The American Water Works Association
Water Conservation Division Subcommittee Report

WATER CONSERVATION MEASUREMENT METRICS

Guidance Report

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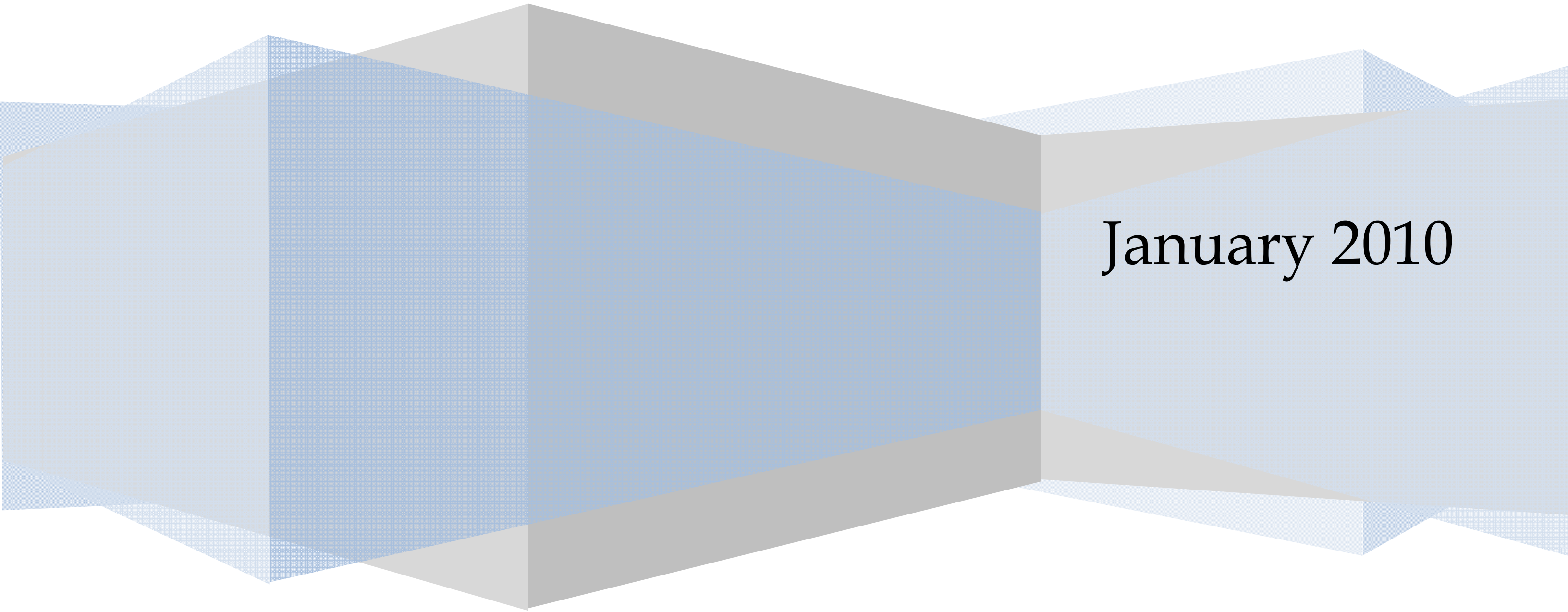

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The data obtained from the participating utilities were used to calculate a number of possible water use metrics, including a subset of metrics for comparing water usage and the associated water conservation effects over time. These metrics are discussed and illustrated with the case study data below.

5 METRICS OF AGGREGATE USE

Several different metrics of aggregated water use (system-wide) can be defined. All three characteristics portrayed in Table 1 above (i.e., average daily production, number of customer accounts, and population served) can be used to represent the size of the water system and its service area. However, these measures of system size do not convey information on the intensity (or average rates) of water use. The average rates of use can be obtained by dividing average daily production or total customer sales by a scaling variable. As mentioned before, the most commonly used scaling variable is population served. A popular metric of aggregate use is known as “per capita use” in gallons per capita per day. This metric is obtained by dividing average daily production (in gallons) by total population served. The appropriate use and limitations of this metric and the availability of alternative aggregate metrics are discussed below.

5.1 Per Capita Daily Production Metric

When calculating the per capita daily production (PQ_c) metric (where subscript *c* indicates per capita), the reported annual volumes of water produced should be matched with the population served in the retail service area. This requires that all wholesale water deliveries outside of the retail service area are metered and deducted from the production volume.[4] Also, any water imported into the distribution system should be added to production records.

Total population served is usually defined as total year-round resident population of the retail service area (urban planners sometimes define resident population as the number of people occupying space in the community on a 24 hour per day, seven-day-per-week, 52 weeks per year basis). Different water utilities use different definitions of population served and, regardless of the definition, in most cases the reported population served estimates represents best guesses of the actual but unknown number. Therefore, the annual per capita per day production (PQ_c) metric that is calculated by dividing annual water production by population served is usually inaccurate due to “definitional noise” in both the numerator and denominator of the metric.

Table 3 illustrates the values of the PQ_c metric that were calculated using data from the seven case study utilities. The values of the metric were obtained by dividing the average daily production numbers by population served.

The values in Table 3 show that per capita production rates change from year to year and differ greatly across the seven utilities. The last column and the last row show the average absolute deviation in the respective row and column data from the mean in each row or column. The average deviations across the utilities are generally six times greater than average deviations of annual data for each utility. Over relatively short time intervals, the year to year changes in a

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[4] Alternately, if the population served by wholesale customers is known, the PQ value can be calculated by dividing total production by the sum of retail and wholesale population served.

single utility are caused primarily by changes in weather conditions. The differences across utilities are caused by two main factors: climate and the composition of water users. Figure 1 shows a plot of annual per capita values for 2008 versus the difference between reference evapotranspiration and effective precipitation during the 5-month growing season (only the 2008 data were available for all seven utilities). For six utilities the per capita values are more or less aligned with the theoretical irrigation water requirement during the growing season. The value for Irvine Ranch lies farther away from the regression line. Water production in Irvine Ranch district includes about 8 mgd of water delivered to agricultural customers and 2.6 mgd in wholesale deliveries.[5] If these two quantities are subtracted from 2008 production, the per capita production would be 214 gpcd and the data point would be moved closer to the regression line.

Table 3. Calculated Per Capita Production Metric (PQ_c) for Participating Utilities

Utility/Year	2002	2003	2004	2005	2006	2007	2008	Average Deviation
Otay	227	206	212	207	209	203	189	7.2
Irvine Ranch	--	--	--	252	279	268	267	7.3
Phoenix	228	211	207	197	198	196	174	11.8
Rio Rancho	--	--	--	--	--	--	146	--
Seattle	109	111	112	100	102	97	95	6.0
Philadelphia	160	166	162	157	153	155	151	4.2
Tampa	--	--	130	112	117	124	116	5.8
Avg. deviation	46.5	35.0	35.9	47.8	52.3	48.5	40.7	44.7

GPCD = gallons per capita per day, -- = data not available. Seattle numbers are based on the sum of both retail and wholesale population.

The data points for Rio Rancho and Phoenix lie below the regression line. In the case of Rio Rancho, the seemingly outlying per capita production value may be partly related to a possibly imprecise estimate of population served. The U.S. Census estimate of the 2007 population for the City of Rio Rancho is 75,978 while the number used in Table 1 (obtained from Rio Rancho's website) is 80,000. Using this population, the per capita production would be 154 gpcd vs. the value of 146 shown on the graph. In Phoenix, the low 2008 value of 174 gpcd could not be explained by any possible imprecision in population or production.

According to the regression equation on Figure 1, per capita production increases by about 3.0 gpcd for each inch of irrigation requirement during growing season. The regression equation displayed on Figure 1 indicates that at zero requirement (when effective rainfall is equal to evapotranspiration) during the growing season the expected value of per capita production would be about 96.2 gallons per capita per day (gpcd). However, the 96.2 gpcd number has no practical value for deriving benchmark usage rates because of the differences in base climate. For example, it is unlikely that Phoenix would experience 96.2 gpcd during a growing season if precipitation was adequate for maintaining the urban landscapes. In essence, each locale or region should have its own regression line that best relates water use with local weather conditions.

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[5] It is important to note that while removing wholesale water from total production makes intuitive sense, removing agricultural deliveries would affect the difference in the composition of demand which tends to be unique in each utility.

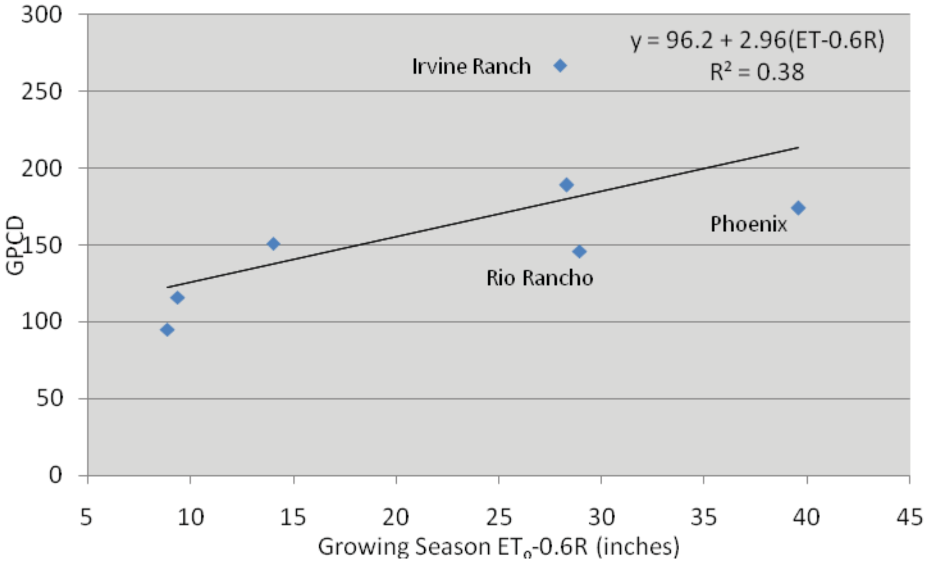

Figure 1. Relationship between Per Capita Production and Evapotranspiration minus Effective Rainfall during Growing Season

5.2 Alternatives to the PQ_c Metric

Because population served is difficult to measure (even if it is precisely defined), a more accurate measure of system size is needed. One measure of system size that is universally available is the number of water service connections. This measure can be defined precisely by making distinctions between specific characteristics of the various types of connections.

For example, a distinction can be made between retail and wholesale connections, metered and unmetered connections and connections with different meter sizes. Alternative definitions include active and inactive customer accounts, customer accounts with non-zero consumption or number of billed accounts. Table 4 compares the average water use per account (i.e., the PQ_a metric where subscript *a* stands for accounts) in the seven utilities. The advantage of this metric is that the data on the number of connections (or accounts) are available on an annual basis. The number of billed accounts is also available for each billing period (i.e., monthly, bimonthly or quarterly). Billed accounts would include all accounts receiving a bill including connections with no metered use – only fixed charges.

Table 4. Calculated Production per Account (PQ_a) Metric for Participating Utilities

Utility/Year	2002	2003	2004	2005	2006	2007	2008	Average Deviation
Otay	832	773	802	781	794	801	769	16.1
Irvine Ranch	--	--	886	868	943	908	892	20.9
Phoenix	865	799	775	743	753	738	659	44.0
Rio Rancho	--	--	--	--	--	--	393	--
Seattle	--	--	--	--	--	--	670	--
Philadelphia	554	570	557	552	539	543	515	12.7
Tampa	--	--	643	596	603	647	607	20.6
Avg. deviation	130.9	96.0	106.1	107.2	124.2	106.0	118.9	119.7

PQ_a = production per account per day in gallons, -- = data not available

As with the per capita production, the PQ_a metric can be used for comparing year-to-year changes in production per account in a single utility. The PQ_a metric is still inappropriate for inter-utility comparisons. The calculated values of the PQ_a metric in Table 4 for 2008 ranged from 393 gpad in Rio Rancho to 892 in Irvine Ranch. However, the 2008 values of PQ_a include wholesale deliveries of water in Otay, Irvine Ranch, Tampa and Seattle, while for Phoenix and Rio Rancho they do not. Therefore, the PQ_a metric can be standardized by narrowing down its definition to include only "water deliveries to the retail area" which would exclude the part of water production sold wholesale.[6] For example, if wholesale deliveries in Seattle are excluded, the value of the 2008 PQ_a metric would be 302 gpad. The PQ_a metric can also be refined further by using total metered sales as the numerator. This modification will remove the effect of non-revenue water, which is usually addressed by separate metrics. Furthermore, wholesale deliveries and agricultural sales can be removed from total metered sales.

Another improvement to the PQ_a would be to convert the total number of connections or accounts (which represent different types of customers or connection sizes) into the number of "equivalent connections" or "equivalent accounts", with reference to single-family accounts. The weights for converting non-single-family accounts into equivalent single-family accounts can be based on average annual consumption by customer type or by meter size (in utilities without customer type designation). The main reason for creating a number of equivalent accounts for each utility is to develop a scaling variable which is similar to population served. Table 5 compares possible weights for calculating the number of equivalent accounts in the six study areas. The city of Philadelphia does not use customer categories and the only feasible weights are those based on average consumption by meter size category.

The weighing ratios in Table 5 illustrate the differences in the composition of demands at the sectoral level. For example, it is important to understand why an industrial customer is on average equal to 106.5 single-family customers in Phoenix, but equal only to 19.6 single-family customers in Irvine Ranch. Also, it is worth determining why a multifamily customer in Tampa is equivalent to 28.6 single-family customers and equates only to 3.1 single-family customers in Rio Rancho. It was determined that in Rio Rancho the multifamily sector includes only tri- and four-plexes. Apartments with five and more units are classified as commercial. Apparently, in Tampa all residential customers other than single-family are included in the multifamily sector. These examples of customer class definitions indicate another source of definitional noise introduced by unique customer classifications schemes.

Table 6 shows the calculated weights based on the 2008 sales data for accounts with different meter sizes in Philadelphia. The single-family sector is assumed to be represented by the meter size of 5/8 of an inch.

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[6] However, the removal of the wholesale deliveries from the production data is not straightforward. Total production is metered accurately on the daily basis while the wholesale deliveries may be reported on monthly basis. Also, line losses between the production meter and the wholesale connection cannot be easily measured.

Table 5. Weighting Ratios and Equivalent Accounts Based on 2008 Sales Data

User Category	Otay	Irvine Ranch	Phoenix	Rio Rancho	Seattle	Tampa
Single-family	1.0	1.0	1.0	1.0	1.0	1.0
Multifamily	8.4	5.9	6.8	3.1	4.4	28.6
Commercial	3.9	11.9	4.9	9.1	--	4.8
Industrial	--	19.6	106.5	229.7	--	59.7
Governmental	--	36.6	14.5	9.1	--	2.4
Public/institutional	19.0	--	7.7	--	--	--
Irrigation (urban)	8.6	--	8.0	--	--	--
Construction	12.7	--	--	--	--	--
Other nonresidential	--	8.7	1.4		5.9	--
Recycled water	14.7	--	--	--	--	--
Fire service	0.03	--	12.2	12.8	0.03	--
Total production, mgd	37.1	88.2	272.8	11.7	125.1	75.9
Total retail sales, mgd	35.5	70.6	258.6	9.9	56.4	66.4
Total accounts	48,202	85,202	413,783	29,787	186,849	125,139
Total equivalent accounts	80,718	201,174	693,277	45,276	277,711	252,853
Retail sales per account (SQ_a), gpad	736	829	625	331	302	519
Sales per equivalent account (SQ_{ea}), gpad	440	351	373	218	203	257

Note: Agricultural deliveries are removed from the retail sales data for Otay and Irvine Ranch.

Table 6. Weighting Ratios Based on Meter Size for Philadelphia

Meter Size (Inches)	Number of Accounts	Gallons/ Account/Day	Consumption Weight
5/8	473,904	189	1.0
3/4	71	466	2.5
1	5,526	856	4.5
1-1/2	2,026	1,998	10.6
2	2,562	3,835	20.3
3	1,227	9,312	49.3
4	920	17,214	91.1
6	331	42,499	224.8
8	66	85,203	450.8
10	29	389,606	2,061.2
12	2	761,826	4,030.5
All accounts	486,664	347.3	--
Equivalent accounts	889,899	189.9	--

The equivalent weights in Table 6 approximately double for each increment in meter size with the exception of 10-inch meter where the weight more than quadruples. Because meter size information is available in all systems, the conversion based on meter sizes would provide a more standard measure of equivalent accounts than the conversion based on customer types; however, this depends on the assumption that accounts are appropriately metered.

5.3 Inter-utility Comparisons of Aggregate Metrics

Table 7 compares five aggregate consumption metrics. The first three metrics are based on total production; the other two are based on total retail sales of water. The five aggregate metrics shown in Table 7 vary among the seven utilities and would result in different ranking of the utilities. For example, Tampa has the lowest PQ_c value but it ranks as the fourth lowest according to SQ_{ea}.

Table 7. Calculated Aggregate Metrics for Participating Utilities for 2008

Utility	Production per Capita (gpcd)	Production/ Account (gpad)	Production/ Equivalent Account (gpad)	Retail Sales/ Account (gpad)	Retail Sales/ Equivalent Account (gpad)
Acronym	PQ_c	PQ_a	PQ_{ea}	SQ_a	SQ_{ea}
Otay	189	769	460	736	440
Irvine Ranch	267	919	438	829	351
Phoenix	174	676	393	625	373
Rio Rancho	146	393	258	331	218
Seattle	193	672	452	302	203
Philadelphia	151	515	282	347	190
Tampa	116	607	300	519	257
Average deviation	34	124	76	174	84
Coeff. of variability, %	27	26	24	40	34

gpcd = gallons per capita per day, gpad = gallons per capita per day

The average deviation and coefficient of variation (c.v.), shown in the bottom two rows of Table 7, indicate that the conversion of the PQ and SQ metrics to the equivalent account shows some improvement in these measures of dispersion over the metric values calculated based on the actual number of total accounts. Also, the coefficients of variation are nearly identical for per capita production (PQ_c) and production per account (PQ_a and PQ_{ea}). However, it is clear that the values obtained for these alternative aggregate metrics are unique to each water utility and their only appropriate use is for comparing trends in annual water usage over time at a single utility.

The problems with the definition and measurement of population served are among several reasons which make the aggregate use metrics inappropriate for comparing the calculated numbers among different utilities (i.e., inter-utility comparisons). The following is a brief listing of the shortcomings of the PQ and SQ metrics:

1. In order to compare PQ_c values across different water utilities, it would be necessary to standardize the measurement of "populations served." For example, the estimates of population served may account for commuters and part time residents (e.g., hotel guests, students, and seasonal residents). The term "functional" population served is used by

some utilities to describe the population served which is adjusted for hotel populations, commuter population and population in group quarters. However, regardless of its definition, population served cannot be measured precisely during each calendar year and will likely be a crude estimate of actual population, however it is defined.

2. The number of accounts used in calculating the PQ_a and SQ_a metrics can also be standardized, possibly through the use of equivalent accounts. Although, the number of accounts or equivalent accounts will be more accurate than population served, the aggregate production or sales metrics cannot be compared across different utilities, because of differences in the composition of sectoral demands.
3. Because the PQ and SQ values will change in response to weather condition, even the utility-specific year-to-year values cannot be meaningfully compared unless the annual water production or total sales are normalized for weather conditions. Adjustments for weather conditions would also be required in order to make the values of aggregate metrics comparable across different utilities, however no meaningful "weather normalization" for multiple locations is generally possible because of fundamental differences in prevailing climate.
4. An absolute benchmark value of the PQ_c or SQ_a metric for all utilities would be impossible to develop even if a precise definition/measurement of population served is used and the adjustments in total production for actual weather conditions are made. The main confounding factor is the difference in the composition of municipal demands which stems from different housing types and a different mix of industrial and commercial activities. For example, a utility with a higher share of commercial and industrial activity in total demand would be expected to have a higher PQ_c value than a utility in which total demand is almost entirely for residential use.
5. Even if two different utilities have the same per capita production rate or average sales per account, and the same sectoral make-up, it would be difficult to judge their relative efficiency if they differ in terms of the determinants of water use that are unrelated to efficiency–such as type of housing stock, average lot size, family incomes, and several other factors. Therefore, without additional information and analysis, one cannot simply assume that a lower (higher) per capita rate is indicative of higher (lower) water using efficiency.

A meaningful comparison of per capita production or average annual sales per account should attempt to account for these types of influences on water use within and among communities. However, the aggregate nature of the PQ and SQ metrics and the infeasibility of developing a single benchmark value for all utilities make these metrics inappropriate for inter-utility comparisons.

6. SECTOR-WIDE ANNUAL USE METRICS

Year-to-year changes in the annual average values of aggregate metrics at a given utility are a result of different weather conditions and changes in the "structure" of total demand. For example, total demand will decrease (or increase) if there is a decline (or increase) in nonresidential customer accounts with water-intensive activities. Some structural changes can also take place in the residential sector. For example, there could be a substantial increase (or decrease) in the number of residences with automatic sprinkling systems or swimming pools.

8.1 Single Utility Comparison

When comparing metrics for a single utility over time it should be sufficient to adjust the calculated metrics for weather conditions. Year-to-year changes in the number of users are accounted for by the scaling variable, while any small changes in other determinants of water use can be neglected over relatively short time intervals. The weather adjustment can be performed directly on the calculated value of any metric with the use of parameters that capture the sensitivity of water use to weather. The two key variables which are used in modeling the effects of weather on urban water demand are precipitation and air temperature. The weather-normalized value of the metric can be calculated as:

$$OUM_{atn}^{SF} = OUM_{at}^{SF} \cdot \left(\frac{T_n}{T_t}\right)^{\alpha} \cdot \left(\frac{R_n}{R_t}\right)^{\beta} \tag{5}$$

Where:

$\mathrm{OUM}_{\mathrm{atn}}^{\mathrm{SF}}$ = weather-normalized single-family outdoor use metric in gallons per account in year t

$\mathrm{OUM}_{\mathrm{at}}^{\mathrm{SF}}$ = calculated value of the metric in gallons per account in year t

T_t = average daily air temperature during the growing season of year t

T_n = normal value of average daily air temperature during the growing season

R_t = total rainfall during growing season in year t

R_n = normal value of total rainfall during growing season

α, β = constant elasticities of temperature and precipitation, respectively

atn = subscripts designating per account use *a* and normal year weather *tn*

Normalizing water use for changes in socioeconomic conditions in a single utility is possible using essentially the same normalizing technique as for weather. All metrics can be normalized for socio-economic conditions. For example, when comparing the $\mathrm{OUM}_{\mathrm{a}}^{\mathrm{SF}}$ metric between two different years, the adjustments for differences in average housing density and average home value can be made using the formula:

$$OUM_{ant2}^{SF} = OUM_{ant1}^{SF} \cdot \left(\frac{D_{t2}}{D_{t1}}\right)^{\lambda} \cdot \left(\frac{V_{t2}}{V_{t1}}\right)^{\eta} \tag{6}$$

Where:

OUM_{ant2}^{SF} = weather-normalized residential single-family outdoor use per account/day in t2

OUM_{ant1}^{SF} = weather-normalized residential single-family outdoor use per account/day in t1

D = average housing density

V = average home value

λ, η = constant elasticities of housing density and home value variables, respectively.

The elasticities that are used in calculating the adjustments should accurately reflect the responsiveness of water use to changes in the values of determinants of water use. Elasticities will vary by user sector. Ideally, the elasticities of the determinants should be obtained from water demand studies for the utility in which the comparisons over time periods are to be made. However, if such studies are not available, then it is possible to derive "generalized" values of elasticities based on the available published studies of water demand.

8.2 Cross-Utility Comparison

Metrics for comparing efficiency of water use across different utilities would have to ensure that all external factors which influence and confound the unit quantity of water used, but are outside the control of water users, are "corrected for." This means that additional data collection and analysis would be required in order to differentiate between the effects of water efficiency improvements and other factors that can affect average rates of water use.

For example, even when comparing a relatively homogeneous sector of single-family residences, because of local conditions, one community could have smaller single family parcels and fewer swimming pools than another community. Per capita residential usage in a more densely developed area would likely be lower than in an area with lower density of single-family housing. Also, the denser urban community could have a greater opportunity to increase indoor water efficiency through the replacement of plumbing fixtures, whereas less dense suburban counterparts might have a greater opportunity to increase the efficiency of landscape watering practices. Because it is possible these situations could be independent of water-use efficiency levels, the unadjusted usage rates cannot be used to infer water efficiency levels. Without additional information, simple comparisons of average water usage rates cannot reveal underlying technological or behavioral practices regarding water efficiency or differentiate among the several market and non-market forces that shape residential demand.

Normalization for weather and other confounding factors across different utilities is problematic. Because of fundamental differences in normal weather within particular climatic zones and the relative presence of particular water end uses even within the same climatic zone, there is no easily accessible way to use such normalization procedures for inter-utility comparisons. Thus, the best approach is to derive a benchmark value of a metric for each utility and divide the weather-normalized value of the metric by a theoretical (derived) value of the benchmark (representing an efficient level of water use).

Therefore, a practical approach to developing metrics for comparing water use efficiency between utilities would be to use metered account-level information for homogeneous groups of customers and the same dimensions of water use (i.e., total annual, seasonal, non-seasonal), then convert the values of the calculated metrics into ratio benchmarks for each utility before making a comparison.

9. WATER CONSERVATION BENCHMARKS

9.1 Water Loss Metrics and Benchmarks

A number of metrics and one ratio benchmark are available for assessing the level of water losses in the water supply and customer billing systems. Several are listed in Table 18 and are briefly discussed below.

Category of Metric	Symbol	Description	Selected Advantages	Selected Limitations
	IUM_c^{MF}	Indoor (nonseasonal) multifamily use metric per capita	Scales indoor use for average number of people residing in households.	irrigated acreage would improve use of account-level data Heterogeneity of customers and class definitions for multifamily and nonresidential categories limits inter-utility comparisons
	OUM_a^{MF}	Outdoor (seasonal) multifamily use metric per account	Isolates weather-sensitive uses	
	IUM_a^{NR}	Indoor (nonseasonal) nonresidential use metric per account	Indoor use perhaps less variable than sector-wide use	
	OUM_c^{NR}	Outdoor (seasonal) nonresidential use metric per account	Convenient measure of weather-sensitive uses	
Leakage and Loss	NRW	Nonrevenue water	Easily computed from commonly available data	Combines real and apparent water losses
	CARL	Real resource loss	Focuses on real (physical) losses	Does not provide any allowances for unavoidable leaks
	ILI	Infrastructure leakage index	Can be used for inter-utility comparisons	Rigid formula for assessing unavoidable leaks
Conservation Indices	ICI^{SF}	Indoor single-family conservation index	Ratio benchmarks with 1.0 target/goal value Can be tailored to reflect service area end use and weather characteristics Can be used for inter-utility comparisons	Indoor use measure may include outdoor uses using minimum month estimation methods Requires definition and calculation of benchmark usage rates for indoor and outdoor use Outdoor benchmark values require multiple assumptions to reflect service area characteristics
	ICI^{MF}	Indoor multifamily conservation index		
	OCI^{SF}	Outdoor single-family conservation index		
	OCI^{MF}	Outdoor multifamily conservation index		

All metrics in Table 25 except the conservation indices are best suited for making comparisons of water use at a single water utility. The ILI, ICI and OCI metrics can be used (with some fundamental caution) in cross-utility comparisons.

10.2 Key Findings

The analysis and comparison of the values of different metrics for the seven case study utilities resulted is several relevant findings. The following is a summary of key findings.

1. Available water production and sales records can be used to calculate both system-wide and sector-specific metrics of water use. However, the only accurate and regularly updated measure of system size is the number of connections or customer accounts. Other measures of system size such as population served, number of housing units, or the number of employees are not precisely defined and at best are updated only on annual basis. For this reason the commonly used metric representing annual production per capita, or GPCD, should not be used as a benchmark.

2. Useful sector-specific metrics can be defined and calculated precisely. However, each water utility uses a different system for classifying customer accounts. This makes it difficult to consolidate the existing customer types into user sectors such as residential, commercial, industrial, and institutional and others. Even if such sectoral groupings are made, their customer characteristics and composition may vary across different utilities.

3. Both system-wide and sector-wide metrics can be used to track water usage per account over time. However, the year-to-year changes of the values of each metric have to be carefully interpreted. These changes may have different causes; oftentimes changes in water use that are related to weather conditions and/or the composition of water users can mask or overwhelm changes in use resulting from water conservation efforts.

4. No metrics of water use (measured in absolute terms) should be used for judging relative water use efficiency across different utilities. Different utilities will likely display uniqueness in terms of the climate and composition of demands in their respective service areas. Only ratio metrics such as the Infrastructure Leakage Index (ILI) with a benchmark value of 1.0 could be used (although with some caution) for inter-utility comparisons.

5. Ratio-type benchmarks can be formulated for different components of sectoral water use. These benchmarks can be compared across different utilities; however the absolute benchmarks on which such ratios are based should be unique to each utility. For example, the proposed Indoor Conservation Index (ICI) would be based on an efficiency goal of indoor use that would take into account specific conditions of each utility.

6. A promising way for developing metrics, absolute benchmarks, and efficiency goals is to disaggregate sectoral demands into specific end uses. End-use specific benchmark values can be formulated based on technological standards and assumptions regarding the intensity or frequency of use. Measurement of water use at an end-use level would naturally improve the indoor and outdoor metrics discussed in this report. Unfortunately, highly disaggregated end use data are not available in most water utilities.

10.3 Recommendations

The results of this study lend support to two major recommendations: one pertains to the data and water use records and the other to the development of supportive information for the conservation benchmarks.

1. Significant improvements in the ability of water utilities to reduce definitional noise and monitor water usage rates over time would be achieved if the water supply industry adopted a standard set of customer types and customer classification procedures. This ability would be enhanced further if water utilities collected and maintained additional characteristics for each customer. These would depend on customer type and could include such measurements as irrigated area, number of dwelling units, number of employees and the presence of specific end uses such as swimming pools or evaporative coolers.[11]

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[11] The authors of this report and some members of the study review committee are currently developing a tailored collaboration study approach for determining information management needs for utility planning.