWWA Free Water Audit Software for the utilities of the NA Dataset, while Figure 2 plots the DVS for the utilities in the NJ Dataset.

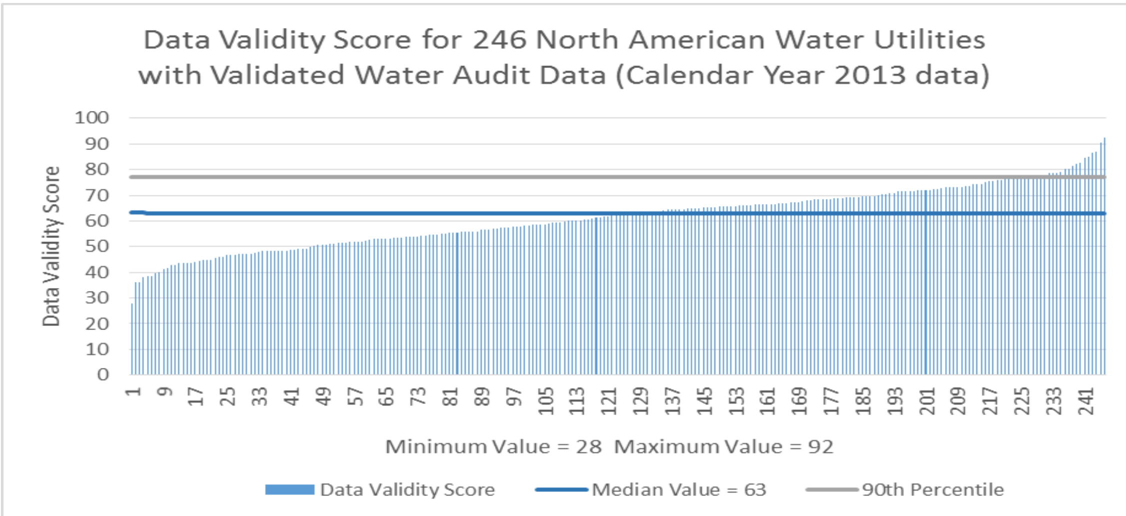

Figure 1 Data Validity Score (DVS) for NA Dataset

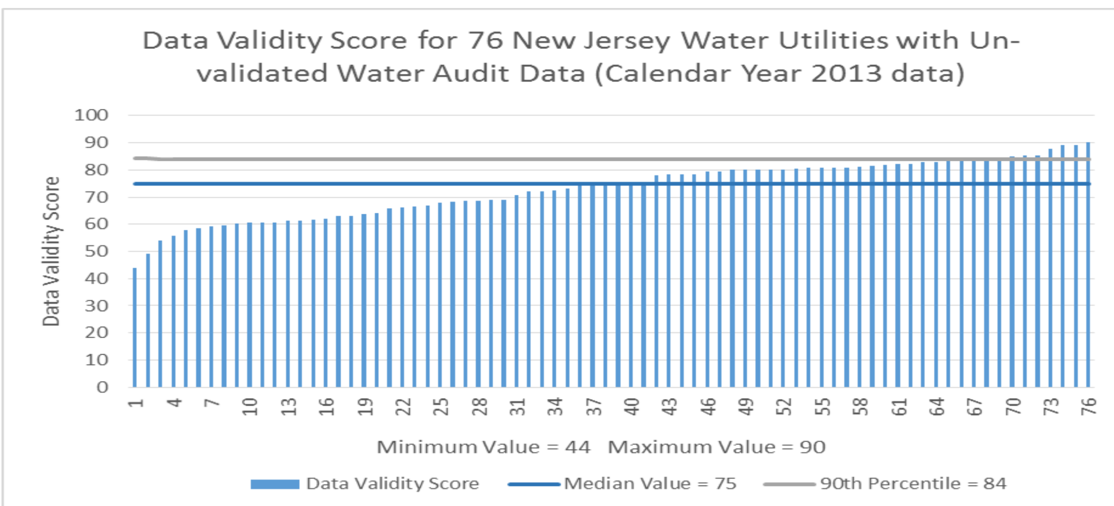

Figure 2 Data Validity Score (DVS) for NJ Dataset

Figure 2 shows a median value of 75 for the utilities in the NJ Dataset, which is notably higher than the NA Dataset median value of 63. Water auditing practitioners have consistently observed that self-reported (unvalidated) water audits contain higher data gradings and higher Data Validity Scores than validated data. This was confirmed in research work conducted as part of the project *Water Audits in the United States: A Review of Water Losses and Data Validity*, published by the Water Research Foundation. The validation process, a quality control process, usually results in reduced gradings since a notable amount of self-reported water audit components are graded at overly-generous levels by utility auditors. This notable difference in median DVS values serves as a strong message in support of data validation in NJ. An additional observation regarding data grading found that the median DVS is 81 for 20 IOU utilities (12 from New Jersey American Water Company, 6 from Aqua New Jersey, and 2 from United/Suez), notably higher than the value of 75 for the entire list of 76 NJ water audits.

Part 2: Non-Revenue Water Comparisons

<u>Apparent Losses</u>**:** Figure 3 plots the value of apparent losses as measured by the Normalized Apparent Loss performance indicator in units of gallons/service connection/day for the NA Dataset, while Figure 4 gives the same presentation for the NJ Dataset.[3]

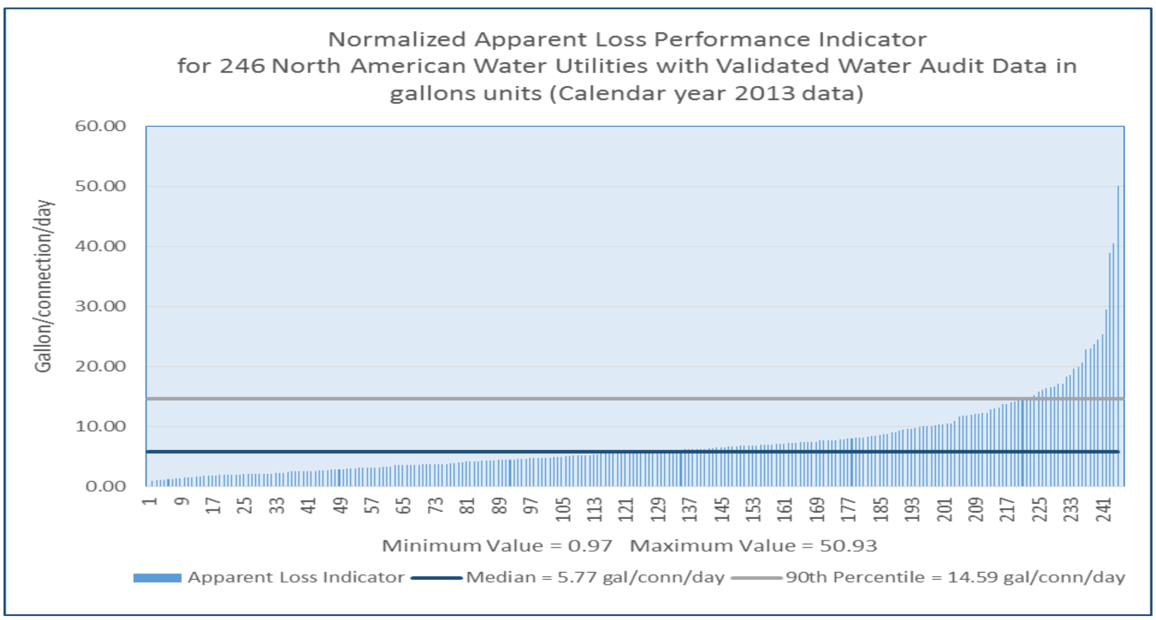

Figure 3 Normalized Apparent Losses for NA Dataset

The median normalized apparent loss rate for the NA Dataset is 5.77 gal/connection/day, while the median rate for the NJ Dataset is 3.24 gal/connection/day. This is a very low value, and the apparent

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[3] Dividing a utility's losses by the number of service connections in its system allows for more useful evaluation of water loss volume data from both large and small utilities.

loss volume for the NJ Dataset is lower than the volume of Unbilled Authorized Consumption: a very unusual occurrence. Additionally, 13 of 76 NJ utilities (17%) have normalized apparent losses less than 1 gal/conn/day. In the NA dataset only one utility of 246 reported a level below 1 gal/conn/day. It has been the author's observation that the concept of apparent losses is not well understood by many water utilities. Utility staff who are untrained in the water audit process, or without validation of their water audit, tend to report low apparent loss volumes, often applying the default values of the AWWA Free Water Audit Software. This results in an understatement of the actual amount of apparent loss occurring in system operations.

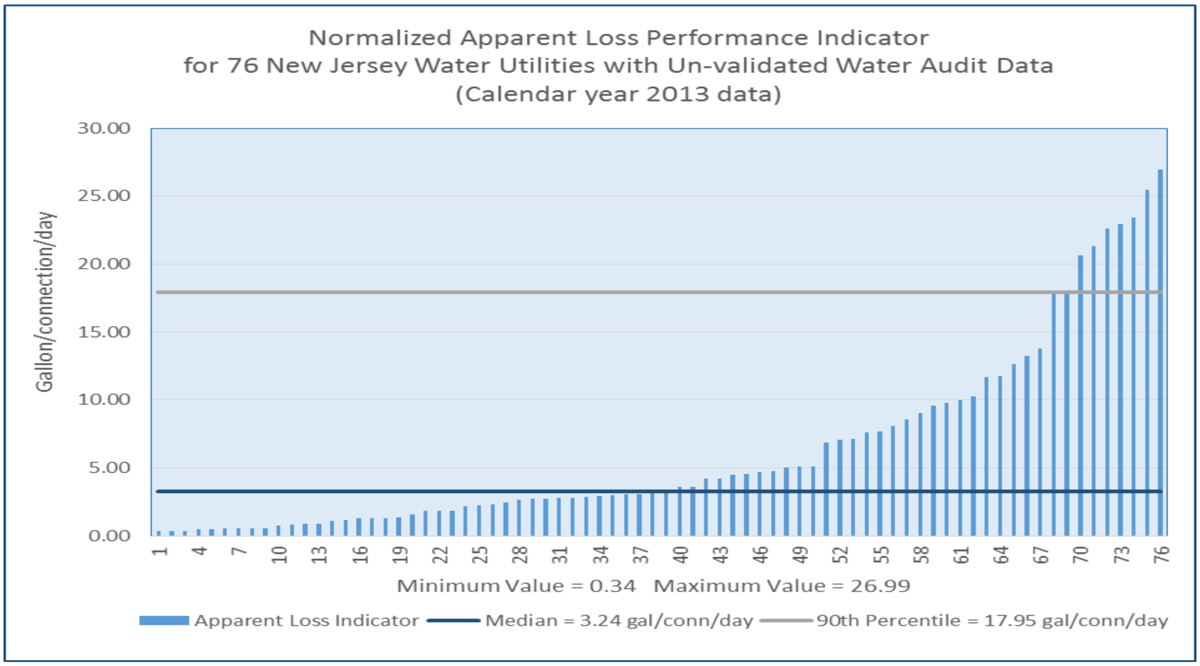

Figure 4 Normalized Apparent Losses for the NJ Dataset

Unfortunately, due to the calculation of real losses as a "catch-all" in the AWWA Free Water Audit Software, when apparent losses are under-stated, then the real loss volume calculated by the Software is over-stated. The findings that the apparent loss volumes of the NJ Dataset are less than the NA Dataset confirm that many NJ utilities have likely under-stated their apparent losses. This stems from a lack of formal training of utilities in the water audit process, and lack of validation of water audits.

<u>Real Losses</u>**:** Figure 5 plots the Normalized Real Loss performance indicator in units of gallons/service connection/day for the NA Dataset, while Figure 6 gives the same presentation for the NJ Dataset.

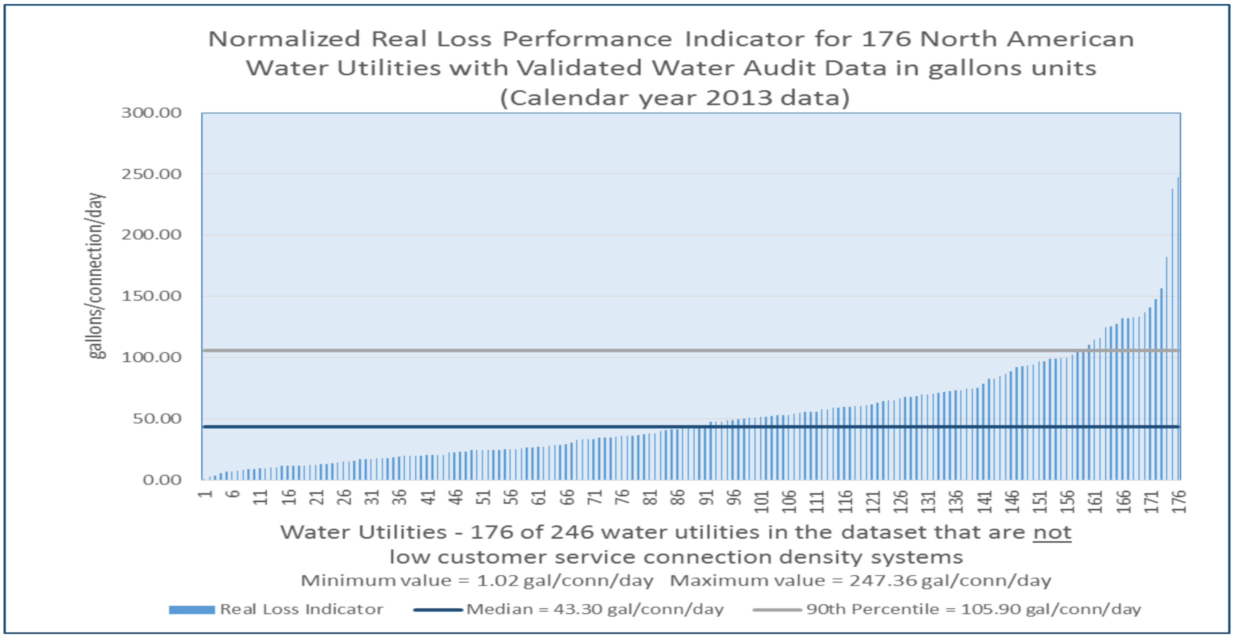

Figure 5 Normalized Real Losses for NA Dataset
(High Customer Service Connection Density Systems)

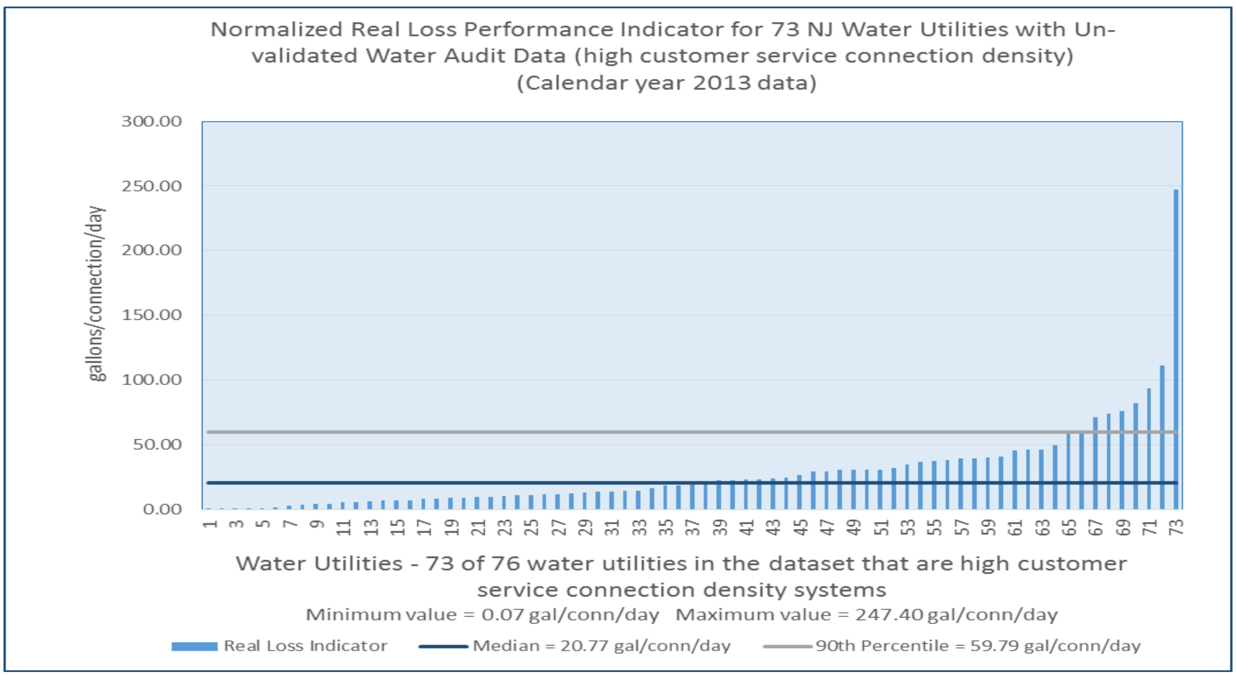

Figure 6 Normalized Real Losses for NJ Dataset
(High Customer Service Connection Density Systems)

The median value of real losses for the NA Dataset is 43.30 gal/connection/day, while the median value for the NJ Dataset is notably lower at 20.77 gal/connection/day. This value is also notably lower than the value of 35.71 gal/connection/day for PA water utilities. Knowing that apparent losses for NJ utilities are likely to be under-stated, and leakage losses are likely to be over-stated, the low value of median normalized real losses is intriguing. The findings of this assessment suggest that NJ water utilities (just like PA utilities) are not suffering leakage rates as high as the utilities included in the national dataset. However, there are many unknown variables in the occurrence and management of leakage in the water utilities of the two datasets, thus it is difficult to make a comprehensive conclusion on the leakage rate of NJ utilities. Still, the lower rate in NJ relative to the NA Dataset is notable.

Figure 7 plots the value of real losses for utilities with a low density of customer service connections, as measured by the Normalized Real Loss indicator in units of gallons/mile of pipeline/day for the NA Dataset, while Figure 8 gives the same presentation for the NJ Dataset.

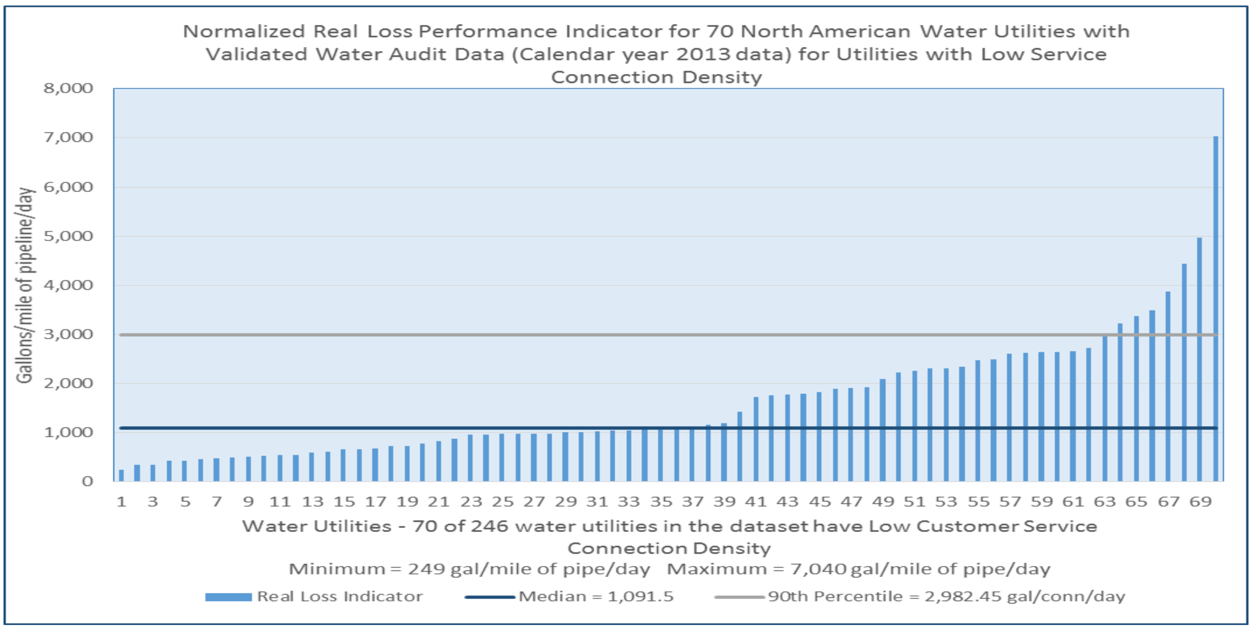

Figure 7 Normalized Real Losses for NA Dataset

(Low Customer Service Connection Density Systems)

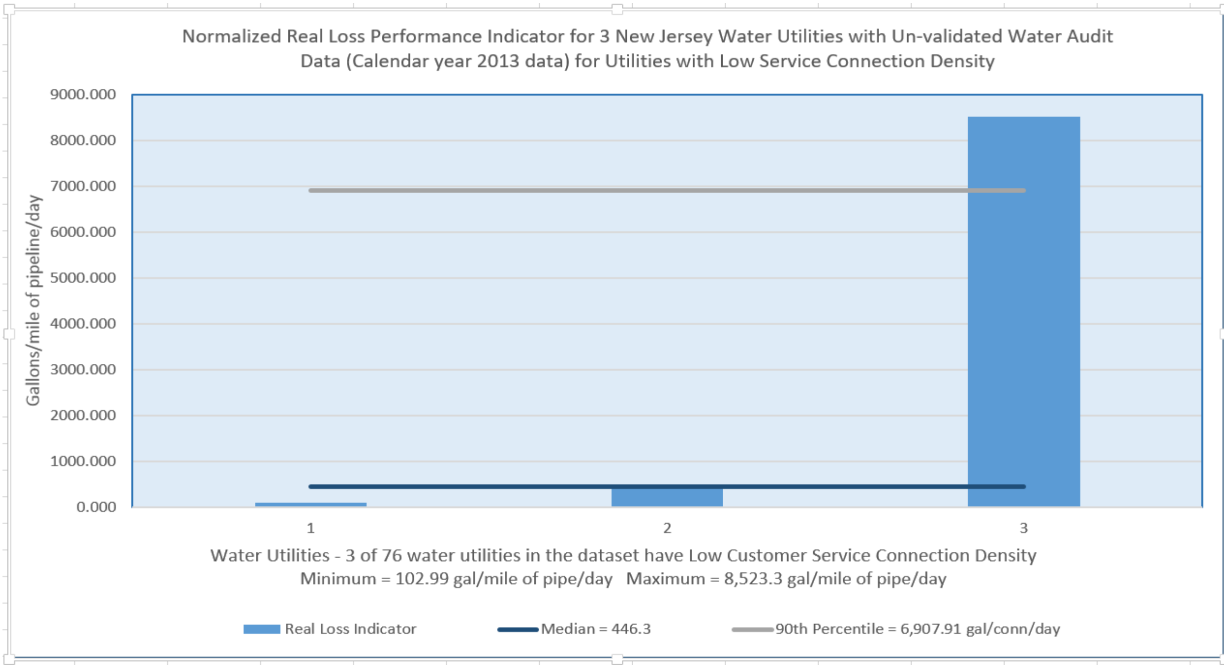

Figure 8 Normalized Real Losses for NJ Dataset

(Low Customer Service Connection Density Systems)

The median value for low density systems in the NA Dataset is 1,091.5 gal/mile of pipeline/day, while the median value for the NJ Dataset is 446.3 gal/mile of pipeline/day. The median value of normalized real loss for low density utilities in NJ is less than half that of the low density systems in the NA Dataset. However, with only three systems included in the NJ Dataset, the sample size of the NJ data is too small to draw a meaningful conclusion. NJ has many very small systems that would be categorized as low density systems as per the AWWA Free Water Audit Software. Unfortunately most of these systems do not currently compile an annual AWWA water audit. More data from NJ low density systems is needed to make a reliable comparison between the NA Dataset and the NJ Dataset for these systems.

Variable Production Costs**:** In addition to assessing normalized loss levels, KWEC also undertook a comparison of costs. These included the two unit costs compiled in the water audit process: the Variable Production Cost (VPC) and the Customer Retail Unit Cost (CRUC). The VPC of the NA Dataset is shown in Figure 9 and the VPC of the NJ Dataset is shown in Figure 10.

The median value VPC for the NA Dataset is $425.60/mg as shown in Figure 9 and the median value VPC for the NJ Dataset is $517.00/mg as shown in Figure 10. The latter figure is very close to the cost of $520/mg for PA water utilities.[4] Thus it appears that the costs to treat and distribute water in NJ water utilities are notably higher than the cost of the NA Dataset.

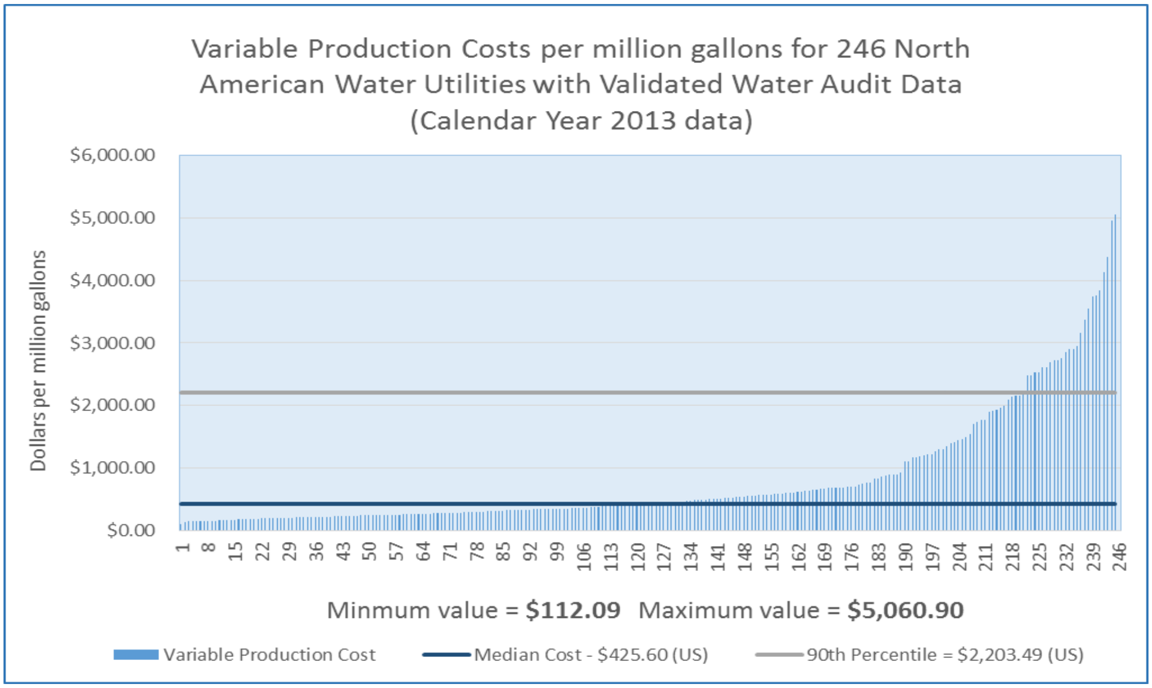

Figure 9 Variable Production Costs (VPC) for utilities in the NA Dataset

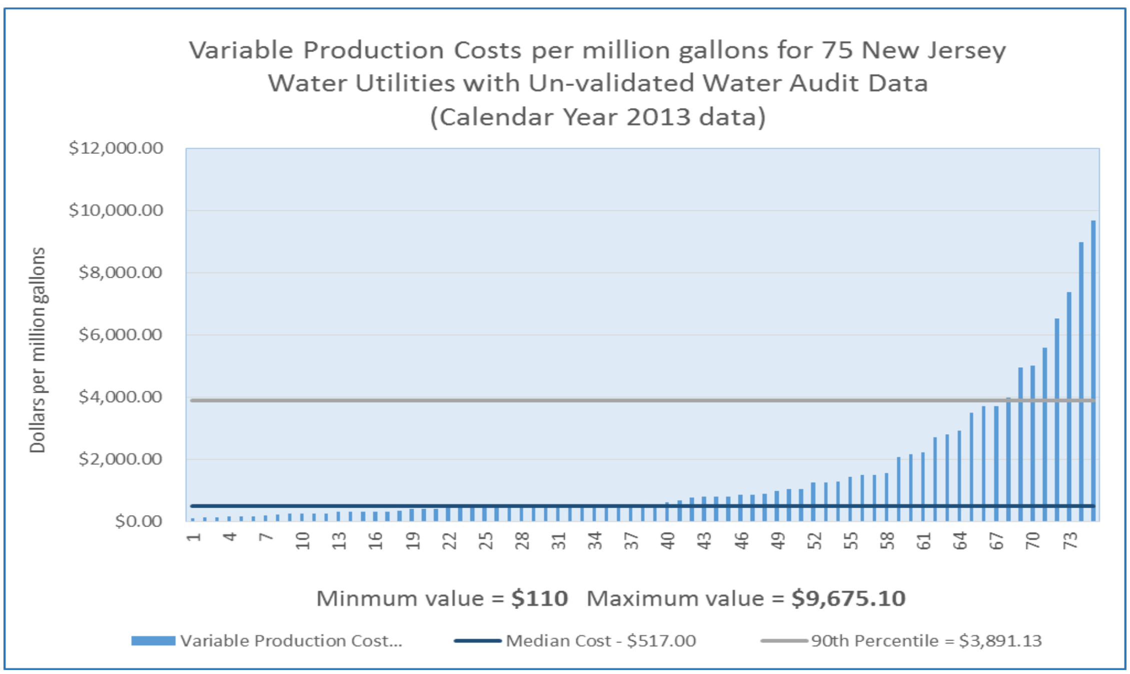

Figure 10 Variable Production Costs (VPC) for utilities in the NJ Dataset

[4] Kunkel Water Efficiency Consulting, *Report on the Evaluation of Water Audit Data for Pennsylvania Water Utilities*, draft November 2016.

Several observations of the NJ data are worth noting. Seven NJ utilities listed a VPC value of less than $10/mg; meaning the utility auditor likely confused the units and under-stated by a factor of 1,000. The values of VPC were multiplied by 1,000 and then included in the above chart. There were 14 values of VPC over $2,000/mg. Often, such high values occur with utilities that import most of their water supply. However, only 7 of the 14 have a large portion of their supply as imported water. Finally, 12 utilities reported a VPC value between $440/mg - $450/mg, with 6 reporting $440/mg. Nine of these 12 are values from New Jersey American Water Company systems, and all 6 of the utilities reporting $440/mg are New Jersey American Water Company systems. Using the same cost for each system over-simplifies the water audit process since the cost to produce water is unique for each water system.[5]

While the NA Dataset includes water utilities from across North America, close to 90% are from the State of Georgia. If Georgia production costs are notably lower than most of the US, then the VPC of the NA Dataset may be low, and perhaps the NJ Dataset is more of an average value. Still, the higher the VPC the stronger the economic incentive for water utilities to address leakage losses. Thus NJ water utilities appear to have strong economic incentive to cut their leakage.

<u>Customer Retail Unit Cost (CRUC)</u>: The CRUC represents the rate charged to customers for water service and any other services that are billed by the volume recorded on the water meter, such as sanitary sewer service. The CRUC is also assigned to the cost value to the volume of apparent losses occurring in the utility. Missed billings due to customer metering inaccuracies, unauthorized consumption, and systematic data handling errors result in under-recovery of revenue. Thus, the higher the CRUC, the stronger the financial incentive for water utilities to control apparent losses.

Figure 11 shows the median value CRUC for the NA Dataset of $4.16/1,000 gallons. The median value CRUC for the NJ Dataset is $5.00/1,000 gallons as shown in Figure 12. The costs that water utilities charge their customers in NJ are somewhat higher than the utilities of the national Dataset. But, the CRUC of NJ utilities is much lower than the median value of $7.66/1,000 gallons for PA water utilities.[6]

[5] One large IOU in the PA Dataset - PA-American Water Company – included a wide range of VPC values for its systems, which is representative of the different costs to produce and distribute water in each of its separate service areas.
[6] Kunkel Water Efficiency Consulting, *Report on the Evaluation of Water Audit Data for Pennsylvania Water Utilities*, draft November 2016.

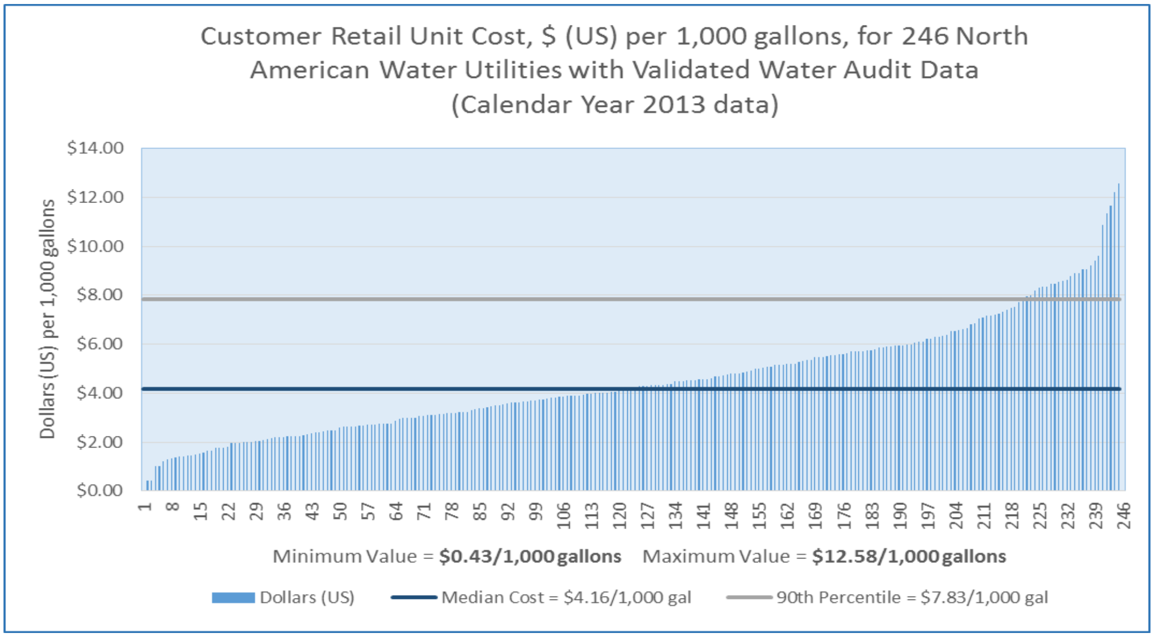

Figure 11 Customer Retail Unit Costs (CRUC) for utilities in the NA Dataset

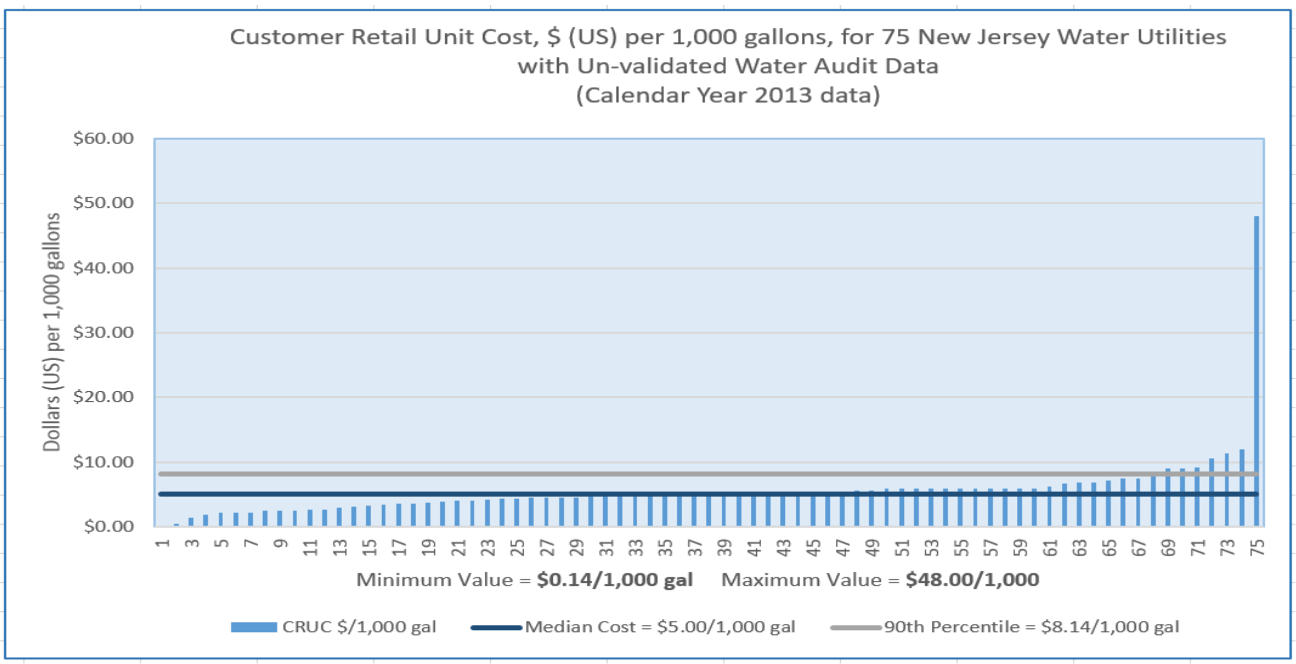

Figure 12 Customer Retail Unit Costs (CRUC) for utilities in the NJ dataset

Several observations of the NJ data are noted. The Borough of Hopatcong reported a CRUC value of $400/1,000 gallons and this value was not included in the analysis. The maximum CRUC retained in the NJ Dataset is a high value of $48.00/1,000 gallons for Pemberton Borough. Two very low CRUC values exist but were included in the analysis: $0.14/1,000 gallons for United/Suez Camden and a value of $0.45/1,000 gallons for Bellmawr Water Department. The trustworthiness of these values is questionable, but not surprising since the NJ data is un-validated. The median value of CRUC for the 18 systems of the two large IOUs in NJ (Aqua-NJ and NJ-American) is $5.72, notably higher than the median of the NJ Dataset. Aqua NJ applied a CRUC of $4.93/1,000 gallons for their 6 systems, and NJ American applied a CRUC value of $5.94/1,000 gallons for 9 of the 12 systems in the company. The CRUC values of the IOUs in NJ have the effect of increasing the median value of the NJ Dataset upwards. The influence of IOUs in the NJ Dataset would be expected to be diluted if the NJ Dataset were expanded to include all of the water utilities in the State of NJ. It is likely that many of NJ's small water utilities who are not included in the NJ Dataset have CRUC that are notably less than the median value of the NJ Dataset; thus a larger dataset will likely result in a lower median CRUC for NJ utilities.

NJ water utilities appear to have good financial incentive to reduce apparent losses and recover additional revenue. With every rate increase enacted by a water utility, the cost of the apparent losses also increases. For those customers who are under-paying (or not paying at all) due to apparent losses, the paying portion of the customer population must pay that much more to enable the water utility to collect sufficient revenue. Apparent losses are an important equity issue that water utilities should manage.

In summary, a comparison of apparent and real losses of utilities in the NJ Dataset and NA Dataset found lower loss rates for NJ utilities for apparent losses and real losses for high customer service density systems than the utilities of the NA Dataset. It was not possible to draw a reliable comparison of real loss rates for low customer density utilities since the number of NJ utilities (three) is too low to serve as a representative sample. Since the NA dataset is a validated dataset and the NJ dataset is not, the lack of validation is a distinct factor that may influence the comparisons. The possibility exists that lower apparent and real losses reported for NJ utilities may be due to the fact that the data has not been "truthed" through the data validation process. Just as gradings are often over-stated in self-reported data, losses may be under-stated in self-reported data. A notable finding is that costs in NJ utilities – just like PA utilities – for both VPC and CRUC are higher than the NA Dataset, but these cost differentials are greater in the PA Dataset than the NJ Dataset. While the cost data is also un-validated and may include some questionable values, the fact that reported costs are comparatively high in NJ provides a strong economic incentive for NJ water utilities to control both real and apparent losses to economic levels.

Part 3: Pressure Levels as a Factor Influencing Water Loss

System Pressure: Many factors have an influence on the occurrence of NRW in water utilities. There are 18 values that water utilities input into the AWWA Free Water Audit Software, and perhaps the most influential factor in leakage levels is the average pressure level. KWEC examined pressure levels in the NA and NJ Datasets and these are discussed below.

Average water pressure data presentations are given in Figure 13 and Figure 14 for the NA Dataset and NJ Dataset, respectively.

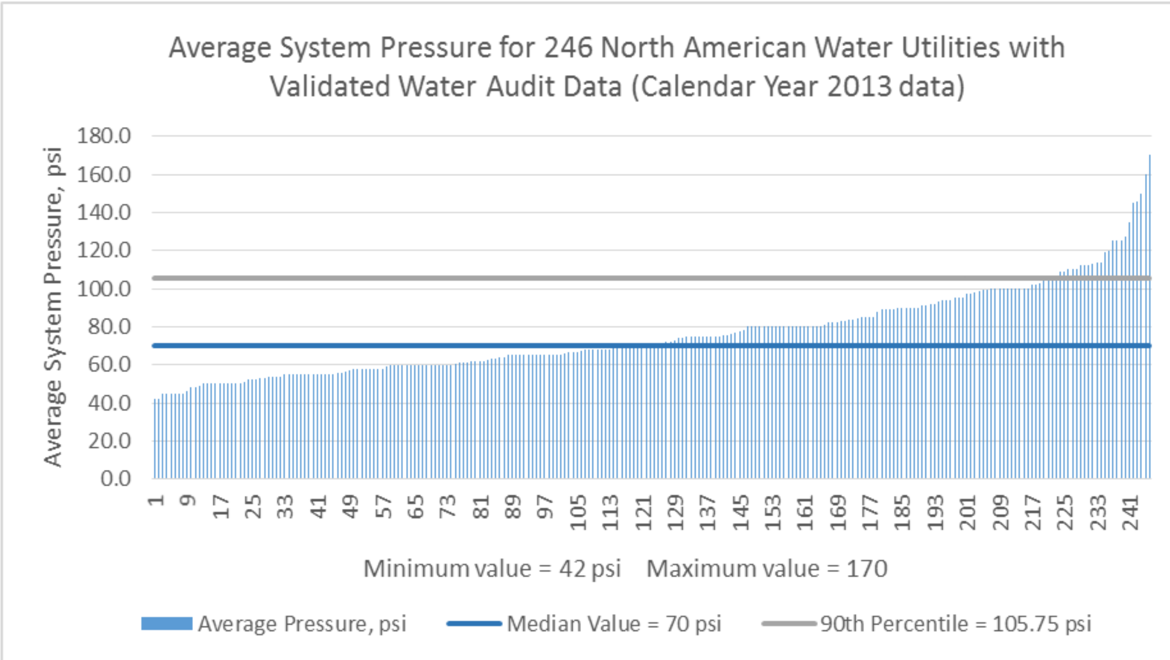

Figure 13 Average Pressure for the NA Dataset

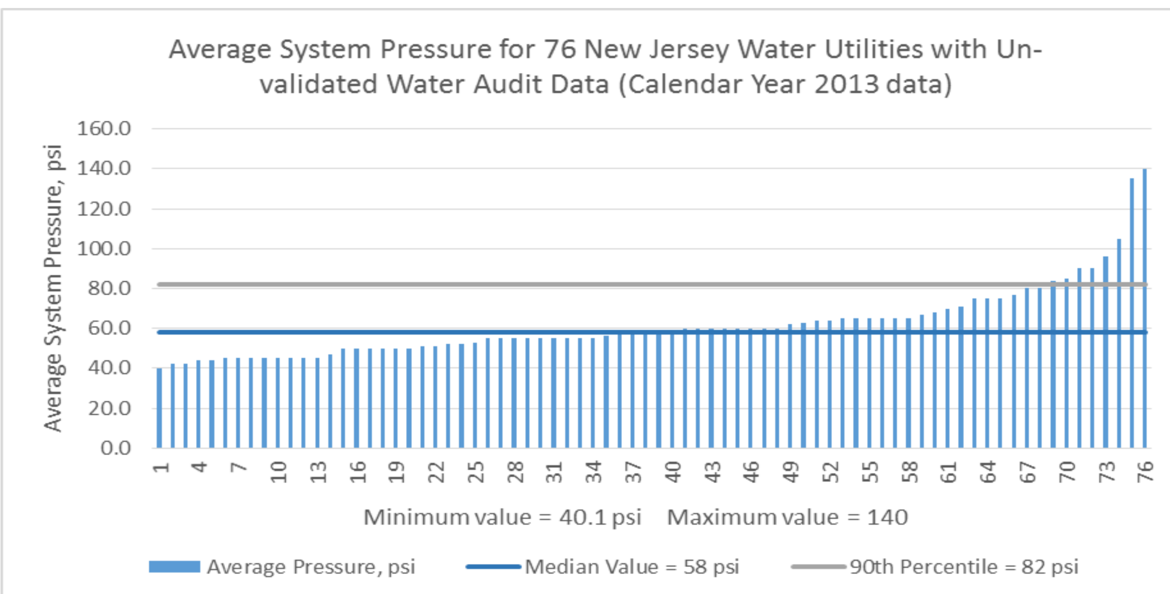

Figure 14 Average Pressure for the NJ Dataset

Figure 13 shows the NA Dataset with a median average system pressure of 70 psi and a 90th percentile value of 105.75 psi. Figure 14 shows the NJ Dataset with notably lower pressure statistics with a median average system pressure of 58 psi and a 90th percentile value of 82 psi. This is not surprising, since high pressure in water utilities is often associated with hilly or mountainous terrain, and NJ does not have widely varying topography.

The "Ten State Standards" (Water Supply Committee of the Great Lakes–Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers *Recommended Standards for Water Works*), stipulates that water systems "shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow." Additionally, the program specifies that the normal working pressure in the distribution system should be "approximately 60 to 80 psi and not less than 35 psi."

Systems with areas of pressure routinely falling below 35 psi may have difficulty providing reliable supply to buildings at higher elevations under all conditions and may struggle to fully meet local fire flow requirements. No utilities in either dataset have an average pressure under 40 psi, a finding which affirms the widely held perception within the water industry that most water utilities are successful in exceeding minimal pressure guidelines.

For systems with pressures above 80 psi, pressure reducing valves may be needed on customer service lines to prevent damage to customer plumbing, hot water heaters, and other customer devices. In the same vein, water distribution systems operating with pressure levels notably higher than 80 psi may encounter a greater opportunity for high leakage and rates of ruptures on water distribution piping. The AWWA Partnership for Safe Water *Self-Assessment Guide for Distribution System Optimization* flags water pressure levels above 100 psi as noteworthy.

In assessing the AWWA Partnership for Safe Water action level of 100 psi, it is interesting to note that 39 of 246 utilities in the NA Dataset (~16%) have an average pressure of over 100 psi. With an average system pressure over 100 psi, utilities will also have a portion of their distribution piping operating at a pressure of well over 100 psi, and these areas of distribution piping are very susceptible to increased leakage and accelerated water main breaks. However, only 3 of 76 utilities in the NJ Dataset (~4%) have an average pressure of over 100 psi. These findings suggest that high water pressure does not have an unusually strong influence on leakage levels in NJ water utilities.

The drinking water industry has well-established guidelines for minimal pressure levels and water utilities have been largely successful in designing and building water infrastructure that meets or exceeds these guideline minimal levels. Unfortunately, definitive maximal pressure level guidelines are lacking, and water system designs seemingly seldom take into account the operational risks of high system pressures over 100 psi. Pressure management has been found to be a highly effective means of economically controlling leakage and slowing the rate of water main ruptures, thereby extending infrastructure life and deferring renewal and rehabilitation of assets prematurely. Unfortunately in North America, the negative impacts of water pressure are not widely recognized and pressure management is greatly under-utilized. A stronger focus that identifies systems with high pressure and projects to implement pressure management could have great potential for improved water utility management in NA systems.

The assessment of factors contributing to NRW was limited to average water pressure in this study. However, in addition to conducting a water audit annually, utility loss control practices management are the most important factors in the level of losses occurring in a given system. For the water audit, information on practices can only be garnered indirectly from data gradings, and no information is available regarding leakage management practices, since real (leakage) losses are not an input to the AWWA Free Water Audit Software, but instead a calculated value. Data on utility loss control practices must be gathered in an effort separate from the water audit in order to assess other contributing factors.

Part 4: Potentially Recoverable Losses in New Jersey Water Utilities

The NJ Dataset of 76 water utilities produced the following totals:

1. Water supplied volume of 45,090 mg (123.5 mgd)
2. Authorized consumption volume of 38,879 mg (106.5 mgd)
3. Non-revenue water of 7,310 mg (20.0 mgd)
    a. Unbilled Authorized Consumption of 1,098.4 mg (3.1 mgd)
    b. Apparent losses of 790 mg (2.1 mgd)
    c. Real (leakage) losses of 5,421 mg (14.8 mgd)
4. The cost impact of Real (leakage) losses (valued at VPC) is $2,535,322
5. The cost impact of Apparent losses (valued at CRUC) is $5,248,420

These statistics reveal moderate water and revenue losses for 76 of NJ's water utilities, out of several hundred that exist in the state; with some of the largest systems in the state excluded from the dataset that was analyzed. It is likely that a large portion of these losses can be considered economic to recover. The most reliable means to identify economically recoverable losses entails assessing each water utility's losses and costs individually, and determining the economic level of apparent and real losses for each system based on its unique costs, loss levels, and specific loss control interventions. Such a detailed assessment of individual systems is beyond the scope of this study. Still, a broad assessment was conducted in order to obtain a general estimation of potentially recoverable losses.

Potentially Recoverable Apparent Losses for Reporting Utilities and Statewide: Apparent losses under-state the volume of water consumed by the customer population, causing under-billings and a loss of revenue. Figure 4 shows that median value of the Normalized Apparent Loss indicator of the NJ Dataset is 3.24 gal/connection/day. Figure 12 shows the median CRUC value of $5.00/ 1,000 gallons.

Figure 15 plots the CRUC vs. the normalized apparent loss performance indicator for 73 systems in the NJ Dataset and gauges the extent to which NJ utilities with high rates of apparent loss also have high retail costs. Two utilities with very high CRUC values were excluded, as well as one with a very low CRUC value; changing the median normalized apparent loss indicator value to 3.13 gal/connection/day. Systems with CRUC over $5.00/ 1,000 gallons and normalized apparent losses over 3.13 gal/conn/day likely have both excessive apparent losses and a strong revenue recovery potential.

Furthermore, the product of median values for CRUC and the volume of apparent losses/connection/day yields a median value for the cost of apparent losses of $5.75/connection/year. Systems with a cost of apparent losses higher than this median value should also have significant revenue recovery potential.

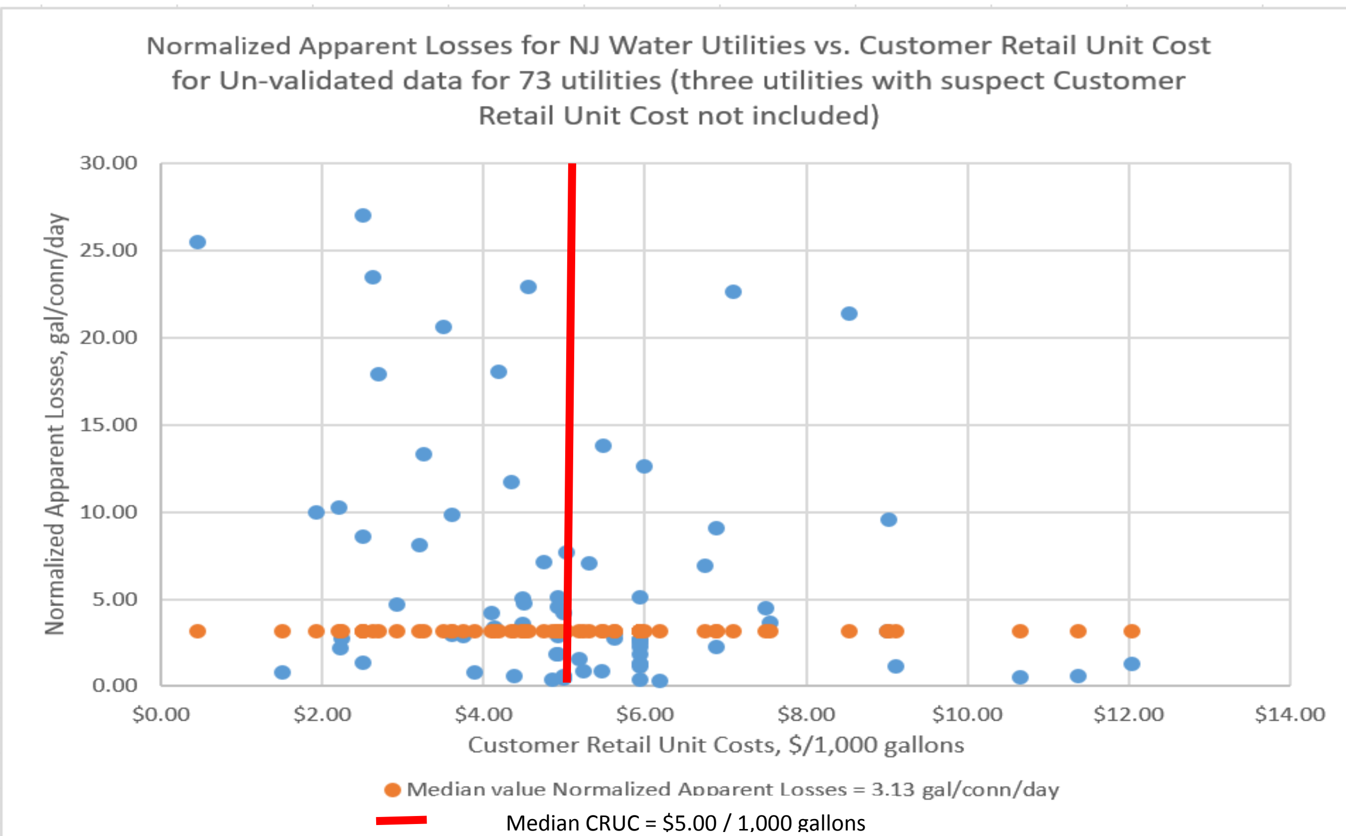

Figure 15 Plot of Normalized Apparent Losses vs. Customer Retail Unit Costs for NJ Utilities

An initial evaluation found that 14 NJ utilities had both normalized apparent losses and CRUC at or above the median levels. Further evaluation found 38 NJ utilities with an annual cost of apparent losses above the median for the NJ dataset. Table 3 shows the analysis of these 38 NJ utilities for potentially recoverable apparent losses, which were quantified by identifying the apparent loss reduction volume for each utility to realize a normalized apparent loss cost rate of $5.75/conn/day (adjusted NJ median). This resulted in a recovery estimate of 287.7 mg (0.79 mgd), out of the total apparent losses of the NJ Dataset of 790 mg (2.1 mgd). The projected cost recovery from capturing missing revenue is shown in Table 3 as $1,244,507, a significant portion of the uncaptured revenue impact of $5,248,420 for the entire NJ Dataset.

Table 3 NJ Water Utilities Assessed for Potentially Recoverable Apparent Losses

Name of City/Utility	Apparent Losses, mg	Number of Active and Inactive Service Connections	Customer Retail Unit Cost	Apparent Loss Cost	Apparent Losses, gallons per service connection per day	Normalized Apparent Loss Cost Rate ($/conn/year) 38 utilities	Normalized Apparent Loss Rate (g/conn/d) if Normalized Apparent Loss Cost Rate = median of $5.75/conn/yr	Annual Apparent Losses (mg) if Normalized Apparent Loss Cost Rate = median of $5.75/conn/yr	Potentially Recoverable Annual Apparent Losses, mg	Potential Additional Revenue Capture
City of Burlington	31.115	3,765	$7.10	$220,920	22.64	$58.68	2.22	3.05	28.07	$199,271
CITY OF MILLVILLE WATER UTILITY	57.805	7,681	$3.50	$202,316	20.62	$26.34	4.50	12.62	45.19	$158,150
City of Bordentown Water	35.211	5,354	$4.18	$147,180	18.02	$27.49	3.77	7.36	27.85	$116,394
FLORENCE TOWNSHIP WATER & SEWER	51.544	5,233	$2.50	$128,859	26.99	$24.62	6.30	12.04	39.51	$98,769
Burlington Twp. Water	43.276	6,634	$2.70	$116,846	17.87	$17.61	5.83	14.13	29.15	$78,700
Borough of Pennington	7.835	1,006	$8.54	$66,913	21.34	$66.51	1.84	0.68	7.16	$61,129
Merchantville Pennsauken Water Commission	45.192	15,245	$3.20	$144,614	8.12	$9.49	4.92	27.39	17.80	$56,955
Township of Moorestown	20.576	7,927	$4.75	$97,734	7.11	$12.33	3.32	9.60	10.98	$52,154
City of Woodbury	9.225	3,669	$6.75	$62,272	6.89	$16.97	2.33	3.13	6.10	$41,175
UNITED WATER LAMBERTVILLE	9.320	1,850	$5.49	$51,169	13.80	$27.66	2.87	1.94	7.38	$40,531
Netcong Borough	8.756	1,046	$4.56	$39,925	22.93	$38.17	3.45	1.32	7.44	$33,911
Salem City Water Department	10.907	2,548	$4.34	$47,338	11.73	$18.58	3.63	3.38	7.53	$32,687
Township of Roxbury	5.780	1,750	$6.88	$39,767	9.05	$22.72	2.29	1.46	4.32	$29,705
Pemberton Borough	0.592	580	$48.00	$28,413	2.80	$48.99	0.33	0.07	0.52	$25,078
Borough of Woodbury Heights	5.244	1,138	$6.00	$31,467	12.63	$27.65	2.63	1.09	4.15	$24,923
New Jersey American Water System PWSID2121001 (Washington)	8.295	4,428	$5.94	$49,272	5.13	$11.13	2.65	4.29	4.01	$23,811
Aqua New Jersey, Inc. Phillipsburg	14.470	8,692	$4.93	$71,339	4.56	$8.21	3.20	10.14	4.33	$21,360
Borough of Allentown	2.480	709	$9.02	$22,373	9.58	$31.56	1.75	0.45	2.03	$18,297
Lower Township MUA	13.348	7,239	$4.48	$59,800	5.05	$8.26	3.52	9.29	4.06	$18,176
Hackettstown Municipal Utilities Authority	24.249	6,486	$2.20	$53,348	10.24	$8.23	7.16	16.95	7.30	$16,054
Borough of Westville	4.891	1,899	$5.30	$25,925	7.06	$13.65	2.97	2.06	2.83	$15,005
East Greenwich Township	4.621	3,502	$7.55	$34,887	3.62	$9.96	2.09	2.67	1.95	$14,751
Sparta Township Water Utility	10.970	6,353	$4.50	$49,365	4.73	$7.77	3.50	8.12	2.85	$12,835
City of Bridgeton Water Department	17.813	5,709	$2.50	$44,534	8.55	$7.80	6.30	13.13	4.68	$11,707
Upper Deerfield Township	4.203	867	$3.25	$13,660	13.28	$15.76	4.85	1.53	2.67	$8,674
Swedesboro	1.721	1,057	$7.50	$12,908	4.46	$12.21	2.10	0.81	0.91	$6,831
Aqua New Jersey, Inc. Woolwich	3.012	1,619	$4.93	$14,850	5.10	$9.17	3.20	1.89	1.12	$5,541
National Park Borough	1.374	1,204	$9.00	$12,367	3.13	$10.27	1.75	0.77	0.60	$5,444
Borough of Elmer	1.613	576	$5.02	$8,097	7.67	$14.06	3.14	0.66	0.95	$4,785
Stockton Borough	1.943	227	$2.63	$5,111	23.45	$22.52	5.99	0.50	1.45	$3,806
Branchville Water Department	1.635	457	$3.60	$5,887	9.80	$12.88	4.38	0.73	0.91	$3,260
Pinelands Water Company	8.941	2,459	$1.92	$17,166	9.96	$6.98	8.20	7.36	1.58	$3,027
Borough of Woodstown	1.581	1,426	$5.62	$8,883	3.04	$6.23	2.80	1.46	0.12	$683
Borough of Alpha Water Department	1.760	1,147	$4.10	$7,218	4.20	$6.29	3.84	1.61	0.15	$622
New Jersey American Water System PWSID2103001 (Belvidere)	1.363	1,384	$5.94	$8,098	2.70	$5.85	2.65	1.34	0.02	$140
Burlington County Institution	0.078	51	$5.00	$391	4.20	$7.66	3.15	0.06	0.02	$98
New Jersey American Water System PWSID1523003 (New Egypt)	0.635	484	$4.48	$2,845	3.60	$5.88	3.52	0.62	0.01	$62
New Jersey American Water System NJ0809002 (Logan)	2.326	2,402	$5.94	$13,815	2.65	$5.75	2.65	2.33	0.00	$3
Totals	**475.7**			**$1,967,875**				**188.0**	**287.7**	**$1,244,507**

This approach makes a broad assumption that it would be financially rewarding for these 38 utilities to enact revenue protection interventions to drive the cost of their apparent losses down to the median level. This may not be the case for all utilities. However, since these utilities have either relatively high CRUC or relatively high apparent loss volumes, they generally have greater financial incentive to control apparent losses compared to other NJ water utilities who do not appear in Table 3. Many NJ water utilities do not compile an annual water audit, including many of the State's largest systems.

The above approach projects potentially recoverable apparent losses for 38 of 73 water utilities that have compiled an annual water audit and have data acceptable for analysis. It is valuable to attempt to project the potential recoverable apparent losses for all water utilities in NJ. However, the vast majority of water utilities are not included in the NJ Dataset and do not regularly compile an annual, standardized water audit. Thus, lacking statewide water audit data, the author devised a projection of statewide apparent losses and potentially recoverable apparent losses by referencing data on public water supply withdrawals from standardized reporting from the United States Geologic Survey (USGS)[7]. The USGS report on water use in 2010 found that total water withdrawals from NJ water utilities were 394,200 mg (1,080 mgd). The total volume of Water Supplied for 76 utilities in the NJ Dataset is 45,090 mg (123.5 mgd). These volumes are shown in Table 4. By calculating the proportion of apparent losses and potentially recoverable apparent losses to the Water Supplied volume of the NJ Dataset, and applying these percentages to the USGS water withdrawal volume shown in Table 4, an extrapolated estimate of total and recoverable apparent losses is projected.

Table 4 Calculation of Potentially Recoverable Apparent Losses in New Jersey Utilities Statewide

Utility Population	Water Supplied/Withdrawn, mg	Apparent Losses, mg	Potentially Recoverable Apparent Losses, mg
NJ Delaware Basin Dataset (76 Utilities)	45,090	790 = 1.75% of Water Supplied	287.7 = 0.638% of Water Supplied
Statewide in New Jersey (number of utilities is unknown)	394,200	(394,200)(0.0175) = **6,898.5**	(394,200)(0.00638) = **2,515.2**

Table 4 illustrates that, by extrapolating the data from 73 utilities in the NJ Dataset to the total public water supply withdrawals in NJ (USGS Report), it is projected that all water utilities in New Jersey experience **6,898.5 mg (18.9 mgd) of apparent losses, and that at least 2,515.2 mg (6.9 mgd) are potentially recoverable**. At the median CRUC, the **value of the potentially recoverable apparent losses is $12,576,000 of uncaptured annual revenue.** Note that these estimates are derived from an extrapolation of values found in the NJ DRBC dataset. Audit reporting by utilities statewide would allow for more refined estimates of loss volumes and potential cost savings.

[7] Estimated Use of Water in the United States for 2010, USGS, Circular 1045 (2014)

By better controlling apparent losses, utilities recover missing revenue that is vital to financing the long-term renewal of deteriorating water distribution infrastructure. Infrastructure renewal – and the ability to pay for it – is one of the greatest concerns for water utilities throughout the USA, yet few utilities focus consistently on their billing efficiency and revenue capture. NJ water utilities have notable potential to save water, fund infrastructure renewal, and improve their finances by better controlling apparent losses.

Potentially Recoverable Real Losses (Leakage) for Reporting Utilities and Statewide: A broad assessment of real (leakage) losses was conducted since leakage causes utilities to withdraw and treat more water than the customer population needs. This assessment plotted VPC vs. the normalized real loss performance indicator for systems with high customer service density. Figure 16 plots these values for 71 of the 76 utilities in the NJ Dataset, along with median values for the group.

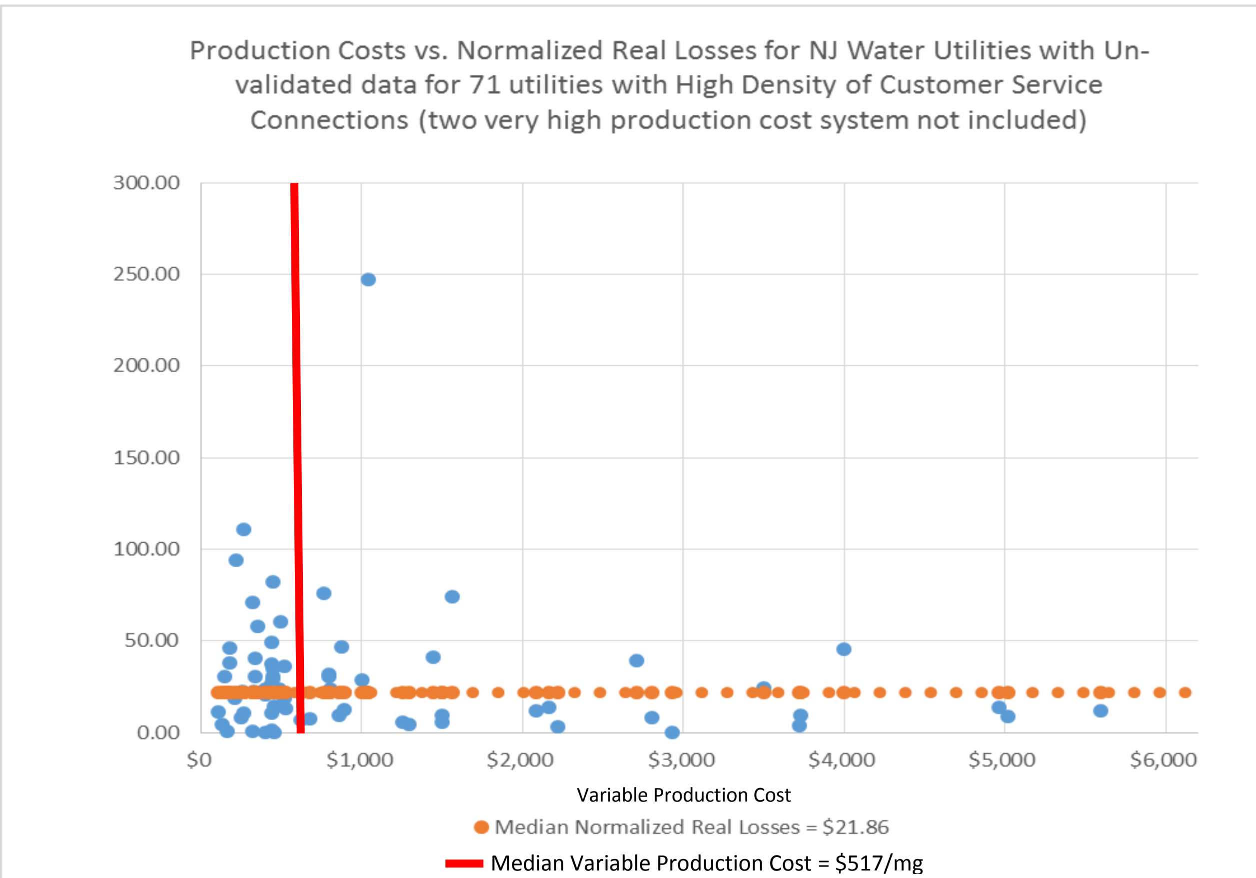

Figure 16 Plot of Production Costs vs. Normalized Real Losses (High Customer Service Connection Density NJ Utilities)

This relationship was examined in order to gauge the extent to which NJ utilities with high rates of real loss also encounter high VPC. Systems with VPC of more than the NJ median values of $517.00/mg and normalized real losses of over 21.86 gal/conn/day likely have both excessive leakage losses that offer good leakage recovery potential and a strong economic incentive to do so. Two utilities with high values of over $8,000/mg of VPC were excluded from this analysis, thus the median Normalized Real Loss and VPC values are slightly different from those mentioned earlier. Utilities with a low density of customer service connections were also excluded.

Additionally, the product of median values for VPC and the volume of real losses/connection/day yields a median value for the cost of real losses of $4.92/connection/year. Systems with a cost of real losses higher than this median value should also have significant leakage reduction potential.

Table 5 NJ Water Utilities Assessed for Potentially Recoverable Real Losses

Name of City/Utility	Annual Real Losses, mg	Number of Active and Inactive Service Connections	Variable Production Cost, $/mg	Real Loss Cost	Normalized Real Losses, gal/service conn/day	Normalized Real Loss Cost Rate ($/conn/year) 35 utilities	Normalized Real Loss Rate (g/conn/d) if Normalized Real Loss Cost Rate = Median of $4.92/conn/yr	Annual Real Losses (mg) if Normalized Real Loss Cost Rate = Median of $4.92/conn/yr	Potentially Recoverable Annual Real Losses, mg	Potential Variable Production Cost Savings
United Water Camden	1,083.597	12,000	$1,040.00	$1,126,941	247.40	$93.91	12.96	56.77	1,026.827	$1,067,901
Township of Maple Shade	78.510	4,720	$4,000.00	$314,042	45.57	$66.53	3.37	5.81	72.705	$290,819
Pemberton Township Water	37.636	4,192	$3,500.00	$131,727	24.60	$31.42	3.85	5.89	31.744	$111,102
NJ American Water System NJ0327001 (Delaware)	1,417.607	104,468	$440.00	$623,747	37.18	$5.97	30.64	1168.14	249.465	$109,765
Sparta Township Water Utility	95.485	6,353	$1,446.00	$138,072	41.18	$21.73	9.32	21.62	73.869	$106,815
Aqua New Jersey, Inc-Lawrenceville	38.294	2,651	$2,707.00	$103,663	39.58	$39.10	4.98	4.82	33.476	$90,620
Borough of Brooklawn	11.392	795	$6,535.90	$74,458	39.26	$93.66	2.06	0.60	10.794	$70,547
Aqua New Jersey, Inc. Phillipsburg	352.060	8,692	$267.00	$94,000	110.97	$10.81	50.48	160.17	191.893	$51,235
Borough of Pennington	6.016	1,006	$7,375.96	$44,377	16.38	$44.11	1.83	0.67	5.345	$39,427
Borough of Westville	9.667	1,899	$4,960.98	$47,959	13.95	$25.25	2.72	1.88	7.784	$38,616
NJ American Water PWSID2121001 (Washington)	132.915	4,428	$449.00	$59,679	82.24	$13.48	30.02	48.52	84.394	$37,893
Collingswood	131.460	5,982	$498.00	$65,467	60.21	$10.94	27.07	59.10	72.361	$36,036
NJ American Water PWSID323001 (Mt Holly-Mansfield)	205.018	15,390	$517.00	$105,994	36.50	$6.89	26.07	146.46	58.560	$30,275
Borough of Alpha Water Department	5.067	1,147	$5,600.00	$28,376	12.10	$24.74	2.41	1.01	4.059	$22,733
FLORENCE TOWNSHIP WATER & SEWER	23.045	5,233	$2,084.28	$48,033	12.07	$9.18	6.47	12.35	10.693	$22,286
Monroe Municipal Utilities Authority	89.260	10,247	$805.66	$71,913	23.87	$7.02	16.73	62.58	26.684	$21,498
City of Bordentown Water	60.318	5,354	$793.00	$47,832	30.87	$8.93	17.00	33.22	27.100	$21,491
Hackettstown Municipal Utilities Authority	168.308	6,486	$316.63	$53,291	71.09	$8.22	42.57	100.78	67.524	$21,380
Township of Moorestown	168.211	7,927	$354.82	$59,685	58.14	$7.53	37.99	109.92	58.294	$20,684
City of Bridgeton Water Department	45.552	5,709	$1,036.00	$47,191	21.86	$8.27	13.01	27.11	18.439	$19,103
Township of Roxbury	6.022	1,750	$3,727.83	$22,449	9.43	$12.83	3.62	2.31	3.712	$13,839
Borough of Allentown	19.658	709	$766.59	$15,070	75.96	$21.25	17.58	4.55	15.108	$11,581
Borough of Woodbury Heights	19.342	1,138	$875.00	$16,924	46.57	$14.87	15.41	6.40	12.943	$11,325
City of Burlington	128.973	3,765	$215.00	$27,729	93.85	$7.37	62.70	86.16	42.816	$9,205
Stockton Borough	6.153	227	$1,560.00	$9,599	74.26	$42.28	8.64	0.72	5.437	$8,482
NJ American Water System NJ0809002 (Logan)	43.419	2,402	$440.00	$19,104	49.52	$7.95	30.64	26.86	16.561	$7,287
Branchville Water Department	1.493	457	$5,020.00	$7,493	8.95	$16.40	2.69	0.45	1.045	$5,244
Newfield Borough Water Department	3.566	713	$2,163.97	$7,717	13.70	$10.82	6.23	1.62	1.945	$4,209
Swedesboro	3.150	1,057	$2,806.24	$8,839	8.16	$8.36	4.80	1.85	1.297	$3,639
Montague Water Company	9.278	791	$795.66	$7,382	32.13	$9.33	16.94	4.89	4.387	$3,490
Harding Woods Mobile Home Park	3.384	319	$1,000.00	$3,384	29.06	$10.61	13.48	1.57	1.814	$1,814
Buena MUA	5.265	1,481	$1,500.00	$7,898	9.74	$5.33	8.99	4.86	0.408	$611
Town of Liberty, Stevensville Water Dist.	5.941	465	$448.38	$2,664	35.00	$5.73	30.06	5.10	0.839	$376
NJ American Water System PWSID2103001 (Belvidere)	15.616	1,384	$449.00	$7,011	30.91	$5.07	30.02	15.17	0.450	$202
NJ American Water System PWSID1523003 (New Egypt	7.153	484	$333.00	$2,382	40.49	$4.92	40.48	7.15	0.002	$1
Totals	**4,438**			**3,452,091**				**2,197**	**2,241**	**$2,311,531**

An initial evaluation found that 15 NJ utilities had both normalized real losses and VPC at or above the median levels of 21.86 gal/conn/day and $517/mg, respectively. Further evaluation found 35 NJ utilities with an annual cost of real losses above the median for the NJ dataset. This resulted in an estimated leakage reduction of 2,241 mg (6.14 mgd) out of the total real losses of the NJ dataset of 5,421.6 mg

(14.85 mgd). The projected annual cost savings from reduced VPC are $2,311,531, a notable portion of the real loss cost impact of $2.53 million for the entire NJ Dataset.

This approach suggests that it would be economic for all 35 utilities to enact leakage interventions to drive their cost of leakage level down to the median level. This will not be the case for all utilities. However, since these utilities have either relatively high VPC or relatively high real loss volumes, they have good economic incentive to control leakage losses compared to the NJ utilities that do not appear in Table 5.

While this assessment is a very general approximation of the "low hanging fruit" of leakage losses in NJ, these figures are attractive in terms of saving significant water volumes lost to leakage, but also reduced production costs to water utilities and indirect benefits such as reduced energy costs for pumping. Generally, such leakage reductions should be considered economic for the utilities shown in Table 5.

The above approach projects potentially recoverable real losses for 35 of 71 water utilities that have compiled an annual water audit and have data acceptable for analysis. It is valuable to attempt to project the potential recoverable real losses for <u>all</u> water utilities in NJ. However, the vast majority of water utilities are not included in the NJ Dataset and do not regularly compile an annual, standardized water audit. Thus, lacking statewide water audit data, the author devised a projection of statewide real losses in the same manner as was executed for apparent losses above. The USGS report on water use in 2010 was again used to calculate total real losses for all NJ water utilities, and potentially recoverable real losses in the State, with calculations shown in Table 6 executed in the same manner as Table 4.

Table 6 Calculation of Potentially Recoverable Real Losses in New Jersey Utilities Statewide

Utility Population	**Water Supplied/Withdrawn, mg**	**Real Losses, mg**	**Potentially Recoverable Real Losses, mg**
NJ Dataset (76 Utilities)	45,090	5,421.6 = 12.02% of Water Supplied	2,241 = 4.97% of Water Supplied
Statewide in New Jersey (number of utilities is unknown)	394,200	(394,200)(0.1202) = **47,382.8**	(394,200)(.0497) = **19,591**

Table 6 illustrates that, by extrapolating the data from 76 utilities in the NJ Dataset to the total public water supply withdrawals in NJ (USGS Report) of 394,200 mg, it is projected that all water utilities in NJ experience **47,382.8 mg (129.8 mgd) of real losses, and that at least 19,591 mg (53.7 mgd) are potentially recoverable**. At the median VPC, the **value of the potentially recoverable real losses is $10,128,547 in reduced production costs.** Note that these estimates are derived from an extrapolation of values found in the NJ DRBC dataset. Audit reporting by utilities statewide would allow for more refined estimates of loss volumes and potential cost savings..

These findings suggest that improved leakage control can save considerable water, energy, and overall production costs for NJ water utilities. Additionally, improved leakage and pressure management can play a strong role in better sustaining and renewing water distribution infrastructure. Many NJ utilities have relatively old water piping infrastructure and disruptive leaks and water main breaks are a frequently unfortunate occurrence. NJ water utilities could prevent many such occurrences by employing improved leakage and pressure management.

The assessment of potentially recoverable losses (real and apparent) discussed herein reveals that good loss recovery potential exists for both types of losses. Loss recovery is attractive from the perspective of saving water and energy (through better leakage control) and increasing utility revenues and promoting equity among the rate-paying customer population (through better apparent loss control). This analysis keyed on utilities that have both high loss rates and high costs, thereby identifying the utilities with the greatest likelihood of developing a positive business case for focused loss control. However, all of the utilities in the NJ Dataset should ultimately review the losses and costs of their operations to determine the level of loss reduction that could be economically attained.

3. Summary

Kunkel Water Efficiency Consulting (KWEC) conducted an assessment of water audit data from New Jersey water utilities which included a comparison with validated water audit data of a larger dataset of North American water utilities. A number of findings and conclusions are drawn from this work, including:

1. **Data Quality**: NJ water audit data is un-validated and – not surprisingly – has a notably higher median Data Validity Score (DVS) of 75 compared to the NA Dataset's median value of 63. Investor owned utilities have a median DVS of 81 for 19 utilities, suggesting an over-statement of the validity of the water audit data of these systems. Every system is unique, thus applying the same data to a group of systems is less accurate. A number of data issues also occur in the NJ Dataset. **These findings suggest that additional training is needed for water utility staff in compiling the water audit, and that Level 1 validation is needed to "truth" the data and make it more representative of the operations of NJ utilities**.

2. **Apparent Loss Rates**: are notably less in the NJ Dataset compared to the NA Dataset. However, these losses are likely to be under-stated in the NJ Dataset; and cause real losses to be over-stated. Analysis found apparent losses of 790 mg (2.1 mgd) occurring in the NJ

Dataset. **It is projected that apparent losses for <u>all</u> NJ water utilities are likely to be approximately 6,898.5 mg (18.9 mgd), and 2,515.2 mg (6.9 mgd) of these losses are likely to be economically recoverable, with a potential revenue recovery of $12,576,000.**

3. **Real Loss Rates**: are notably less in the NJ Dataset compared to the NA Dataset. Analysis found real (leakage) losses of 5,438.5 mg (14.9 mgd) occurring in the NJ Dataset. **It is projected that real losses for <u>all</u> NJ water utilities are likely to be approximately 47,382.8 mg (129.8 mgd), with 19,591 mg (53.7 mgd) of these losses estimated to be economically recoverable, with a total production cost savings of $10,128,500.**

4. **Costs**: the median Variable Production Costs and Customer Retail Unit Costs of NJ utilities are both higher than the median value of utilities of the NA Dataset. **This generally gives NJ water utilities solid financial incentive to pursue loss reduction activities**.

The results of the analysis undertaken by KWEC to assess annual water audit data of New Jersey water utilities is likely the first study of its kind to develop estimates of potentially recoverable losses (apparent and real) for water utilities across the State. The findings show a good potential for water and energy to be saved, infrastructure to be better maintained, cost savings to be garnered by water utilities, and improved equity of payments for water customers to be achieved. It is time for all New Jersey water utilities to lay the foundation for cost-effective water loss reduction programs by completing standardized water audits on an annual basis and reporting validated results to their customers and state agencies.