PUBLIC REVIEW DRAFT REPORT TO THE LEGISLATURE ON RESULTS OF THE INDOOR RESIDENTIAL WATER USE STUDY

DWR WUE

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Acknowledgments:

The Department of Water Resources sincerely thanks the participation of members of the public, stakeholders, members of the Water Use Studies Working Group, technical advisor consultants, participating suppliers, and State Water Resources Control Board staff. Without their input, feedback, and dedicated effort, this report and its comprehensive evaluation of indoor residential water use would not have been possible.

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1.0 INTRODUCTION

1.1 Background

Water planning has always been important for urban retail water suppliers (Suppliers) but is even more critical today, as development progresses and California grapples with frequent droughts and expected long-term climate impacts. Prior to the adoption of the Urban Water Management Planning (UWMP) Act in 1983, there were no specific requirements that mandated urban water suppliers to conduct long-term water resources planning. While many Suppliers did conduct long-term water planning, those that did not were more vulnerable to supply disruptions during dry periods and catastrophic events. Urban water management planning is needed at the local level because only local Suppliers have the knowledge and ability to tailor their planning to their unique conditions and involve their local community in the planning effort.

The UWMP Act has been modified over the years in response to the State's water shortages, droughts, and other factors. A significant amendment was made in 2009, after the drought of 2007- 2009, as a result of the Governor's call for a statewide 20% reduction in urban water use by the year 2020. This was the Water Conservation Act of 2009 (SB X7-7, Steinberg). SB X7-7 required agencies to establish water use targets for 2015 and 2020 in order to achieve a statewide goal of 20% reduction in urban per capita water use by 2020. This was a major shift in the approach to water management planning (www.drought.gov). This volumetric reduction approach to water use efficiency was a precursor to the current approach to water use efficiency and water resources management that is based on standards and objectives.

In 2018, two policy bills were enacted by the California Legislature, Assembly Bill 1668 (AB1668, Friedman) and Senate Bill 606 (SB606, Hertzberg), collectively referred to as the "2018 Water Conservation Legislation." The 2018 Water Conservation Legislation revised the California Water Code (Water Code) enacting measures aimed at adopting long-term standards for the efficient use of water as we move beyond 2020 and into a water future where water supplies and uses will be greatly affected by climate change, population growth, and new development. These standards are the basis of determining Suppliers' water use objectives to ensure efficient beneficial use of the State's limited water supplies. This approach to water use efficiency, based on standards and objectives, is informed by the framework for one of the four SB X7-7 methods that could be used to calculate water use targets.

From the 2018 Water Conservation Legislation, a Supplier's ***water use objective is determined by the sum of the following standards***, considering local conditions and characteristics (population, landscape area, and others):

1. Indoor residential water use standard for efficient use.
2. Outdoor residential water use standard for efficient use.
3. Large commercial, industrial, and institutional (CII) landscape areas irrigated with dedicated meters or in-lieu technologies standard for efficient use.
4. Water losses.
5. Variances for unique uses of water that have a material effect (for example, seasonal populations that may artificially increase the calculated water use per person).
6. Bonus incentives for potable reuse.

1.2 How Water Use Standards Are Used

All of the standards will apply to Supplier service areas on an annual aggregate basis; they will not apply to individual customers nor will they be assessed daily or monthly. The standards are applied to the Supplier's conditions and characteristics and summed to represent the Suppliers' "urban water use objective". This allows a Supplier to be above or below any individual efficient water use standard, so long as the Supplier's annual water use does not exceed the aggregate sum of all the standards plus variances and bonus incentives terms (water use objective).

The Suppliers' water use objectives are effective after June 2022, when the State Water Resources Control Board (Water Board) adopts urban water use efficiency standards, performance measures, and variances. The 2018 Water Conservation Legislation does not modify the current statewide goal of a 20-percent reduction in urban per capita use by 2020 or limit individual customers' water use.

1.3 Statutory Indoor Residential Water Use Standard

The indoor residential water use standard is a service area average for indoor residential water consumption in order to accommodate inherent variability in local service area characteristics and individual customer needs and use (Water Code §10609(a)). The indoor residential water use standard was set by the Legislature, independent of the other standards, as:

Water Code Section 10609.4:

> *(a) (1) Until January 1, 2025, the standard for indoor residential water use shall be 55 gallons per capita daily.*
>
> *(2) Beginning January 1, 2025, and until January 1, 2030, the standard for indoor residential water use shall be the greater of 52.5 gallons per capita daily or a standard recommended pursuant to subdivision (b).*
>
> *(3) Beginning January 1, 2030, the standard for indoor residential water use shall be the greater of 50 gallons per capita daily or a standard recommended pursuant to subdivision (b).*

DWR's Directive

Water Code Section 10609.4

> *(b) (1) The department, in coordination with the board, shall conduct necessary studies and investigations and may jointly recommend to the Legislature a standard for indoor residential water use that more appropriately reflects best practices for indoor residential water use than the standard described in subdivision 10609.4 (a)(1).*

1.4 Development of Remaining Standards

The outdoor residential and CII large landscape irrigation efficient water use standards, along with the variances, are set through a process where the Department of Water Resources (Department) conducts studies, in coordination with the Water Board, and makes recommendations to the Water Board by October 1, 2021, for the Water Board to adopt as regulation.

1.5 Stakeholder Process

In developing these studies and standards, Stakeholder collaboration is required by statute (Water Code Section §10609.4(b)(2))[1].

The Water Use Studies Working Group was formed by the Department in July 2019 and comprised of water suppliers, non-governmental organizations, and State and local agency personnel. Three meetings were held with this 33-member Working Group to present and solicit stakeholder feedback on the study approach, study results, and the Department and Water Board proposed joint recommendations. Stakeholder meetings were open to the public with attendance typically over 180 participants.

Additional public outreach and engagement was accomplished through meetings requested by individual stakeholders, the Association of California Water Agencies (ACWA), and a presentation given at the California Water Efficiency Partnership (CalWEP) Peer to Peer Conference (December 8, 2020). The indoor residential water use study team also received feedback from the 18 Suppliers' study participants who were selected to provide data and collaborate with the Department on the study.

Beginning October 2019, monthly coordination meetings were held with the Water Board. Shortly thereafter, beginning July 2020, weekly and bi-weekly coordination meetings were held to collaborate on the study and development of the joint recommendations.

1.6 Study Purpose and Goals

Following the legislative directive of Water Code §10609.4(b), the Department, in coordination with the Water Board, conducted a study on indoor residential water use and prepared this report. In accordance with the

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[1] Water Code Section 10609.4 (b) (2) The studies, investigations, and report described in paragraph (1) shall include collaboration with, and input from, a broad group of stakeholders, including, but not limited to, environmental groups, experts in indoor plumbing, and water, wastewater, and recycled water agencies.

legislative directive, this study was to include the information necessary to determine if a recommendation was needed and if so, support any joint recommendation made with the Water Board on a different indoor residential water use standard that more appropriately reflects best practices (Water Code §10609.4(b)(1)). The goals of this study and report were to:

- Identify what the current or baseline, statewide average indoor residential water use is in gallons per capita (person) per day (R_i-gpcd) for California. This information can be used to determine how different the baseline is from any standard.
- Identify whether demographic or geographic factors associated with Suppliers may relate to high (or low) R_i-gpcd.
- Identify the current and future projected statewide Supplier R_i-gpcd distribution to:
    - Inform how many suppliers and total population would be affected and how much water savings may be achieved with any standard.
    - Ensure that lower income service areas are not disproportionately affected by any standard.
    - Inform if statewide climate zones/hydrologic regions are disproportionately affected by any standard.
- Qualitatively identify benefits and impacts on water supply, recycled water, and wastewater systems of a changing indoor residential water use standard.
- Inform the joint recommendation for an indoor residential water use standard that more appropriately reflects best practices.

1.7 Overall Study Approach

With the technical assistance of acknowledged water use experts and in consultation with Suppliers, the Department developed a robust study plan to estimate the current statewide average per-capita indoor residential water use (R_i-gpcd) and the current distribution of Supplier service area average

(R_i-gpcd). The current distribution of Supplier R_i-gpcd was also projected for 2025 and 2030 in order to capture the effects of a stepped-down standard.

The difficulty in analyzing indoor residential water use is that residential water meters measure total residential water use and as such, do not distinguish between indoor and outdoor water use; indoor use must therefore be inferred from the total residential water use through calculations or models in a process referred to as 'disaggregation'.

The Department used total residential water use data from three main sources to characterize the current statewide average indoor residential water use and both the current and future projected distribution of indoor residential water use across all Suppliers.

1.7.1 Baseline Indoor Residential Water Use

The current statewide average indoor residential water use (Baseline) analysis was determined to allow for a direct comparison with the SB X7-7 2020 statewide average total water use target of 158 gpcd [2] because the legislative directive for efficient water use standards includes ensuring that the overall per-capita water use remains below the SB X7-7 water use target for 2020. This analysis used customer-level data from the entire service areas of 18 Suppliers, which provides for a robust statistical analysis at the Census tract-, Supplier service arear-, and state-level. This approach stands in contrast to previous disaggregation studies of residential water use that typically relied on simple methods applied to monthly water use data that had been rolled-up to the Supplier-level or very short duration, high-frequency data from a few carefully selected customers[3]. Although the few high-frequency water use studies can provide accurate results, the short duration and limited number of metered sites do not allow for a robust

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[2] State of CA, CNRA, Department of Water Resources, August 2017, Status of 2015 Urban Water Management Plans, A report to the Legislature pursuant to Section 10644 and 10608.42 of the California Water Code
[3] Mayer, P.W., W.B. DeOreo, et. al. 1999. Residential End Uses of Water. American Water Works Association Research Foundation, Denver, CO.; DeOreo, W.B., P. Mayer, J. Kiefer, and B. Dziegielewski. 2016. Residential End Uses of Water, Version 2. Water Research Foundation. Denver, CO

statistical analysis or an accurate characterization of Supplier service area or statewide indoor residential water use.

The baseline analysis was conducted using primarily customer-level monthly billing data from 18 Suppliers and United States Census (Census) tract characteristics that represent the diversity of all Census tracts in California. Hourly meter read data from Advance Meter Infrastructure (AMI or Smart Meters) was also explored to see if hourly data could provide a more precise analysis.

1.7.2 Supplier R_i-gpcd Distribution

Because the baseline analysis was performed using only 18-Suppliers' customer-level monthly data, a simple disaggregation analysis of rolled-up, Supplier service area (Supplier-level) water use data, reported annually to the Water Board (electronic Annual Report [eAR] data), was used to characterize the distribution and range of Supplier R_i-gpcd. This distribution analysis estimated Supplier level R_i-gpcd from the eAR data using one of the simplest methods that was also used in the baseline analysis. The resulting Supplier-level R_i-gpcd distribution analysis allows for an estimate of the magnitude of any standard's effect (i.e., how many suppliers and population could be affected by any standard). A comparison of the Supplier-level R_i-gpcd analysis to the baseline study results, described in Section 4.1, and using the more robust methods and data, confirmed the applicability of using the monthly Supplier-level data to inform the R_i-gpcd distribution.

1.7.3 Projected Statewide R_i-gpcd in 2025 and 2030

The current Water Code indoor residential water use standard steps down in 2025 and again in 2030. To assess the suitability of long-term standards, it was important to estimate what the Supplier-level R_i-gpcd will be in the future. Future Supplier-level R_i-gpcd was projected to 2025 and 2030 by applying estimates of 'natural' water use reductions due to plumbing codes and 'natural' appliance turnover rates, by county.[4] These 'natural' reductions (passive conservation) are based on estimates of new housing built to

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[4] M Cubed, August 2016, TM - Projected Statewide and County-Level Effects of Plumbing Codes and Appliance Standards on Indoor gpcd, (see Appendix F)

current water efficient codes, turnover of existing housing stock subject to efficient toilet and fixture requirements, as well as replacement of old appliances with newer water-efficient appliances. This projection did not include any adjustments in indoor residential water use for potential pandemic effects, changes in population, or accelerated reductions from conservation programs (active conservation).

1.7.4 Benefits and Impacts

To address Water Code Section §10609.4(b)(2), a qualitative analysis was performed on water supply, wastewater, and recycled water systems' benefits and impacts that may result from a changing R-gpcd standard. Benefits and impacts to these inter-related sectors are highly variable and depend on local systems' conditions, as well as the magnitude of the effect of a changing standard within the local agencies service area. As such, a quantitative analysis is beyond the scope of this study.

1.8 Best Practices

This study is required to include the information necessary to support a different indoor residential water use standard that more appropriately reflects best practices (Water Code §10609.4(b)(1)). These "best practices" can include practices that Suppliers can implement (e.g., fixture and appliance rebate programs, conservation education, leak detection programs) and those that individual customers can implement (e.g., actual fixing of leaks, replacing appliances and fixtures, and changes in behavioral water use patterns). In considering best practices, it is important to note that while water use efficiency improvements depend on both Suppliers and their customers implementing best practices, the indoor residential water use standard applies only to Suppliers and not to individual customers.

California's urban water supplier best management practices and potential-best management practices were developed in the late 1990s and 2000s and administered through the California Urban Water Conservation Council (CUWCC) and now maintained by the California Water Efficiency Partnership

(CalWEP). Cost-effectiveness has always been a key consideration for selecting best practices in California.[5]

There is guidance on ongoing best practices available through partnerships including: the Alliance for Water Efficiency[6], California Water Efficiency Partnership (CalWEP) (formerly the California Urban Water Conservation Council (CUWCC) established in 1991), SoCal Water$mart (established in 1990), Regional Water Authority Water Efficiency Program (formed in 2001)[7], Santa Ana Watershed Project Authority (established in 1968)[8],and Bay Area Water Supply & Conservation Agency (established in 2002)[9] to name a few.

How effective or appropriate a best practice is will depend on a number of factors including: cost, saturation (e.g., how many customers have already replaced high water use fixtures and appliances with efficient ones), customer behavior and culture (e.g., how long people shower or how many times they flush their toilets), water conservation programs currently being implemented, demand hardening,[10] as well as local conditions such as climate, water scarcity, pricing, and other factors.

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[5] California Water Efficiency Partnership. Utility Operations BMP Implementation Guidebook, https://calwep.org/wp-content/uploads/2020/04/UtilityOperationsGuidebook.pdf
[6] Alliance for Water Efficiency Water Conservation Programs, Planning, and Evaluation, https://www.allinaceforwaterefficiency.org/rsources/programs. Accessed April 1, 2021.
[7] Regional Water Authority Water Efficiency Program Available at: https://rwah2o.org/programs/wep/. Accessed April 1, 2021.
[8] Santa Ana Watershed Project Authority. Water Use Efficiency Info and Tools to Assist Retail Water Agencies. Available at: https://sawpa.org/water-use-efficiency/. Accessed April 1, 2021.
[9] Bay Area Water Supply & Conservation Agency. Available at: (http://bayareaconservation.org). Accessed April 1, 2021.
[10] Investments in long-term conservation programs can make achieving demand reductions difficult during periods of extended shortage since there is less discretionary use for the customers to cut back.

A good way to understand why a service area demonstrates high (or low) R_i-gpcd, is through a comprehensive End Use study.[11] A comprehensive End Use study can identify the household factors that influence indoor and outdoor residential water use and their specific effects on service area R_i-gpcd. End Use studies can identify the efficiency of a residence's fixtures and appliances, presence of leaks, and customer water use patterns, all of which affect indoor residential water use. End Use studies also allow for an estimation of what appropriate best practices might be and what effect those could have on the service area R_i-gpcd. A comprehensive End Use analysis was not conducted for this study because of time and resource constraints.

2.0 METHODS

Included in this section are the methods used to estimate and evaluate the statewide indoor residential water use for the Baseline and the Supplier Distribution. This section presents the different types of data that were available and used in the analyses, the methods of disaggregating total residential water use into its indoor and outdoor components from monthly billing data, hourly meter reads, end-use (pilot study) components, and aggregate water use reported by Suppliers to the State Water Board. Also discussed, is a comparison of indoor residential water use estimates for single-family and multi-family dwelling units. Details on methods are included in Appendices A - G.

2.1 Indoor Residential Use Study Components

The statewide baseline R_i-gpcd and R_i-gpcd distribution among Suppliers was estimated based on disaggregating single-family total residential water use data[12] to separate out the indoor fraction.

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[11] Unique local conditions are recognized in Water Code and may be subject to variances (CWC §10609.14) such as high seasonal populations where service area RI-gpcd does not reflect service area indoor residential water use because the population count does not capture all of the water users.
[12] Multi-family residential water use data was disaggregated for a few of the 18-Suppliers and the estimated RI-gpcd were found to be not very different, on average, than single-family RI-gpcd. However, inherent difficulties in

Customer-level data is the most appropriate data for determining indoor residential water use. Collecting and analyzing customer-level data from all 400-plus Suppliers in California was not feasible within the timeframe[13]. Therefore, a subset of 18 Suppliers was selected to conduct the analyses for the baseline statewide central tendency (e.g., average). The 18 Suppliers were selected to provide a good geographic mix of tracts and sufficient variation in household and tract characteristics to build models for estimating the baseline R_i-gpcd. Refer to Appendix D – Sample Selection Tool Description and Appendix E – Sampling Strategy to Estimate Central Tendencies for details on Supplier selection and suitability for analysis. The baseline analysis was then augmented with analysis of a larger set of Supplier-level aggregated values in order to better inform the distribution and range of Suppliers' R_i-gpcd. Figure 2.1-1 shows the location of Suppliers contributing to this study:

disaggregating total residential water use into indoor and outdoor components from multi-family account data resulted in extreme variability between census tract averages of Single- and Multi-family RI-gpcd estimates within a Supplier's service area.

[13] For the Department to acquire the customer-level data used in the disaggregation analyses, a Non-Disclosure Agreement (NDA) with Suppliers was needed to protect private information pursuant to the California Consumer Privacy Act of 2018. Obtaining signed NDA's with and data from each supplier can be a lengthy process, is not always guaranteed, constitutes hundreds of thousands to millions of monthly records, and is subject to the Suppliers' agreement and resources constraints.

Figure 2.1-1. Study Participants and Locations [14]

2.1.1 Baseline Analysis for Statewide Central Tendencies

The statewide baseline central tendencies provides a measure of the statewide current average R-gpcd for comparison with the SB X7-7, 20-percent reduction in statewide average per capita water use by 2020 target. Customer-level monthly billing data from 18 Suppliers distributed throughout California allowed for use of four different disaggregation methods and two statistical methods for extrapolating results to Supplier service areas and for statewide Baseline. Suppliers used for the baseline analysis were selected

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[14] In addition to the monthly disaggregation participants shown, the following suppliers also participated in the hourly disaggregation: Eastern MWD, Folsom, Redwood City, and Sacramento

based on service area characteristics that represent demographic characteristics known or suspected to affect indoor residential water use based on the results of previous studies as summarized in described in Section 2.2.1 and described in Appendix C – Pilot End-Use Analysis.

The statewide estimates of indoor residential water use is the average of 2017, 2018, and 2019 data to represent baseline conditions (2020 will not be available until summer 2021). This three-year average was used because high variability in water use from year to year precludes use of a single-year, where possible. Additionally, water use during the 5-year California drought from 2011-2016[15] that preceded 2017 does not represent 'normal' conditions because of the associated voluntary and regulatory required reductions and overall water use has changed considerably in the past two decades.

Although 2017 may retain some lingering effects associated with the 5-year drought, 2018 was a below normal water year[16] that may have encouraged extra water use. Based on the expertise of the technical advisory team, the average of all three years provides a reasonable 'current' indoor residential water use estimate in the absence of detailed information about individual Supplier and customer practices during that time frame.

Disaggregated customer-level data from the 18-Suppliers' were rolled up to the tract level and combined with American Community Survey (ACS) tract-level data and characteristics. A key assumption is that the tract estimates from the 18-Suppliers are representative of similar tracts statewide. Using this assumption, two different approaches were then used to extrapolate the tract estimates of R_i-gpcd used for estimating the statewide Baseline:

1. Strata-Based Approach
2. Correlation-Based Approach

Two types of analyses were run on the tract-level averages of R_i-gpcd from the 18-Supplier customer-level data. Because the tract-level averages are

[15] https://www.drought.gov/states/california#historical-conditions
[16] http://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST

based on customer-level data, confidence intervals for the averages (margins of error) could also be determined.

Strata-Based Approach

The Strata-Based Approach divided up all 8,057 tracts within California and classified them into 'strata' or 'bins' with similar demographic characteristics as derived from the ACS data. Tracts were grouped into 54 different strata based on similarities in their ACS characteristics including the representation of population over 65, age of housing stock, and median household income (refer to Appendix E for more details):

- **Age of housing stock.** Age of housing is well-documented as affecting indoor residential water use because of housing codes in effect at the time of construction, as well as wear and tear on household water infrastructure fixtures and appliances. This study did not look at what effects retrofit and replacement programs may have had on baseline water use.
- **Median Household Income and Disadvantaged Community Status.** Higher economic status can indicate a greater likelihood of home improvements that could reduce indoor residential water use. Additionally, in high income areas, there may be fewer people in larger residences.
- **Population over 65.** The population over 65 is expected to capture situations where customers are home during the day and may show higher residential water use.

For example, a 'bin' may be created for all tracts with median plus or minus 25 percent: population over 65, median household income, and housing built after 2000. Some of the tracts in this bin would have estimated R_i-gcpd, some would not.

Rolled-up customer-level R_i-gpcd estimates were derived for each sampled Census tract (tract estimates). The population-weighted average of these tract estimates were then used as the best estimate of R_i-gpcd for entire strata the tracts fell within (e.g., population-weighted average of all sampled tracts that fell within the bin for 25-percent less than to 25-percent more than median population over 65, median household income, and housing built after 2000). Next, the strata-level estimates were aggregated to the statewide-level with strata population serving as the weight. Because the tract estimates also have an associated standard error based on the customer-level data analysis, these error terms could be carried through to the strata estimates and statewide aggregate Baseline (assuming independence of standard errors across tracts) to generate a confidence interval for the estimated Baseline for each disaggregation method.

The advantage of the Strata-Based approach is that minimal assumptions are made about what household characteristics cause variations in tract estimates of R_i-gpcd. As long as the Suppliers selected for producing the tract estimates have sufficient tract diversity to be representative of statewide diversity, this Strata-Based roll-up can lead to robust statewide estimates. A more detailed description of how strata are defined, the total number of tracts within each strata, and the number of sampled tracts from the 18-Suppliers within each strata statewide is included in Appendix D - Sample Selection Tool Description.

Correlation-Based Approach

Using the same 18-Supplier tract estimates, correlations using regression models were developed based on ACS tract characteristics as opposed to strata classifications. For example, instead of using a 'bin' average for all tracts within the strata, the tract estimates were correlated with each tract's actual percent population over 65, median household income, and housing built after 2000. A regression equation was developed to model this relationship between factor percentages and tract estimate of R_i-gpcd. This analysis allowed for exploration of tract characteristics that can explain variation in R_i-gpcd across tracts, which may provide meaningful policy insights.

The model included factors for:

- Proportion of housing in a tract built pre-1979
- Proportion of housing in a tract built between 1980-1999
- Proportion of housing in a tract built after 2000
- Tract median household income
- Proportion of tract population over 65
- Total residential per-capita water use (R-gpcd)

The resulting R_i-gpcd equations were then applied to all other census tracts where customer-level data was not obtained and tract R_i-gpcd were not directly estimated. The predicted tract-level R_i-gpcd could then be rolled up into a statewide average with tract population serving as the weight. Similar to the Strata-Based approach, error terms from the analyzed tract-level data could be carried through to provide confidence intervals for the statewide Baseline. A weakness of the Correlation-Based approach is that there are more assumptions in the equations used to estimate R_i-gpcd. The Correlation-Based approach was also used to produce Supplier-level estimates because mapping of tracts to agency boundaries is known.

2.1.2 Distribution Analysis

Although the customer-level data allowed for use of more robust equations in the Baseline Analysis, the limited sample size of 18 Suppliers meant that the range of statewide tract R_i-gpcd was not well-captured. To better capture the distribution of Supplier R_i-gpcd throughout the State, a simpler disaggregation method and the less robust monthly, aggregated Supplier-level data, reported annually to the Water Board (electronic Annual Report [eAR] data), were used. This allowed the Department to infer R_i-gpcd for 157 Suppliers who had sufficient information for the Distribution Analysis. To predict the 2025 and 2030 distributions, the expected 'natural' declines by county were applied to each Supplier's R_i-gpcd (see Appendix F). This larger set of Supplier R_i-gpcd could then be used to better inform the effect of any standard. Neither the baseline nor the future year projected R_i-gpcd includes any adjustments for effects of potential pandemic, active conservation, or changes in population.

2.1.3 Pilot End-Use

A pilot End-Use study was also conducted within the service area of one study participant to test deployment of a non-invasive, high read-frequency metering device. The pilot study provides a limited verification of the monthly and hourly data disaggregation results that have limited applicability. Only 20 households could be metered and readings did not occur during the same timeframe as the Baseline or Distribution Analysis study data. However, this allowed the Department to compare household water use with tract-level estimates and assess efficacy of expanding the End-Use study to a larger sample. A larger sample from multiple Suppliers would assist in understanding the causes for different household R_i-gpcd and inform how Supplier service area R_i-gpcd efficiencies could be achieved.

Homes were fitted with a Flume Smart Home Water Monitor device capable of continuously measuring flow at 5-second increments for at least 30 days during July and August 2020. Similar to previous studies using high frequency read meters (see Appendix C), these data were disaggregated into indoor and outdoor residential water use, as well as characterization of specific indoor water uses including the type of water use, flow rate, and duration (e.g., length of showers, flow rates of faucets, etc.). Details of this analysis are described in Appendix C.

2.2 Data

2.2.1. Data Sets and Quality Assurance

Four datasets were used in this study:

1. Five to ten years (2011 - 2020) of total single-family residential **monthly/ bi-monthly** customer-level water use billing data from 18 Suppliers using the methods described in Appendix A - Monthly Analysis. Results from this analysis are used to estimate the baseline statewide R_i-gpcd central tendencies.
2. One year (2019) of total single-family residential customer-level **hourly** water use data from four water Suppliers. Methods for this analysis are described in Appendix B – Hourly (AMI) Analysis. Results from this analysis inform and validate monthly R_i-gpcd single-family and multi-family residential water use disaggregation.
3. Three years (2017, 2018, and 2019) of Supplier-level single-family residential monthly total residential water use data, reported annually to the Water Board (**eAR data**). 157 Suppliers had sufficient data to use for this analysis. Details on the methods are described in Appendix H - Distribution Analysis (eAR Data).
4. 30 days (July/August 2020) of 5-second interval water use data from the pilot **End-Use study** for 20 homes also with AMI water meters. Details are described in Appendix C – Pilot End Use Analysis

All customer-level data was screened for consistency and errors then cross-compared with the different data sets before conducting the disaggregation analysis. This step is important because water use data can be noisy due to the presence of estimated meter reads, erroneous meter reads, extreme meter reads caused by leaks, and missed meter reads. Additionally, billing corrections may result in negative meter reads and input errors can occur when reporting data in the eAR.

Rules to detect and remove suspect customer-level monthly/bi-monthly billing data and hourly data are described in Appendix A and B, respectively. The rules to detect and remove or correct suspect Supplier-level eAR data are described in Appendix H. In some cases, the screening resulted in elimination of a customer or Supplier from the study analysis.

Disaggregation methods were validated by results from the four data sets (customer-level monthly/bi-monthly billing data, hourly AMI data, Supplier-level eAR data, and pilot End-Use study 10-second interval meter read data).

2.2.2 Customer-Level Data for Baseline Central Tendencies Analysis

Monthly billing data from the 18-Suppliers contained 896,000 residential accounts distributed across 699 census tracts (256 tracts were split between one or more Suppliers). The data set included customer-level billing data from January 2011 to June 2020, although not every study participant provided data for the full time period. Four Suppliers also provided hourly AMI data for 2019 from 290,000 residential accounts distributed across 336 census tracts. Additional hourly data from March 2020 was collected from two Suppliers to estimate the COVID-19 shelter-in-place orders' effect on indoor residential water use. Customer-level meter service points were geocoded if this had not already been provided by the Supplier in order to match the billing data to census tracts.

The disaggregation analysis was conducted primarily on single-family residential accounts to avoid inherent difficulties with multifamily accounts. Ideally, billing data would be paired with household occupancy data to allow direct estimation of residential water use rates (R-gpcd)[17] Therefore, it

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[17] In addition to incomplete coverage, the occupancy data provided by the few utilities that had it included default estimates for most households which limited its usefulness.

was necessary to estimate water use rates by dividing average water use per dwelling by estimates of average household occupancy derived from the Census data. This approach produces a biased estimate of water use rates. A bias correction was therefore applied to the final water use rate estimates. The magnitude of the correction varied by Census tract but was typically less than 1.0 gpcd. Details of the water use rates calculation and bias correction are provided in Appendix A - Monthly Analysis.

2.2.3 Use of Multi-Family Billing Data

Unlike single-family residential, multi-family data provided by the study participants was of poor quality because Suppliers' classification of multi-family accounts does not always align with Census definitions of multi-family housing and Suppliers do not often record the number of dwelling units in a multi-family complex. With single-family accounts, average water use per meter is equivalent to average water use per dwelling, which is used to estimate water use rates per person. Only about one-third of the study participants had sufficient information for estimating multi-family water use rates. However, if single- and multi-family R_i-gpcd are similar, the single-family R_i-gpcd estimates can be used as the statewide estimated R_i-gpcd.

2.2.4 Supplier-Level Data for Distribution Analysis

Data reported to the Water Board by Suppliers for 2017, 2018, and 2019 through the eAR were used for the Supplier-level R_i-gpcd distribution analysis. This included monthly reported total amount of potable water delivered to single-family residential customers, single-family residential service connections, and dedicated irrigation meter monthly water use (see Section 2.3.1, which explains the need for this data). Supplier single-family residential population was reported by Supplier's through the eAR.

The eAR Supplier-level data could only be checked for missing data and obvious reporting errors; but any errors associated with rolling up the data, classification of accounts as residential or non-residential, or small typographical errors in entering data could not be identified. Where data could be fixed (e.g., misreported gallons instead of millions of gallons), adjustments were made. Where data could not be fixed or explained, the Supplier was eliminated from the data set used in the analysis. Over one-half of the Suppliers did not have complete information to conduct the analysis.

2.2.5 Landscape Area and Weather Data

Two of the study's indoor residential water use estimation methods (see Section 2.3.1), Landscape Adjustment Method (LAM) and Rainfall Adjustment Method (RAM), require data on landscape area, rainfall, and air temperature. Landscape area data came from either the study participants or the Department's Residential Landscape Area Measurement Study. Weather data were collected from National Oceanic and Atmospheric Administration (NOAA) weather stations proximate to each service area. Further details on the landscape area and weather data sources are provided in Appendix A – Monthly Analysis.

2.2.6 Pilot End-Use Data

The Department, in collaboration with a Supplier in Northern California, performed a pilot End-Use study with 20 individual customers to verify the hourly and monthly indoor disaggregation methods. Customers' meters were fitted with a non-invasive Flume Smart Home Water Monitor device, which measured flow at 5-second increments for 30 continuous days during July and August 2020. Data collected by the Flume unit was disaggregated into individual end-uses by customer, including toilet flushes, faucet draws, shower, clothes washer cycle, leaks, and others.

The analyses and results from the 20-home sample do not represent the diversity of residential water use within California. The pilot end-use study was performed to prove the usefulness of End-Use analysis in combination with more readily available data sets for future indoor and outdoor water use studies.

2.2.7 Pandemic Effect Data

Before COVID-19, many people worked away from their residences and their work-hours water use are not included in the measured residential water use or in the Baseline Analysis. Additional customer-level data was collected to examine the pandemic Shelter-In-Place orders effect on indoor residential water use.

- Monthly billing data was collected from four of the Suppliers through June 2020 in three cases and through April 2020 in one.

- Hourly data was collected from two Suppliers from January 2020 through March 2020.

2.2.8 Population

Population is one of the most important numbers used in determining water use rates because water use is divided by population to determine the gallons per capita per day (gpcd); a population value that is too high will artificially lower the gpcd and a population value too low, will artificially increase the gpcd. The most defensible population estimates would be from the 2020 U.S. Census, which will not be available at the tract-level until later in 2021.

- **Study Participants and Baseline Central Tendencies Analysis.** The Department's tract estimate R_i-gpcd were calculated for each measured census tract fully within the 18-Suppliers' service areas using tract-level 5-year population estimates from the 2018 ACS. Tract-level 5-year population estimates from the ACS were also used for population-weighted strata, Supplier, and statewide averages.
- **Distribution Analysis.** The R_i-gpcd for informing the distribution was calculated by pairing the number of single-family accounts provided by Suppliers with the average persons per household (pph) from the Suppliers associated City or County 2019 California Department of Finance[18] data or from the U.S. Census' ACS if Department of Finance data was not available.

2.3 Disaggregation Methods

2.3.1 Disaggregation of Customer-level Data for Baseline Central Tendencies Analysis

Indoor residential water use is not directly metered and therefore must be inferred. The monthly data analysis used four different methods to disaggregate indoor from outdoor residential water use by adjusting winter water use for outdoor consumption. However, one was used just for

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[18] State of California, Department of Finance, 2011-2020 with 2010 Census Benchmark. Available at: https://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-5/

informational purposes. The details of each method described below are provided in Appendix A – Monthly Analysis. The analysis also included the simple Minimum-Month method for comparison purposes.

For all methods used, there are strengths and weakness, and situations or local conditions, where one or another will perform better, or where none are quite suitable. Nonetheless, as will be shown in the Results (Section 4.0 and 5.0), all methods provide a similar value for the central tendency indicating that any individual errors are averaged out when applied across a broad scale.

Minimum Winter Month Water Use Method (Minimum-Month or MMM)

Traditionally, the standard approach has been to assume that water use in the minimum winter consumption month is entirely indoor water use (Billings and Jones 2008). However, in California, winter irrigation is common, especially in non-coastal regions of California. Estimates of indoor residential water use based on the winter minimum consumption month will therefore be biased upward unless adjustments are made to remove outdoor water use. This method is not used in the Baseline Analysis and is provided for comparison purposes only.

Seasonal Adjustment Method

The Seasonal Adjustment Method (SAM) uses billing data from dedicated irrigation meters to infer residential winter irrigation water use. The key assumption used in this method is that, for a given location, the seasonality of residential and non-residential irrigation is broadly similar. This identifying assumption is used to infer winter residential irrigation, which is not directly observable, from non-residential irrigation served by dedicated irrigation meters, which is directly observable. Removing the inferred amount of winter irrigation from winter minimum-month consumption provides an estimate of indoor water use. For this analysis, the minimum winter water use month was assumed to be February and the maximum summer water use month was assumed to be August. This is a reasonable approach because monthly billing water use data is not necessarily confined to water used only during a particular month; it depends on when the meters are read. Use of February and August standardizes the dataset and analysis.

Landscape Adjustment Method

The Landscape Adjustment Method (LAM) uses household-level data on irrigated landscape area to infer residential winter irrigation water use. This method relies on the fact that winter irrigation, where it occurs, is directly related to landscape area: more landscape area requires increased winter irrigation and vice versa. A statistical model is used to estimate this relationship while controlling for other factors affecting winter water use. Once this relationship is determined, the statistical model is used to construct a counterfactual[19] prediction of winter water use assuming each household in the sample has zero irrigated landscape area. This counterfactual prediction provides an estimate of indoor water use.

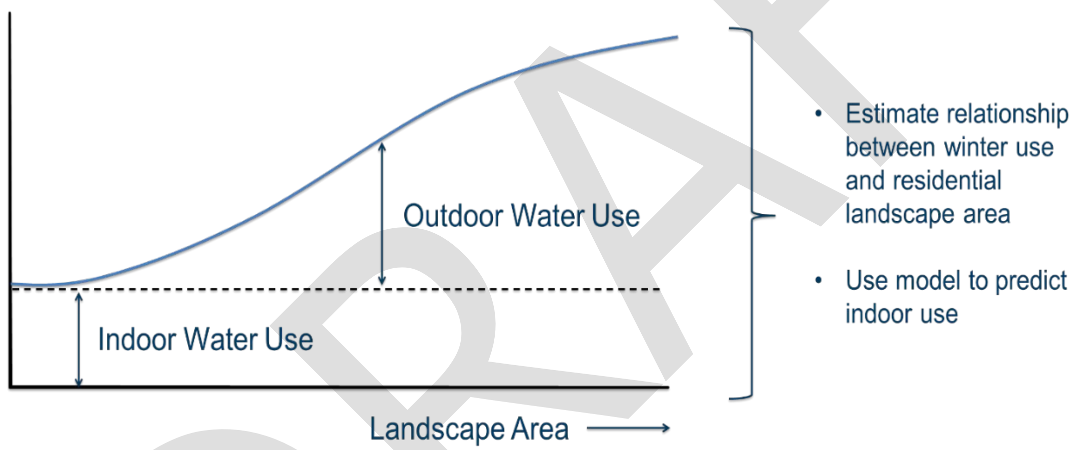

Figure 2.3-1. Description of LAM Indoor Water Use Estimation Strategy

Rainfall Adjustment Method

The Rainfall Adjustment Method (RAM) uses data on rainfall to infer residential winter irrigation water use. This method relies on the fact that winter irrigation is negatively related to rainfall; increases in rainfall reduce or eliminate the need for winter irrigation. A statistical model is used to estimate this relationship while controlling for other factors affecting winter water use. Once the relationship is determined, the statistical model is used to construct a counterfactual prediction of winter water use assuming rainfall

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[19] A method of understanding the cause associated with observed result to what you would expect if the effect had not been implemented is known as the "counterfactual." Estimation is performed with use of a statistical model, such as regression analysis, to answer the question; "If I didn't have any landscape to irrigate, my total residential water use would be X."

is at the upper end of its historical range when outdoor water use would be expected to be zero or very close to it. This counterfactual prediction provides an estimate of indoor water use.

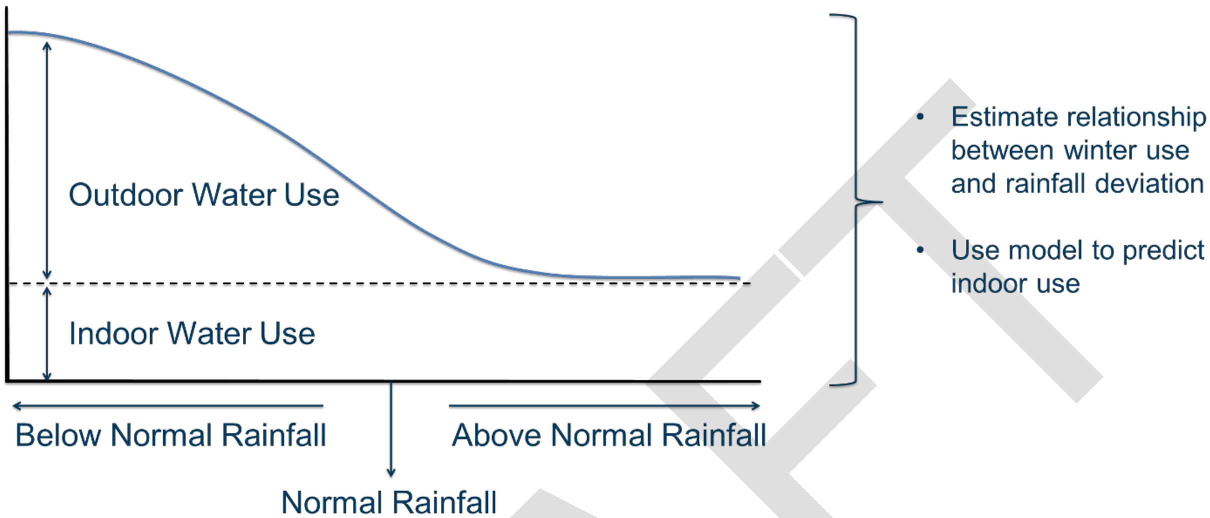

Figure 2.3-2. Description of RAM Indoor Water Use Estimation Strategy

Hourly Data Disaggregation

Four different approaches were used to calculate R_i-gpcd from hourly water consumption data for each single-family residence.

1. **Low Water Use Month: *February Averages.*** These approaches simulate the situation where higher resolution data is unavailable as is the case for Suppliers with only monthly or bi-monthly billing data. However, unlike monthly billing data, the hourly data set allows for exact determination of water use from the beginning of a month to the end of a month and for each day in the month. This method assumes February usage is entirely indoors.
2. **Entire Month of February Average (Month).**[20] The overall average daily usage for February is used as a benchmark for indoor use for all other months in the year after adjusting for the different number of days in each month. Total monthly usage above the adjusted February amount is treated as outdoor water use.

[20] February is typically the lowest water-use month in California.

3. **Daily February Average (Daily).** Each total daily usage throughout the year is compared to the average daily usage during February. On days where use exceeds the average February daily usage, the portion of use above the threshold is considered outdoor use. This approach will treat some of water use in February as outdoor use (on days where total daily usage exceeds the average).

3. **Numerical Approach:** This approach is based on previous findings that even under congested household water use conditions (multiple appliances or water fixtures running within the same hour of the day), indoor residential water use seldom exceeds 100 gallons per hour (gph) (DeOreo et al 2011). More recent end-use evaluation of 20 efficient homes in the Sacramento Valley from July 2020 revealed a threshold of approximately 45 gph (see Section 3.2). Therefore, this analysis disaggregated indoor from outdoor usage by using a set of thresholds between 45 gph and 100 gph for the maximum indoor water use rate; all hourly water usage above the cutoff is considered outdoor use.
4. **Profile Approach:** In this approach, information at both hourly and daily levels are used, assuming customers will have sets of days where they use water in similar ways. An algorithm groups together each customer's daily usage patterns based on how much water is used at each hour of the day producing a "usage profile." Each usage profile is then assigned one of three labels: Indoor only, Indoor + Outdoor, or Outdoor only. The amount of water used during Indoor only days is then used to disaggregate indoor from outdoor on all other days.

Pilot End-Use Disaggregation

A pilot End-Use study on 20 Sacramento Valley households was conducted to assess the feasibility of deploying an End-Use study and to provide more detailed information to compare disaggregation results via other methods. Data was collected through a non-invasive strap-on meter in combination with machine-learning data analysis to determine specific indoor end uses (e.g., toilet flushing) by household. These high-resolution (5 to 10 second) meter reads are used to separate out water use from individual indoor appliances and fixtures, even with multiple indoor appliances concurrently running, from the total water use[21]. These data can help inform where household efficiency improvements could occur within a Supplier's service area. A discussion on the pilot study and its uses is included in Appendix C – Pilot End Use Analysis.

2.3.2 Disaggregation of Supplier-Level Data for Distribution Analysis

The Seasonal Adjustment Method (as described above in Section 2.3.1) was used to disaggregate total single-family residential water use and obtain a the current R_i-gpcd estimate for each Supplier with sufficient data to run the analysis (see Appendix H for details on the analysis). The eAR Supplier-level data does not contain sufficient information to use either the LAM or RAM disaggregation approaches because those require customer-level data. However, for Suppliers that include dedicated irrigation meter account data in their eAR, the SAM method can be used.

Suppliers with data reported for dedicated irrigation meters and with values for 2017, 2018, and 2019 were included in the distribution analysis. Three variations of SAM were applied to the eAR data to estimate R_i-gpcd:

- Variation 1 uses the Single-Family minimum winter and maximum summer month total residential water use.
- Variation 2 uses the dedicated irrigation meters minimum winter month and maximum summer month water use.
- Variation 3 uses February and August as the fixed minimum winter and maximum summer water use months.

Because there is no preponderance of evidence to suggest that one variation is better than the other, the average of all the three variations, for each year (nine total values) was used to estimate baseline R_i-gpcd for each Supplier in the distribution analysis. For some Suppliers, one or more variations did not work and those Suppliers were excluded from the analysis. See Appendix H for more detail.

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[21]Water Research Foundation. 2016. Residential End Uses of Water, Version 2; Aquacraft. 2011. California Single Family Water Use Efficiency Study Final Report. Sponsored by DWR; Mayer, P, et al. 1999. Residential End Uses of Water. Sponsored by AWWA Research Foundation.

The distribution analysis also considered characteristics known to affect R_i-gpcd as identified in the baseline analysis (median household income, population over 65, and age of housing stock), along with hydrologic region and climate region that may affect R_i-gpcd but were not included in the baseline analysis factors.

2025 and 2030 Projected R_i-gpcd

Indoor residential water use was also estimated for 2025 and 2030, by Supplier, to provide a basis for evaluating longer-term indoor residential water use standards. An analysis prepared for the Department and Water Board (Mitchell, 2016) provided county-level estimates of the percent reduction in indoor residential water use based on implementation of current building and plumbing code requirements, housing stock sales, and new development (refer to the analysis report in Appendix F).

Current plumbing code requires use of water efficient shower heads, faucets, and toilets for all new development and for re-sale of existing housing stock. Additionally, all new fixtures and appliances must meet certain water efficient metrics in order to be sold in California.[22,23] As fixtures and

[22] AB 715, enacted in 2007, requires that any toilet or urinal sold or installed in California on or after January 1, 2014 cannot have a flush rating exceeding 1.28 and 0.5 gallons per flush, respectively. On April 8, 2015, in response to the Governor's Emergency Drought Response Executive Order (EO B-29-15), the California Energy Commission approved new standards for urinals requiring that they not consume more than 0.125 gallons per flush, 75% less than the standard set by AB 715.
[23] Water use standards for residential and commercial clothes washers and dishwashers are established by the U.S. Department of Energy through its authority under the federal Energy Policy and Conservation Act.

appliances wear down and are replaced, they can be expected to be replaced with more water efficient ones.[24,25]

3.0 STUDY PARTICIPANTS' RESULTS

The basis for the statewide central tendencies analyses is the results from the 18-Supplier customer-level data summarized in this section. Individual customer-level R_i-gpcd were averaged for each tract completely within the 18-Suppliers service areas. The determination of R_i-gpcd estimates assumed a set number of people per household (customer account) based on ACS 5-year population estimates; the best available population estimates are at the tract level. Household water use estimates are not shown because of the Non Disclosure Agreement (NDA) and the extreme variability in household population which directly affect gpcd estimates. Because of the extreme variability in individual household population over time, there is over- and under-counting of individual household population and consequently, over- and under-estimates of individual household water use. When water use of all the households are averaged at the tract level, the variability associated with household population is reduced. Based on this observation, the smallest representative unit of household water use that can be confidently reported is at the tract level and therefore tract level estimates are used to determine the baseline.

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[24] SB 407, enacted in 2009, mandates that all buildings in California come up to current State plumbing fixture standards within this decade. For single-family residential property, the compliance date is January 1, 2017. For multi-family and commercial property, it is January 1, 2019. This law establishes requirements that residential and commercial property built and available for use on or before January 1, 1994 replace plumbing fixtures that are not water conserving, defined as "noncompliant plumbing fixtures" as follows:

- Any toilet manufactured to use more than 1.6 gallons of water per flush;
- Any urinal manufactured to use more than 1.0 gallon of water per flush;
- Any showerhead manufactured to have a flow capacity of more than 2.5 gallons of water per minute; and
- Any interior faucet that emits more than 2.2 gallons of water per minute.

3.1 Monthly Data Analysis

R_i-gpcd results from the 18-Suppliers span the years 2011-2019. For comparison purposes, the results were binned into four water use condition periods[26]:

- Pre-Drought (2011-2013)
- Voluntary 20% Conservation Executive Order (2014)
- State Conservation Reduction (2015-2016)
- Post-Drought (2017-2019)

Table 3.1-1 provides summary statistics of the single-family results for each period. The Minimum-Month Method (MMM) results are included only for comparison because this method is often used to estimate indoor residential water use. The MMM results are not further used in the study analysis or discussion.

Three important points to note are:

1. These results are not the statewide estimates of indoor residential gpcd, which are presented in Section 4.0, but are presented as a comparison of the R_i-gpcd summary estimates for the sampled census tracts.
2. Not every one of the 18 Suppliers was able to provide billing data for the 2011-2016 period. The estimates for the earlier periods cover fewer census tracts and thus provide less geographic coverage than the estimates for the Post-Drought period.
3. The Post-Drought period (2017-2019) data was used for estimating current indoor residential water use because it is most proximate to the present day and it has the broadest geographic coverage without being confounded by the water use restrictions in place during the drought. Data from other periods informed the LAM and RAM analysis, which control for potential external factors.

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[26] There is a lag-time between when the drought began and Suppliers' customer water-use response to the drought. Therefore, the pre-drought water use conditions extended into the first couple of drought years.

Table 3.1-1. Study Participant's Single-Family R_i-gpcd Estimates by Method for 2011-2019 Time Period
†MMM results are presented for comparison only.

Time Period	***No. of Tracts *****	**MMM† Mean* *gpcd***	**MMM† Median *gpcd***	**SAM Mean* gpcd**	**SAM Median gpcd**	**LAM Mean* gpcd**	**LAM Median gpcd**	**RAM Mean* *gpcd***	**RAM Median *gpcd***
Pre-Drought (2011-2013)	*340*	79.0 (4.0)	73.9	54.0 (3.4)	49.0	64.9 (2.9)	62.1	63.2 (2.9)	57.9
Voluntary 20% Reduction (2014)	*401*	83.3 (4.6)	74.8	56.5 (4.3)	52.1	63.2 (2.6)	57.6	61.0 (2.6)	55.2
Required Reduction (2015-2016)	*508*	58.4 (4.8)	51.0	47.4 (5.2)	44.3	54.6 (3.3)	46.4	52.4 (3.1)	46.0
Post-Drought (2017-2019)	*699*	63.9 (4.5)	58.7	52.4 (3.8)	50.2	52.2 (3.2)	48.0	52.4 (3.1)	48.4
All Years Average (2011-2019)		71.8 (4.5)	66.3	52.7 (4.1)	49.9	55.7 (3.1)	50.5	55.1 (3.0)	49.9

*Value in parenthesis is the standard error associated with R_i-gpcd estimate average (mean)

Where MMM = Minimum-Month Method, SAM = Seasonal Adjustment Method, LAM = Landscape Adjustment Method, RAM = Rainfall Adjustment Method.
**Not all suppliers had data for all years

Because customer-level data was used, margins of error could be calculated for the tract-level averages and applied to the statewide averages. The details of the margin of error calculation (Table 3.1-1) are summarized in Appendix G. The margin of error indicates how much the estimate may differ from the true value. The magnitude of the margin of error varies by census tract, but typically is on the order of +/- 8 percent.[27]

There is substantial variation in tract-level R_i-gpcd, regardless of estimation method used. This variation is illustrated in Figure 3.1-1, which shows box and whisker plots of the estimated R_i-gpcd for the Post-Drought period (current conditions). The width of each box shows the range between the 25th and 75th percentile estimates, while the belt through the interior of each box shows the median (50th-percentile) estimate for sampled census tracts (also shown in Table 3.1-1)[28]. The whiskers on either side of each box show the full range of the results, excluding outliers. Roughly, this range is from 20 to 80 gpcd with approximately two-thirds of the estimates falling between 40 and 60 R_i-gpcd. The 18-Supplier estimate of R_i-gpcd centers on 52 gpcd.

[27] The margin of error is based on a 90% level of statistical confidence, meaning that, under repeated sampling, the interval defined by the margin of error would be expected to contain the true population value 90% of the time. This is the same level of statistical confidence used by the Census Bureau for margins of error attached to published American Community Survey estimates.

[28] The 25th percentile means that 25% of the tract average R_i -gpcd fell below that value; the 50th percentile means that 50% of tract average R_i -gpcd are above that value and 50% are below that value; the 75th percentile means that 25% of tract average R_i -gpcd values are above that value.

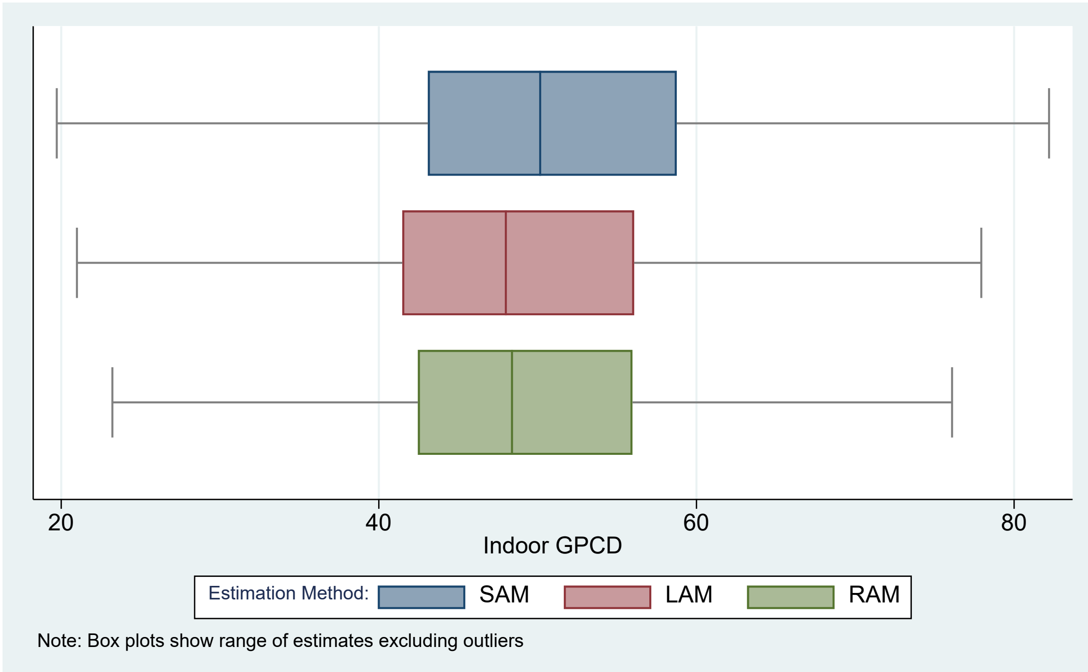

Figure 3.1-1. Distribution of 18-Supplier Tract Average R_i-gpcd

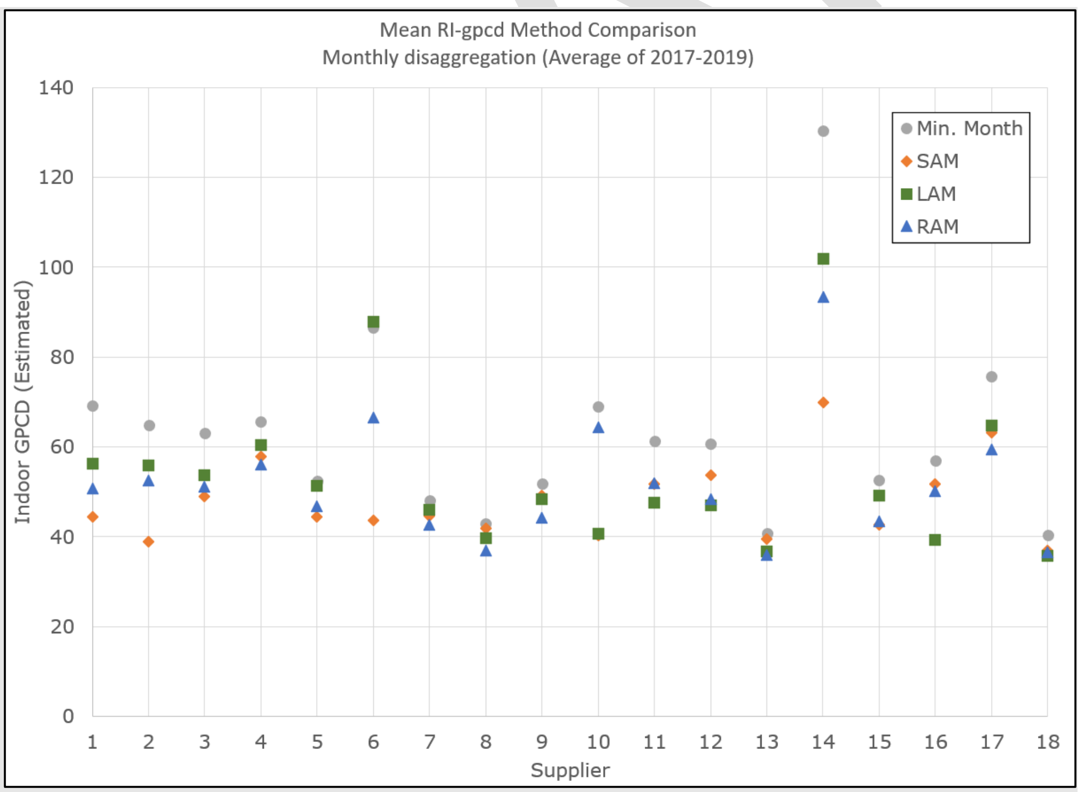

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Figure 3.1-2. Study Participants' Results of All Monthly Disaggregation Analysis.

3.2 Hourly Data Analysis

A summary of hourly single-family R_i-gpcd estimates from 2019 is shown in Table 3.2-1. Suppliers participating in the hourly analysis were from geographically and demographically diverse locations. Results from single-family customers also indicate variation in indoor water usage between summer and winter in two of the communities studied, with more water being used during summer months. Potential explanations include unobserved increases in occupancy (e.g., children home from school) or behavioral factors (e.g., use of swamp coolers).

Table 3.2-1a. Hourly Data R_i-gpcd: Daily February Average and Month of February Average Approaches

Supplier	Daily February Average* gpcd	Month of February Average* gpcd
1	41.6 (5.5)	44.3 (6.4)
2	56.2 (5.0)	56.0 (5.5)
3	36.4 (6.1)	38.5 (6.3)
4	48.0 (8.4)	52.6 (9.6)

*Where value in parenthesis is the standard error

Table 3.2-1b. Hourly Data R_i-gpcd: Threshold Approaches

Supplier	45 gph* gpcd	75 gph* gpcd	100 gph* gpcd
1	34.8 (4.8)	43.8 (5.8)	47.5 (6.2)
2	44.9 (4.8)	56.5 (5.5)	62.1 (6.4)
3	35.7 (5.5)	41.7 (6.5)	44.3 (7.0)
4	43.8 (7.3)	54.5 (9.0)	59.0 (10.0)

*Where value in parenthesis is the standard error

Table 3.2-1c. Hourly Data R_i-gpcd: Profile Approaches

Supplier	No Leak Filter* gpcd	Leak Filter* gpcd
1	45.6 (5.9)	44.5 (5.6)
2	57.8 (5.8)	51.9 (5.3)
3	41.5 (6.4)	40.6 (6.0)
4	55.7 (9.2)	49.7 (7.2)

*Where value in parenthesis is the standard error

Except for Supplier 2, the Daily February Average method resulted in a lower estimate of R_i-gpcd compared to the Month of February Average method.

For all four Suppliers, the Month of February Average, 75 gph Threshold, and Profile (no leak filter) Approaches produced similar R_i-gpcd estimates. In principle, the 100 gph approach approximates an estimated upper-bound indoor residential water use (based on the sum of all indoor appliances and fixtures being in use at the same time) and the 45 gph estimate provides a lower bound estimate (based on our small sample observation of efficient homes from the Pilot End Use Study). The 75 gph reflects a more middle ground hourly cutoff. The estimate from the 75 gph lines up the best with the Threshold approaches that looks for structural breaks in the hourly data, indicating these service areas are likely an even mix of high and low Ri-gpcd households or that most households gpcd are "middle of the road".

3.3 Methods Comparison

Figure 3.3-1 and Table 3.3-1 show results from all customer-level data analyses. Monthly results are an average of 2017, 2018, and 2019; hourly results are from 2019; and the Pilot End-Use Study results are from 20 customers for the month of July and August 2020.

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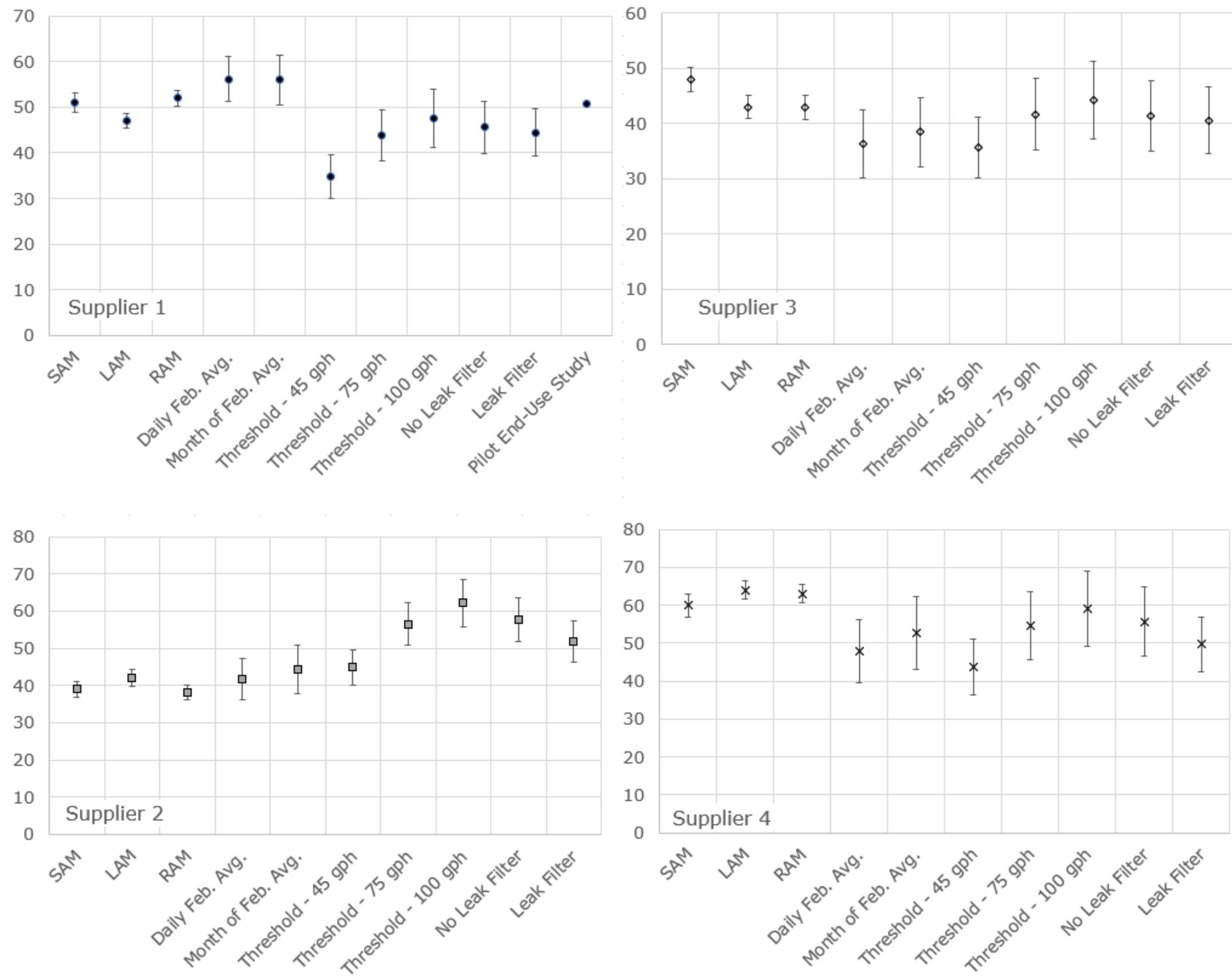

Figure 3.3-1. Comparison of Disaggregation Method R_i-gpcd Using 2017-2019 Tract Aggregated Customer-level Monthly Billing Data and Hourly AMI Data, and 20 Customer Pilot End Use Study Data.

Table 3.3-1. Comparison of Disaggregation Method R_i-gpcd Using 2017-2019 Tract Aggregated Customer-level Monthly Billing Data and Hourly AMI Data, and 20 Customer Pilot End Use Study Data.

Type of Data	Disaggregation Method	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Monthly / Bi-Monthly	SAM[a]	51 (2.1)	39 (2.1)	48 (2.2)	60 (3.0)
Monthly/ Bi-Monthly	LAM[a]	47 (1.6)	42 (2.2)	43 (2.1)	64 (2.3)
Monthly / Bi-Monthly	RAM[a]	52 (1.8)	38 (2.0)	43 (2.2)	63 (2.4)
Hourly	Daily February Average[b]	56.2 (5.0)	41.6 (5.5)	36.4 (6.1)	48 (8.4)
Hourly	Month of February Average[b]	56 (5.5)	44.3 (6.4)	38.5 (6.3)	52.6 (9.6)
Hourly	Threshold - 45 gph[b]	34.8 (4.8)	44.9 (4.8)	35.7 (5.5)	43.8 (7.3)
Hourly	Threshold - 75 gph[b]	43.8 (5.5)	56.5 (5.5)	41.7 (6.5)	54.5 (9.0)
Hourly	Threshold - 100 gph[b]	47.5 (6.4)	62.1 (6.2)	44.3 (7.0)	59 (10.0)
Hourly	No Leak Filter[b]	45.6 (5.8)	57.8 (5.9)	41.5 (6.4)	55.7 (9.2)
Hourly	Leak Filter[b]	44.5 (5.3)	51.9 (5.6)	40.6 (6.0)	49.7 (7.2)
End Use	End Use Algorithms[c]	50.8	NA	NA	NA

a – average of 2017 to 2019, b – 2019 data only, c – July/August 2020, n=20 accounts; Value in parenthesis is Standard Error

Based on these limited results, the hourly disaggregation analyses may provide more reasonable values for Suppliers with high (Supplier 4) or low (Supplier 2) R_i-gpcd compared to using the monthly methods. However, the sample size is too limited and other factors such as geographic location or demographic characteristics may account for the differences.

3.4 Pandemic Effect Results

Table 3.4-1 shows the pandemic shelter-in-place order effects on indoor residential water use for six Suppliers. This approximately 3-5 gpcd increase in R_i-gpcd is roughly equivalent to about two to three extra toilet flushes per person. Extra toilet flushing may explain most of the observed increase in indoor residential water use. This is consistent with the pilot End-Use Study conducted during July and August 2020 that measured an average toilet flush rate of three more flushes per person per day than has been recorded in previous End-Use studies.[29]

[29] See Mayer et al. (1998), Mayer et al. (2011), and Mayer et al. (2016).

Table 3.4-1. Increase in Single-Family Indoor Residential Water Use Following Pandemic Shelter-in-Place Orders

Supplier	Analysis *Monthly or Hourly*	Per Household *gpd**	Per Person *R_i-gpcd*
Coachella Valley WD	Monthly	7.2 (1.1)	3.0
Eastern MWD	Monthly	11.1 (0.3)	2.9
CWS S. San Francisco	Monthly	12.6 (1.4)	3.7
CWS Livermore	Monthly	35.9 (2.9)	12.2
Redwood City	Hourly	8.8 (0.9)	3.1
City of Folsom	Hourly	13.3 (1.3)	4.5
Mean Effect	All	NA	*4.9*
Excluding Livermore	All	NA	3.4

*Standard error of estimate in parentheses

3.5 Multi-Family Residential

To inform whether the statewide R_i-gpcd could be represented by single-family residential (SFR) water use, the disaggregation analysis was performed for several Suppliers with sufficient multi-family residential (MFR) monthly and hourly customer-level data.

3.5.1 Monthly Analysis MFR R_i-gpcd

Table 3.5-1 demonstrates the variability and similarity between multi-family and single-family residential R_i-gpcd for all four disaggregation methods. In some cases multi-family residential R_i-gpcd is higher than single-family residential and in some cases it is lower, depending on the Supplier and on the method used. In general, though, the R_i-gpcd standard errors for the MFR were greater than those for SFR, which is to be expected because of the potential for greater variability in the MFR sector (e.g., with or without on-site laundry) and the difficulty in obtaining good data to disaggregate (e.g., number of occupied units).

In addition to incomplete MFR account information and data, the occupancy data provided by the few Suppliers that had MFR information included default estimates for most households which limited its usefulness. A comparative analysis of five Suppliers with sufficient data indicated an approximate equivalency in four of the five Suppliers for which both MFR and SFR estimates of R_i-gcpd could be developed.

For the overall multi-family sample, the mean estimate of indoor residential water use is 49 gpcd with the SAM and RAM methods and 50 gpcd with the LAM method. The median estimate is 48 gpcd with the SAM and LAM method and 46 gpcd with the RAM method.

- Multi-family **SAM** analysis showed weaker correlations than the SFR analysis but tell a story similar to SFR R_i-gpcd in terms of which factors are stronger predictors and which factors are weaker predictors of variation in R_i-gpcd (refer to section 2.1.1 for SFR R_i-gpcd factors). This indicates the reasonableness of using SFR as a proxy to describe all residential R_i-gpcd.

- The **RAM** analysis did not work well with MFR data because of the extreme variability in types of multi-family account: e.g., multifamily accounts can include small 2-4-unit master-metered properties as well as much larger master-metered properties.

- A **sensitivity analysis** confirmed the ability to use SFR R_i-gpcd as a surrogate for all residential R_i-gpcd. Assuming that multi-family R_i-gpcd is 10% higher than corresponding SFR R_i-gpcd in each tract, the statewide average would increase by 1.2 R_i-gpcd compared to assuming single-family and multifamily have the same R_i-gpcd. If MFR R_i-gpcd is 10% lower, the statewide average drops by 1.2 gpcd (Statewide baseline estimates are discussed in Section 4.0). This increase or decrease is close to the margins of errors associated with each estimation method.

Table 3.5-1. Monthly Data Analysis Average of 2017-2019 Multi-Family Residential (MFR) R-gpcd Compared to Single-Family Residential (SFR) for Five Suppliers

Supplier	**MMM MFR *gpcd***	**MMM SFR *gpcd***	**SAM MFR *gpcd***	**SAM SFR *gpcd***	**LAM MFR *gpcd***	**LAM SFR *gpcd***	**RAM MFR *gpcd***	**RAM SFR *gpcd***
Sac River	63 (5.9)	61 (3.3)	60 (5.6)	54 (3.0)	64 (5.0)	47 (2.3)	63 (4.9)	49 (2.4)
C. Coast	42 (3.9)	40 (2.5)	41 (3.7)	39 (1.0)	39 (3.1)	36 (0.9)	38 (3.1)	35 (1.0)
S. Coast	45 (5.8)	54 (2.4)	39 (6.1)	48 (2.1)	42 (2.1)	50 (2.2)	38 (2.0)	44 (2.0)
S. Coast	50 (3.4)	60 (2.7)	50 (3.5)	61 (2.5)	49 (2.9)	40 (1.8)	48 (2.9)	52 (2.4)
SF Bay	49 (6.7)	44 (2.4)	48 (6.8)	39 (2.2)	43 (3.3)	39 (2.1)	43 (3.3)	40 (2.2)
All	**54 (5.2)**	**56 (2.7)**	**50 (5.2)**	**48 (2.5)**	**53 (3.6)**	**45(2.1)**	**52 (3.6)**	**47 (2.2)**

* Value in parenthesis = standard error

3.5.2 Hourly Analysis MFR R_i-gpcd

The Month of February (Low Water Use Month) and Profile methods, described in Section 3.2, were used to disaggregate R_i-gpcd for multi-family residential. A summary of multi-family R_i-gpcd estimates are shown in Table 3.5-2 below.

Table 3.5-2. Hourly Data Analysis of 2019 Multi-Family Residential (MFR) R_i-gpcd* Compared to Single-Family Residential (SFR) For Three Suppliers.

Supplier	Average Day MFR, *gpcd*	Average Day SFR, *gpcd*	Calendar Month MFR, *gpcd*	Calendar Month SFR, *gpcd*	Profile No Leak Filter MFR, *gpcd*	Profile No Leak Filter SFR, *gpcd*
S. Coast	50.3 (30.5)	41.6 (5.5)	51.9 (32.5)	44.3 (6.4)	42.3 (35.4)	45.6 (5.9)
SF Bay	42.8 (10.2)	36.4 (6.1)	43.4 (11.9)	38.5 (6.3)	40.5 (18.0)	41.5 (6.4)
Sac River	60.3 (28.6)	48.0 (8.4)	62.4 (29.8)	52.6 (9.6)	43.6 (31.1)	55.7 (9.2)

*Values in parentheses are standard error

Each of these methods makes different assumptions to estimate indoor residential water use. All of the different hourly disaggregation methods for estimating indoor residential water use produces consistent, reasonable estimates for both MFR and SFR. This independently confirms the monthly disaggregation conclusion of inferring MFR R_i-gpcd with SFR R_i-gpcd.

4.0 BASELINE CENTRAL TENDENCIES RESULTS

The two analyses using the tract level estimates of R_i-gpcd were the Strata-Based and Correlation-Based analyses (refer to Section 2.1 for an explanation of these methods).

These analyses were conducted using only single-family residential customers data; as noted above, single-family and multi-family R_i-gpcd are comparable (see Section 3.5) and population estimates and water use data associated with single-family residential are more complete allowing for a better disaggregation and determination of R_i-gpcd.

Both the Strata-Based and Correlation-Based estimates produce good statewide averages and comparable results. The Strata-Based estimates may be more reliable because fewer assumptions are used. The Correlation-Based estimate is much more data-intensive and the results are limited by the constraints of the study scope. However, the Correlation-Based estimates confirm use of the factors classifying each strata.

Comparison between the Strata-Based and Correlation-Based Baseline central tendencies indicate agreement by all five analysis that are within the margins of error of each. The Correlation-Based confidence intervals are tighter than the Strata-Based statewide aggregation because more information is used to develop the Correlation-Based tract level predictions. The differences across approaches and methods are small, suggesting that current R_i-gpcd statewide average is within the range of 49-52 gpcd.

4.1 Strata-Based Estimates

Tract-level estimates were developed from SFR customer-level billing histories using the four monthly disaggregation methods. Statewide Baseline results in the Strata-Based Approach are presented in Table 4.1-1. These averages were developed from 453 census tracts wholly within the service areas of 18 Suppliers that were selected to represent the statewide diversity. Section 2.1.1 describes the methodology used for aggregating tract-level estimates up to the state level.

Strata-Based Analysis provides Tract-Level R_i-gpcd that can be rolled up to a statewide average. Strata-Based results and analysis presented in this report are for the tract-level aggregated R_i-gpcd that are further summarized on a statewide basis.

Table 4.1-1. Strata-Based Statewide Baseline: Tract-Level R_i-gpcd Estimates (Average of 2017-2019).

Method	Average R_i-gpcd	95% Confidence Interval
MMM	62.5	± 1.9
SAM	49.5	± 1.0
LAM	52.2	± 1.6
RAM	51.5	± 1.4

As noted in Section 3.1, the 2017-2019 years appear to be least affected by the 2012-2016 drought and are the most representative of California's current R_i-gpcd.

The MMM results are included for informational purposes only and will not be discussed further. It is included because the MMM is often used to estimate indoor residential water use, however the MMM analysis does not remove winter irrigation and can overestimate indoor water use, especially where winter irrigation is quite significant, such as in Southern California.

4.2. Correlation-Based Estimates

Correlation-Based estimates provide Tract-Level R_i-gpcd that can be aggregated at the Supplier or statewide levels. Correlation-Based results and analysis presented in this report are for the Supplier aggregated R_i-gpcd that are further summarized on a statewide basis.

Table 4.2-1 shows the Baseline statewide R_i-gpcd estimated using the Correlation-Based Approach. The SAM and RAM Correlation-Based R_i-gpcd estimates for 384 Suppliers does well predicting the central tendency of statewide average R_i-gpcd. The median R_i-gpcd using SAM disaggregation process is 50.1 gpcd and the median for the RAM disaggregation process is 49.8 gpcd. However, the distribution is tightly clustered for both with a standard deviation of 2.6 and 5.6 gpcd, respectively.

Table 4.2-1. Correlation-Based Statewide Baseline: Supplier Aggregated R_i-gpcd Estimates (Average of 2017 to 2019).

Method	Average R_i-gpcd	95% Confidence Interval
SAM	50.5	± 0.26
LAM	50.9	-
RAM	50.7	± 0.23

Table 4.2-1 does not show results for the Minimum Month Method as described before.

Correlation-Based Analysis comparison of disaggregation methods are:

- **SAM.** The SAM estimate has limited ability to explain the characteristics of indoor residential water use because SAM R_i-gpcd tract estimates tightly cluster near the mean. This means that SAM poorly represents the tails of the R_i-gpcd distribution. However, the Correlation-Based SAM estimate detected both a post-2000 housing effect and population over 65 years old effect. The tight R_i-gpcd clustering and the ability to detect only the post-2000 housing effect and population over 65 effect indicates that the Correlation-Based SAM estimate can explain some factors associated with indoor residential water use but has limitations.

- **LAM.** The LAM estimate produces the least desirable result because it does not detect a post-2000 housing effect or income effect. Additionally, the LAM estimate has the largest effect from total residential water use, compared to the other methods, which indicates LAM did not separate out the outdoor water use from total water use as well as the other methods.

- **RAM.** The RAM estimate performed the best (highest R-square, coefficients are reasonable and significant) of the three Correlation-

Based estimates. The RAM estimate detected significant effects for all three factors: population over 65, housing built after 2000, and median household income. Only under the RAM estimate does the impact of income appear statistically significant. The coefficient associated with the RAM estimate for household income suggests that for every $10,000 increase in tract household income, R_i-gpcd rises by 0.3 gpcd, a relatively weak but significant effect.

The SAM estimate produces reasonable and significant model/equation coefficients, but the model's explanatory power is lower when compared with the RAM estimate. Overall, the Correlation-Based SAM estimate is good for estimating a statewide average and the RAM estimate does a better job capturing the tails of the R_i-gpcd distribution.

However, none of the three Correlation-based estimates are able to robustly characterize the tails (high and low R_i-gpcd values) of the distribution and all demonstrated a low R-squared value. Only the SAM disaggregation could be used for the Distribution Analysis because of dataset limitations. Refer to Appendix G.

4.3 Factors Influencing Variation in R_i-gpcd Across Tracts

Regression models were used to explore which factors influence variation in R_i-gpcd across the 453 census tracts selected to represent California. Effects of tract characteristics, obtained from the Census (housing stock age, median household income, and tract population over-65 years in age), on tract-level R_i-gpcd was determined for the SAM and RAM disaggregated data from single-family residential accounts.

- **Population Over 65 Correlated With <u>Higher</u> R_i-gpcd.** The models detect a strong, significant effect of the percentage of over-65 population on R_i-gpcd. For every 10% increase in the over-65 population proportion, R_i-gpcd increases by approximately 3-5 gpcd. For example, tracts with 60% of the population over 65 can be expected to have 15-25 gpcd higher indoor per-capita use than tracts where only 10 percent of the population is over-65 years of age, with all other factors being equal.

- **Housing Built After 2000 Correlated With <u>Lower</u> R_i-gpcd.** Post-2000 households are expected to be associated with more efficient indoor use. Both the Correlation-Based SAM and RAM estimates confirm that hypotheses, while the LAM estimate does not, which reduced confidence in using the LAM estimate for current statewide R_i-gpcd.

The proportion of post-2000 housing in a tract is a statistically significant predictor of lower R_i-gpcd. However, no water use efficiency gradient is detectable within housing stock constructed prior to 2000.

  - Tracts with all housing built after 2000 have an R_i-gpcd that is 5-6 gpcd below tracts, where all housing was constructed prior to year 2000, with all other constraints being equal.
  - There is no statistically significant difference between homes built between 1980-1999 and those built prior to 1980. Older housing stock is subject to similar influences due to updates in plumbing codes, appliance efficiency standards, and agency-sponsored incentive programs starting from the early 1990s causing water use efficiency levels for households to increase at roughly the same rate.

- **Median Household Income Weak Correlation With <u>Higher</u> R_i-gpcd.** Median household income has a weak, but positive effect on R_i-gpcd. For every $10,000 increase in median household income, per-capita indoor water use increases by roughly 0.3 gpcd.

4.4 Multi-Family versus Single Family Tract Level Estimates using SAM and RAM

Multi-family estimates could only be generated from a smaller subset of tracts than the number of tracts used in the Single Family indoor residential estimates. Multi-family data was not used from the eAR data. Because of the limitations of multi-family data described in Section 3.5, there is limited utility in including multi-family R_i-gpcd estimates in the statewide indoor residential estimates. The limited multi-family data R_i-gpcd tract level estimates are approximately similar to single-family indoor residential tract level estimates with the SAM and RAM approaches as shown in Figure 4.4-1 and Figure 4.4-2.

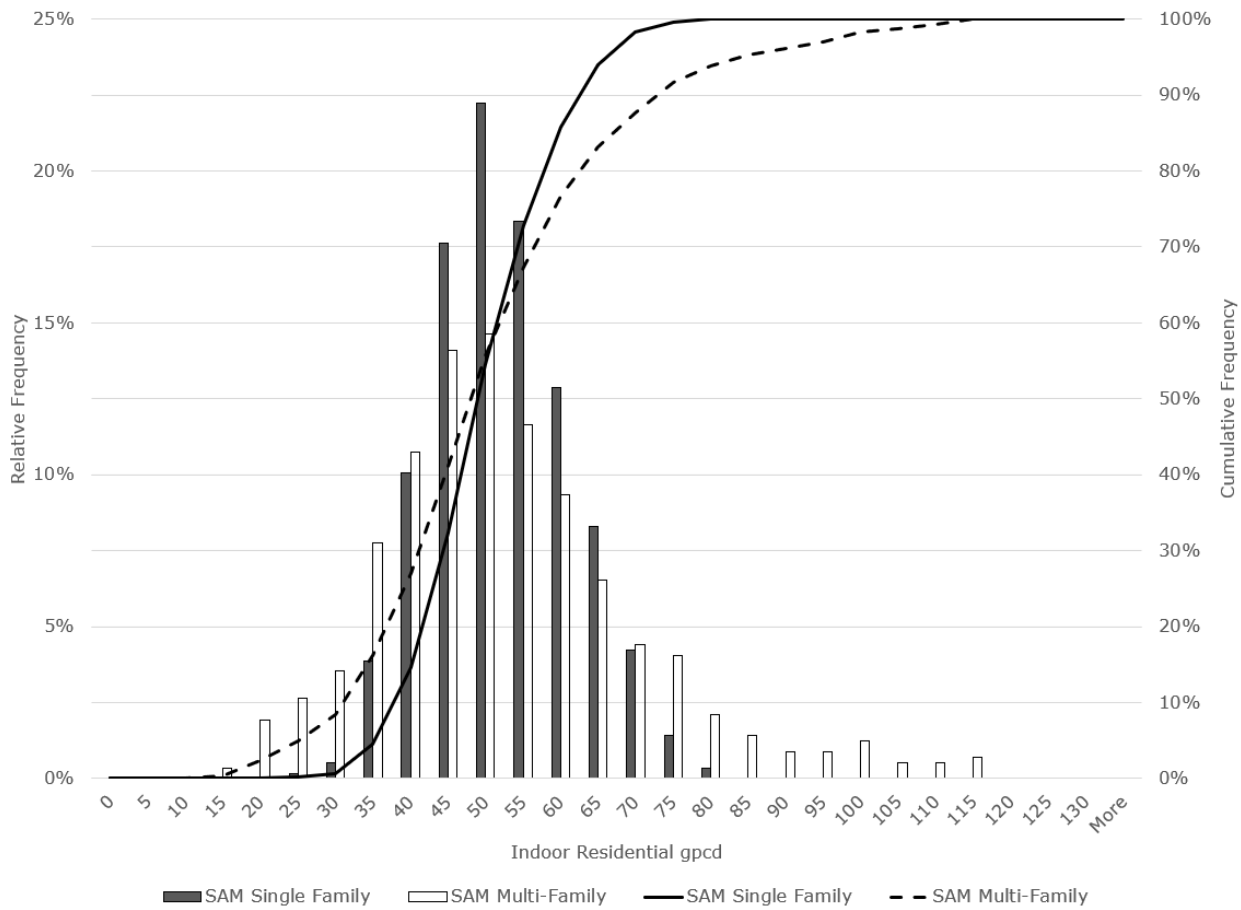

Figure 4.4-1. Single Family compared to Multi-Family: **SAM** Tract R_i-gpcd Estimates

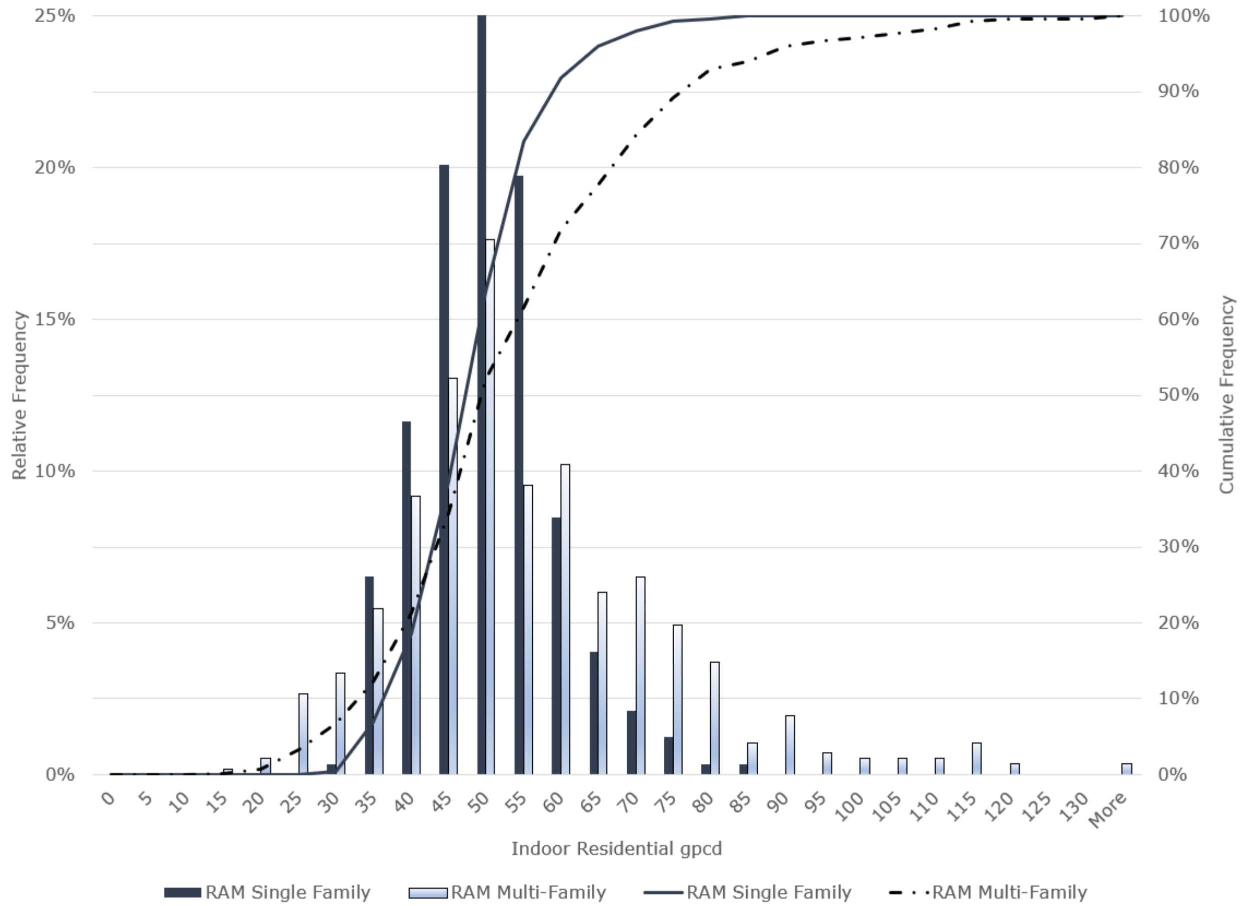

Figure 4.4-2. Single Family compared to Multi-Family: **RAM** Tract R_i-gpcd Estimates

Table 4.4-1. SAM and RAM Single-Family versus Multi-Family Tracts by R_i-gpcd

Hydrologic Region	**MMM MFR*** *(R_i-gpcd)*	**MMM SFR*** *(R_i-gpcd)*	**SAM MFR *** *(R_i-gpcd)*	**SAM SFR*** *(R_i-gpcd)*	**LAM MFR*** *(R_i-gpcd)*	**LAM SFR*** *(R_i-gpcd)*	**RAM MFR*** *(R_i-gpcd)*	**RAM SFR*** *(R_i-gpcd)*
Sac River	63 (5.9)	61 (3.3)	60 (5.6)	54 (3.0)	64 (5.0)	47 (2.3)	63 (4.9)	49 (2.4)
C. Coast	42 (3.9)	40 (2.5)	41 (3.7)	39 (1.0)	39 (3.1)	36 (0.9)	38 (3.1)	35 (1.0)
S. Coast	45 (5.8)	54 (2.4)	39 (6.1)	48 (2.1)	42 (2.1)	50 (2.2)	38 (2.0)	44 (2.0)
S. Coast	50 (3.4)	60 (2.7)	50 (3.5)	61 (2.5)	49 (2.9)	40 (1.8)	48 (2.9)	52 (2.4)
SF Bay	49 (6.7)	44 (2.4)	48 (6.8)	39 (2.2)	43 (3.3)	39 (2.1)	43 (3.3)	40 (2.2)
Average	**54 (5.2)**	**56 (2.7)**	**50 (5.2)**	**48 (2.5)**	**53 (3.6)**	**45(2.1)**	**52 (3.6)**	**47 (2.2)**

*Standard Error in parenthesis, values are average of 2017 to 2019 data

5.0 DISTRIBUTION ANALYSIS RESULTS

The current condition distribution of Supplier R_i-gpcd in California is represented by the 157 Suppliers in this study and shown in Figure 5-1. These values represent an average of 2017, 2018, and 2019 SAM analysis of Supplier-level (eAR) data. The distribution is slightly skewed to the lower end with some Suppliers showing extreme values. Extreme values may be artifacts of the analysis, data, or indicate unique water use that may be subject to variance[30] conditions.

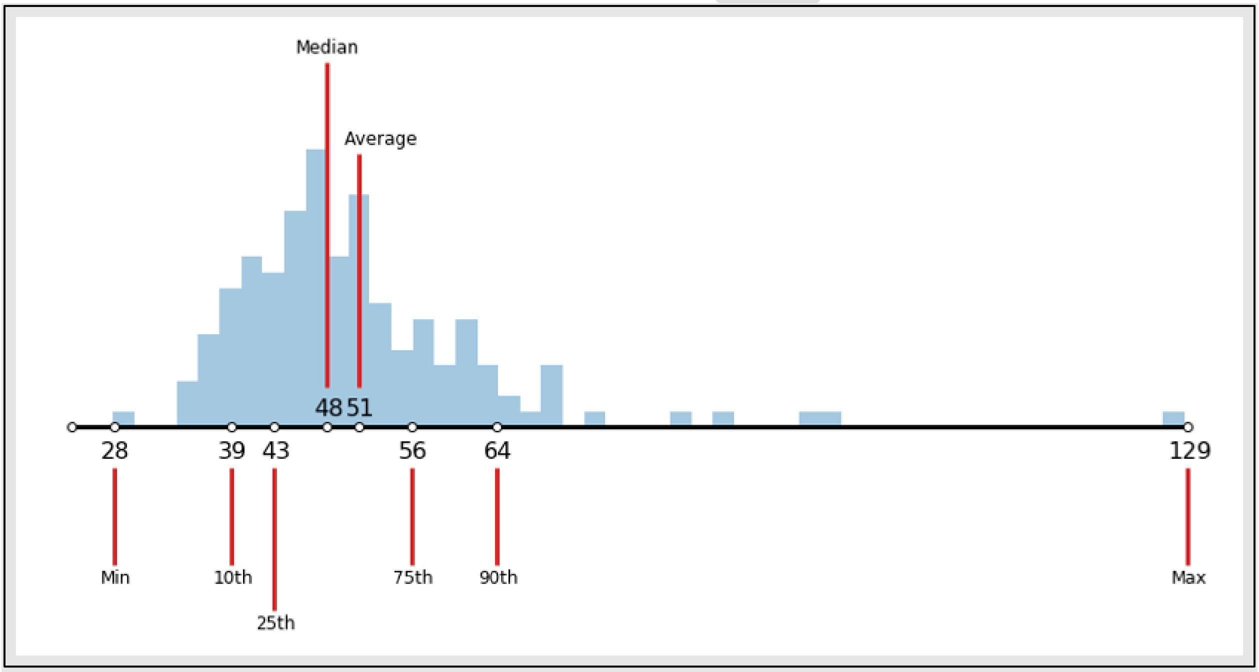

Figure 5.1 Current Conditions Distribution Analysis Results for 157 Suppliers (Where Ri-gpcd values are along the horizontal axis and frequency of occurrence for histogram bars is on the vertical axis. Distribution statistics along the horizontal axis are included for reference.)

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[30] Variances are additions to the water use objective that can be claimed for Suppliers with unique uses of water in their service area that has a material effect on their water use objective. The variances are currently under study and development but include uses such as large population of horses and other livestock, seasonal populations, use of evaporative coolers, large areas of commercial and non-commercial agriculture, to name a few.

From the analysis in Appendix J, a non-wasteful household without efficient fixtures and appliances can expect an R_i-gpcd of about 55 gpcd. Based on this study's analysis, the lower R_i-gpcd does appear to suggest that residential customers in California, on average, are currently achieving some measure of efficient indoor residential water use that demonstrates efforts Suppliers and customers have already put towards water conservation.

5.1 Distribution Analysis Results Comparison to Central Tendencies

R_i-gpcd estimates from the monthly and hourly customer-level Baseline Analysis validates the Supplier-level dataset (eAR) SAM analysis to represent the Statewide R_i-gpcd distribution (variability) of Suppliers. Table 5.1-1a and 5.1-1b show how closely the average between all the analyses agree.

Table 5.1-1a. Strata-Based Approach Summary From Tract Aggregated Ri-gpcd for Baseline Analysis SAM, LAM, and RAM and Aggregate Supplier-Level Estimated Ri-gpcd For Distribution Analysis SAM.

Statistic	**Distribution Supplier-Level Data (eAR) SAM** *(R_i-gpcd)*	**Baseline SAM** *(R_i-gpcd)*	**Baseline LAM** *(R_i-gpcd)*	**Baseline RAM** *(R_i-gpcd)*
Average	**51.1**	**49.5**	**52.2**	**51.5**
95% Confidence	NA	±1.0	±1.6	±1.4

Table 5.1-1b. Correlation-Based Approach Summary Statistics From Supplier-Aggregated R_i-gpcd.

Statistic	**Supplier-Level Data (eAR) SAM (*R_i-gpcd*)**	**Correlation-Based Baseline SAM (*R_i-gpcd*)**	**Correlation-Based Baseline LAM (*R_i-gpcd*)**	**Correlation-Based Baseline RAM (*R_i-gpcd*)**
Number of Suppliers	157	384	384	384
Average	**51.1**	**50.5**	**50.9**	**50.7**
95% Confidence	NA	±0.3	NA	±0.2
Minimum	27.8	44.2	39.3	39.3
Maximum	128.7	63.4	84.8	82.2
Median	**48.3**	**50.1**	**50.0**	**49.8**
Std. Dev.	12.7	2.6	5.9	5.6
Standard Error	-	0.141*	0.166*	0.138*
10^{th} Percentile	39.3	47.8	44.6	44.7
25^{th} Percentile	43.7	48.8	46.9	47.0
75^{th} Percentile	56.1	51.5	53.7	53.4
90^{th} Percentile	63.5	53.6	58.3	57.6

*Standard Error (of the mean) is calculated by Supplier based on tract-level estimates. Standard error cannot be calculated using Supplier-Level eAR data. Standard error estimates how well the sample data represents the whole population; with aggregated Supplier data, not enough information is available to estimate how good R_i-gpcd SAM eAR data estimates represent tracts or individual households within that Supplier.

However, as Table 5.1-1 shows, the range of R_i-gpcd distribution is greater for the Distribution Analysis because the Baseline Analysis, by nature, will tend to produce less variable results. Agreement on the averages indicates that use of the Supplier-level data disaggregated using the SAM method can be useful for informing the statewide variability in R_i-gpcd at the Supplier-level and effects of changing the R_i-gpcd standard.

Figure 5.1-1 shows the range and spread of the various analysis. LAM relative and cumulative frequency distributions are shown only for comparison because this analysis was generally found to produce less defensible results.

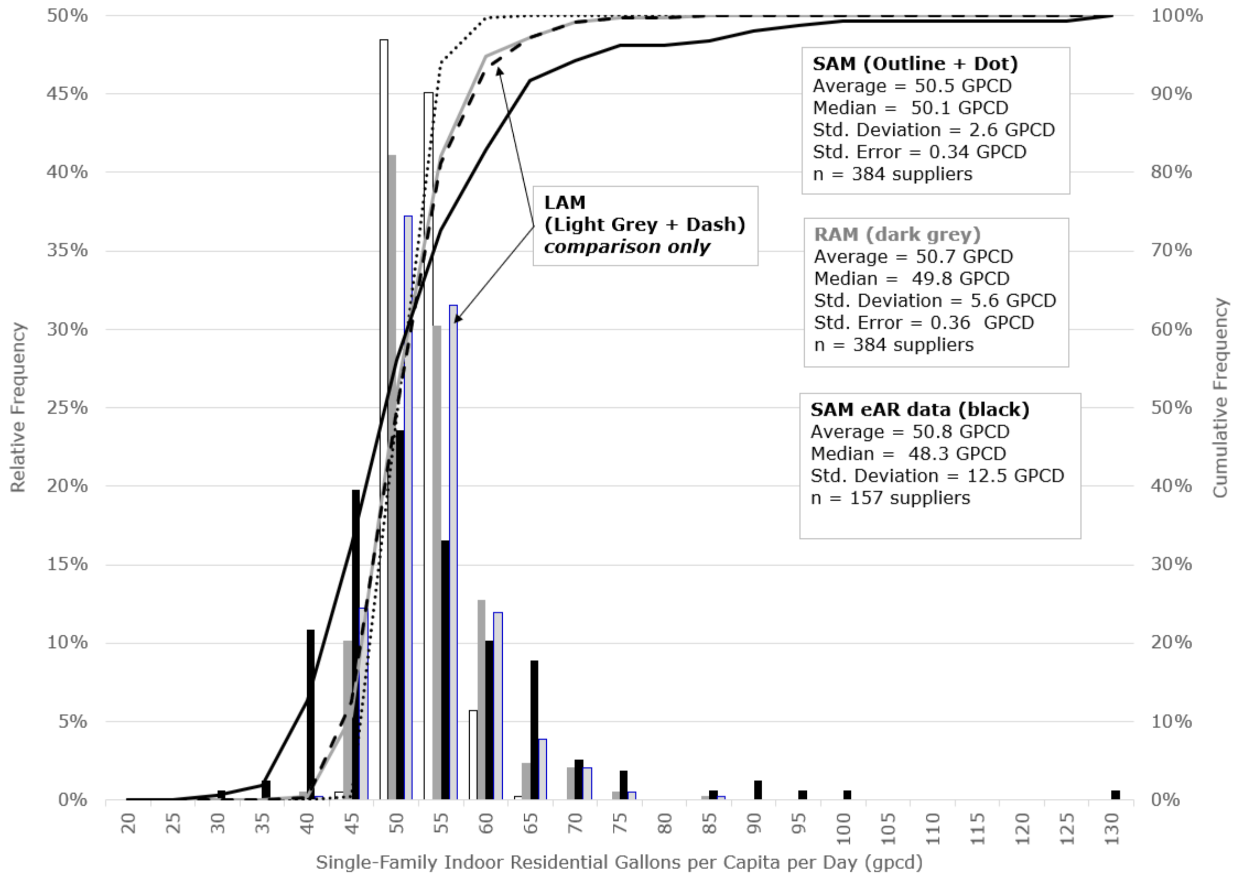

Figure 5.1-1. California Indoor Residential gpcd Distribution with SAM, RAM, and LAM*
Correlation-Based Supplier Estimates, and SAM Supplier-level data using an Average of 2017-2019.

5.2 Current and Future Projected R_i-gpcd Distribution

The indoor residential water use standard in statute reduces from 55 to 52.5 gpcd in 2025 and reduces from 52.5 to 50 gpcd in 2030. Therefore, it was important to understand what the projected R_i-gpcd distribution would be.

R_i-gpcd can be expected to decline 'naturally' because of plumbing code effects, appliance and fixture turnover, and new housing (passive conservation). It can also decline because of conservation programs and efforts (active conservation), which will be locally variable and depend upon the individual programs, customer response to programs, and the level of ‘saturation’ (e.g., how close the service area is to having all toilets replaced with efficient toilets). Because the Department has no ability to assess the likely effect of active conservation, the Department estimated projected R_i-gpcd for 2025 and 2030 based on current R_i-gpcd for the 157 Suppliers, along with county estimates for passive conservation from Mitchell (2016) (refer to Appendix F).

Figure 5.2-1 and 5.2-2 show the projected distributions for 2025 and 2030, respectively. This analysis indicates that the average and median R_i-gpcd is projected to decline, due to passive conservation, by about four gpcd by 2030 without any active conservation efforts or any standard in effect.

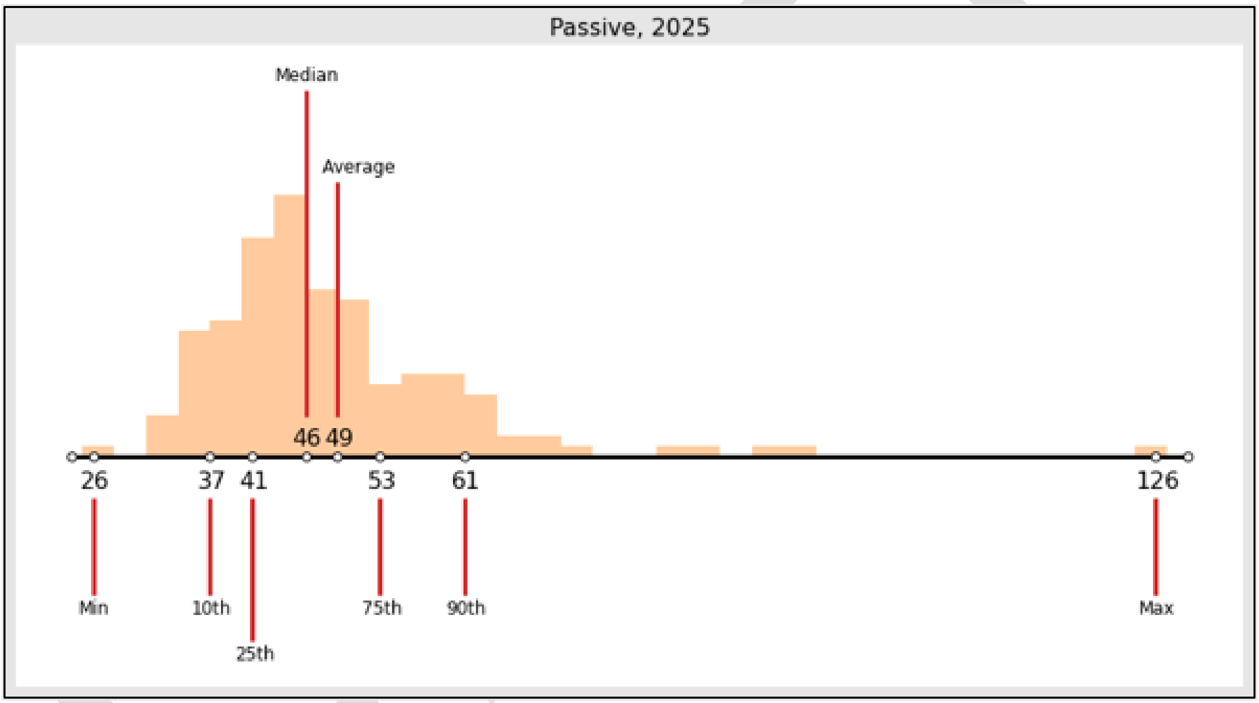

Figure 5.2-1. 2025 Projected Distribution Analysis Results for 157 Suppliers (Where Ri-gpcd values are along the horizontal axis and frequency of occurrence for histogram bars is on the vertical axis. Distribution statistics along the horizontal axis are included for reference.)

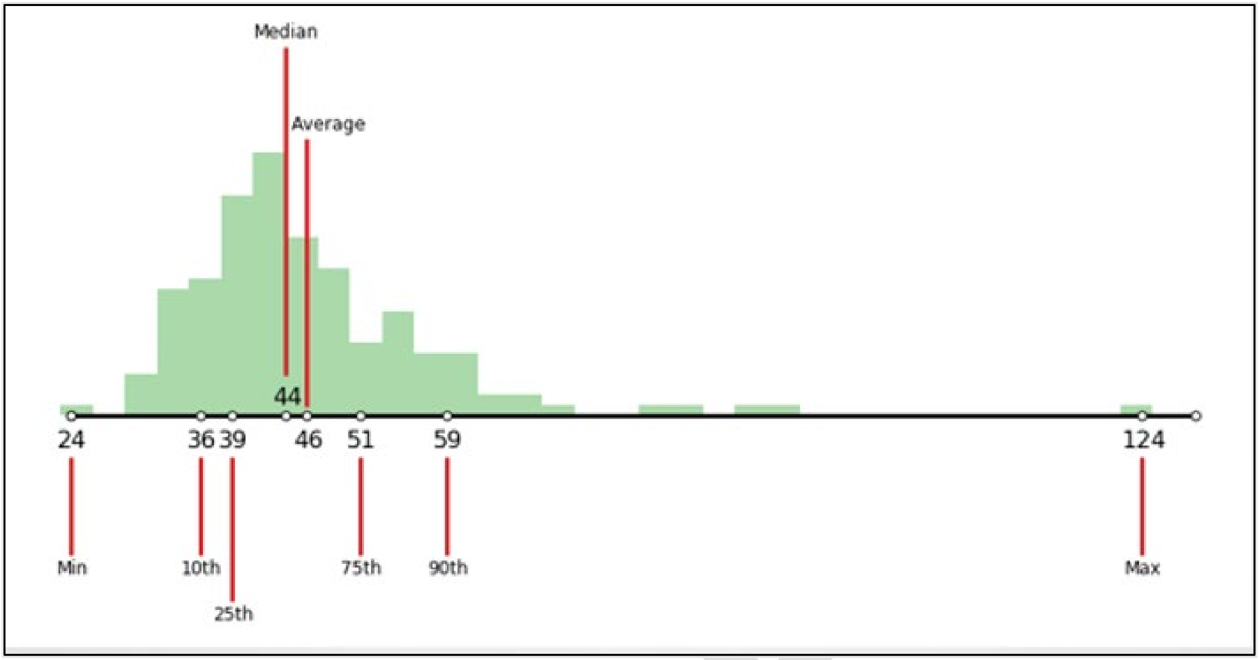

Figure 5.2-1. 2030 Projected Distribution Analysis Results for 157 Suppliers (Where Ri-gpcd values are along the horizontal axis and frequency of occurrence for histogram bars is on the vertical axis. Distribution statistics along the horizontal axis are included for reference.)

5.3 Standards Effects

In order to provide a study that informs any recommendations, potential effects of any standard were estimated using a Decision Support System (DSS) tool to examine how many Suppliers and the population that would be affected by a recommended standard and what the magnitude of effect would be. This tool incorporated information from the Distribution Analysis Supplier R_i-gpcd, Supplier population, and high poverty status based on Census tract data.

There are three main assumptions that need to be considered when looking at the analysis:

1. Suppliers with estimated service area R_i-gpcd above the standard are assumed to drop down to the standard. This assumption means that estimated effects may be high because:
    - Suppliers do not have to meet individual standards; they may accommodate an exceedance of any standard by being sufficiently

under one of the other standards so long as their overall water use does not exceed the water use objective.

- It is very possible that a variance[31] is applicable for Suppliers with high R_i-gpcd. If a variance is granted, water use may not decrease.
- High R_i-gpcd in the dataset may have occurred because of incomplete separation of indoor from outdoor residential water use.

2. Urban retail Suppliers with estimated service area R_i-gpcd below the standard remain the same. This assumption means that estimated effects may be high because:
   - Similar to the above situation, a Supplier may use their lower R_i-gpcd to accommodate exceedance of one of the other standards, so long as their overall water use does not exceed the water use objective.
   - Low R_i-gpcd in the dataset may have occurred because the model underestimated the amount of outdoor water use.
3. Population remained the same in 2025 and 2030. This assumption means that estimated 2025 and 2030 effects may be low because averages and quantities were population-weighted.

Figures 5.3-1a to 5.3-1c show examples of the DSS tool using 157 Supplier R_i-gpcd values for each assessment year (2020, 2025, or 2030), derived from the Distribution Analysis, along with the current Water Code standard for that year. Red bars highlight Suppliers that are predicted to be above the standard, with blue highlighting those below the standard. Darker shaded bars denote Suppliers with high poverty levels compared to the rest of the Suppliers (75 percent of Suppliers have lower levels of poverty compared to the Suppliers with shaded bars). The reasonably even distribution indicates any standard will not be biased towards Suppliers with high poverty levels, however, it also indicates that any standard will affect some Suppliers with high poverty levels. The DSS tool allowed for selection of any standard and computed summary information, some of which is presented in the following tables.

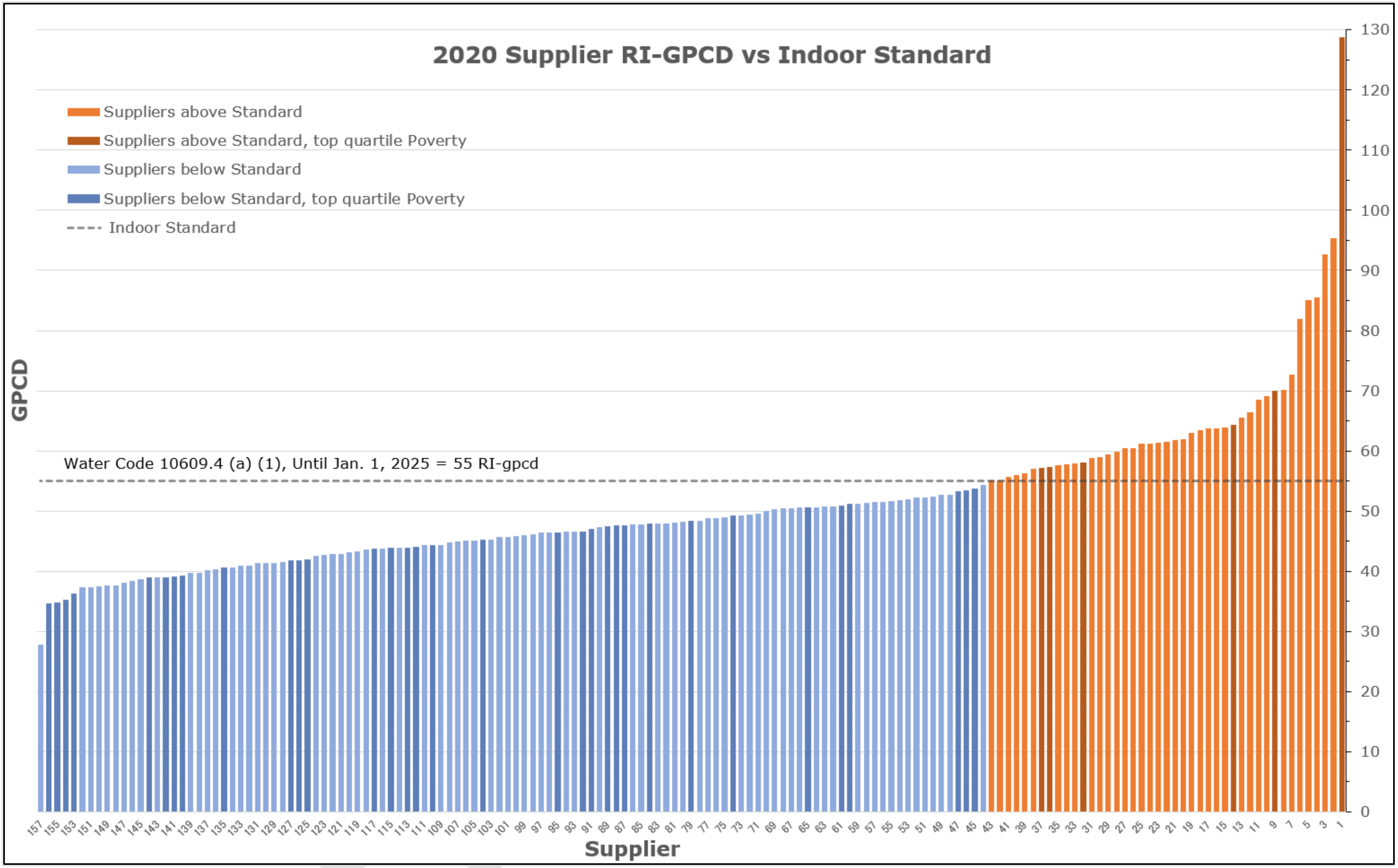

Figure 5.3-1a. Estimated 2020 Supplier Ri-gpcd (eAR Data) With Water Code 2020 Indoor Standard

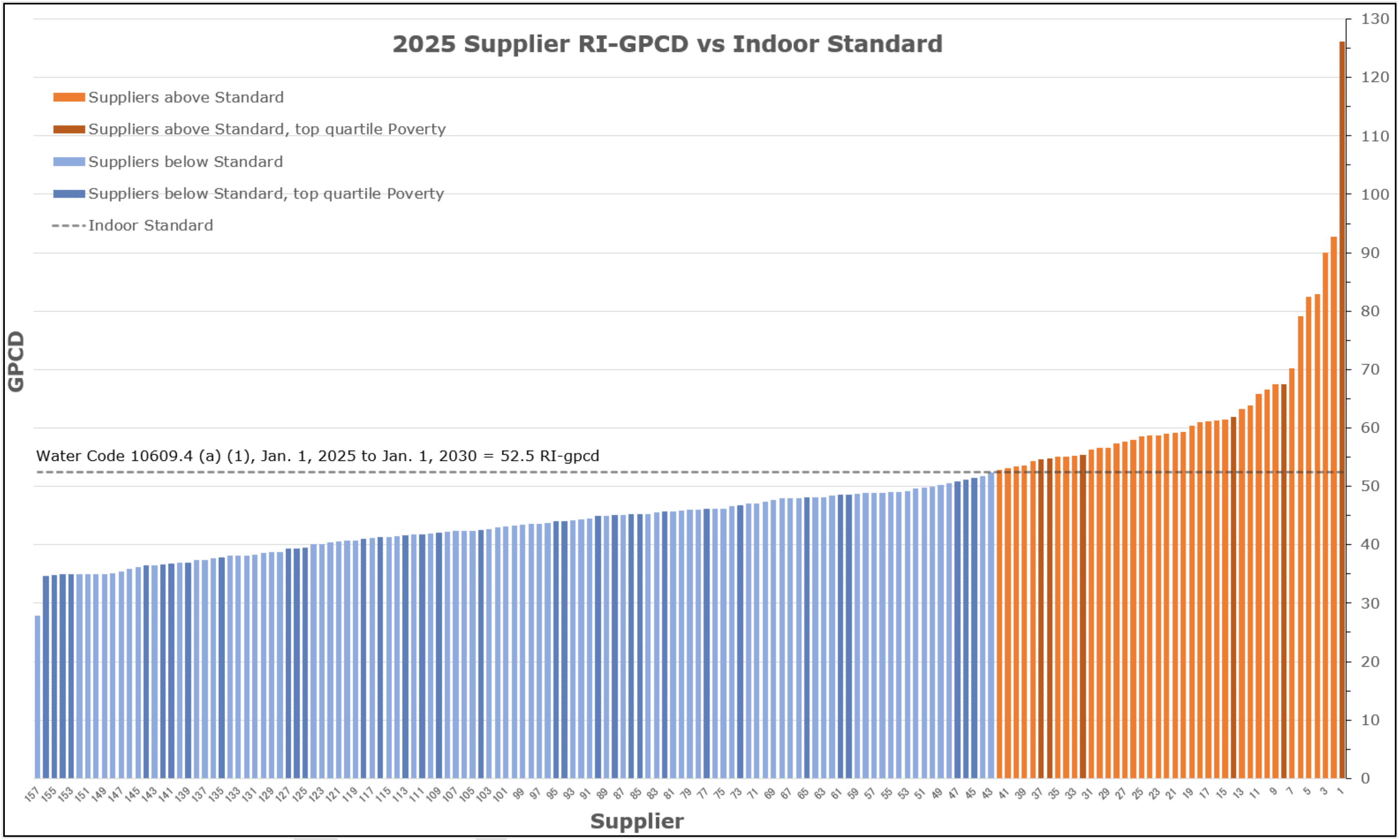

Figure 5.3-1b. Projected 2025 Supplier Ri-gpcd (eAR Data) With Water Code 2025 Indoor Standard

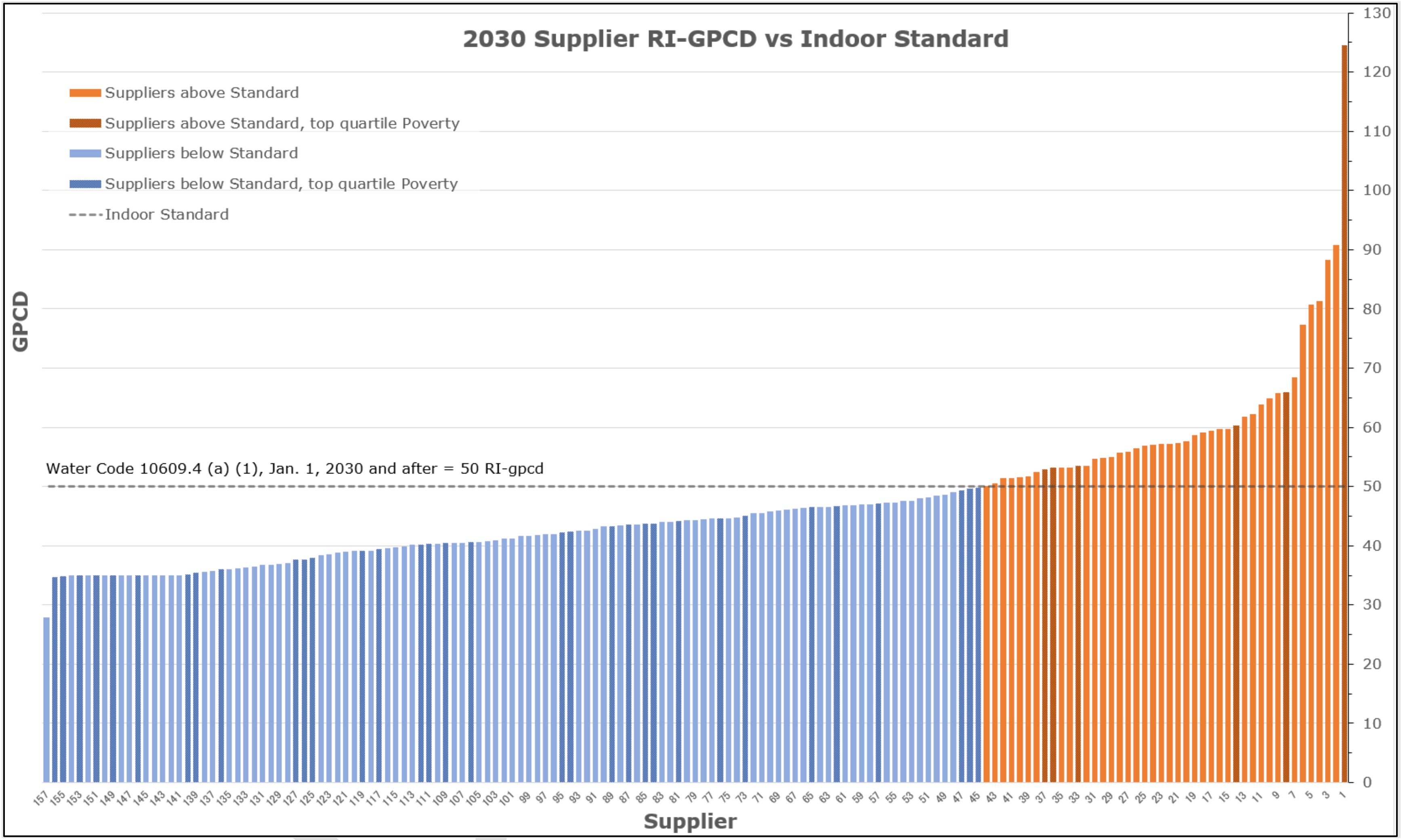

Figure 5.3-1c. Projected 2030 Supplier Ri-gpcd (eAR Data) With Water Code 2030 Indoor Standard

Tables 5.3-1a to 5.3-1c summarize potential effects of the statutory standard and standards that could affect approximately 25-percent, 50-percent, and 75-percent of Suppliers on estimated Statewide average R_i-gpcd, water savings, and associated populations. The SAM analysis of Supplier-Level data (eAR), Values for one gpcd increments are included in Appendix H - Distribution Analysis (eAR Data) and values for two gpcd increments are included in the April 22, 2021 Working Group meeting PowerPoint presentation slides.

Compared to the expected Statewide R_i-gpcd averages, implementation of the Water Code standard could reduce the expected Statewide 2020-2025 average R_i-gpcd (50.8 gpcd) by 2.2 gpcd resulting in a potential water savings of 89,883 acre-feet per year (AFY) compared to no-standard. For 2025-2030, the Water Code standard could reduce the expected Statewide average R_i-gpcd (48.2 gpcd) by 2.2 gpcd, with a potential water savings of 89,522 AFY compared to no-standard. For 2030 and onward, the Water Code standard could reduce the expected Statewide R_i-gpcd average (46.6 gpcd) by 2.3 gpcd, with a potential water savings of 97,166 AFY compared to no-standard.

Table 5.3-1a Potential Estimated Effects of Standards For 2020-2025

Standard Tested, *gpcd*	New Average R_i-gpcd	Water Savings, *acre-feet/ year*	Suppliers Above Standard, %	Suppliers > 5 gpcd Above Standard, %	Population Above the Standard, %
56	48.8	81,231	25	16	21
55	48.6	89,883	27	17	23
48.5	46.2	189,005	49	29	58
43	42.3	352,435	76	52	81

Table 5.3-1b Potential Estimated Effects of Standards For 2025-2030

Standard Tested, *gpcd*	New Average R_i-gpcd	Water Savings, *acre-feet/ year*	Suppliers Above Standard, *%*	Suppliers > 5 gpcd Above Standard, *%*	Population Above the Standard, *%*
53.5	46.2	80,634	25	16	20
52.5	46.0	89,522	27	17	23
46	43.7	186,134	50	29	58
41	40.2	331,227	75	50	78

Table 5.3-1c Potential Estimated Effects of Standards For 2030+

Standard Tested, *gpcd*	New Average R_i-gpcd	Water Savings, *acre-feet/ year*	Suppliers Above Standard, *%*	Suppliers > 5 gpcd Above Standard, *%*	Population Above the Standard, *%*
51.5	44.6	83,078	25	16	21
50	44.3	97,166	28	18	23
44.5	42.2	181,299	50	29	57
39	38.4	340,515	76	52	80

6.0 BENEFITS AND IMPACTS SUMMARY

A qualitative analysis of the benefits and impacts on water supply, wastewater, and recycled water systems was conducted through case study interviews with four utilities and prior assessments by the California Urban Water Agencies (CUWA) in 2017 (Adapting to Change; Utility Systems and Declining Flows). These utilities represent a diverse set of experiences and reflect variations in geography, source supplies, service area size, and topography, all of which may affect benefits and impacts from changing R_i-gpcd. [Refer to Appendix I - Benefits and Impacts of Changing R_i-gpcd, for details on this study. Benefits are further discussed in Appendix I Section 2 and adverse impacts are presented in Section 3.]

Water and wastewater systems are interconnected; any standard's effect on R_i-gpcd may alter hydraulics in these systems: total volumes and velocities may be affected along with water and wastewater quality, energy use, operation and maintenance requirements, and planning and design.

Whether or not a benefit or impact will occur depends on local conditions and how much a changing standard may affect a Supplier's water use. If a Supplier service area R_i-gpcd is at or below the standard, the standard will have little to no effect on the related systems. If the Supplier service area R_i-gpcd is higher than the standard, effects will depend on the magnitude of exceedance, along with locally-specific characteristics of the system.

For an area where the existing R_i-gpcd is higher than the standard, the benefits of reduced R_i-gpcd are similar for water and wastewater systems because reduction in total volumes allows for reduced treatment costs and energy use, and for excess capacity to support growth or defer capital investment for expansion. However, adverse impacts vary greatly, reflecting the differences in water and wastewater system infrastructure needs and expectations.

The acknowledgment of adverse impacts under this situation is not to imply that emphasis on conservation and water use efficiency should be relaxed, or that potable water use remains the same or should increase to avoid impacts. Rather, it is to acknowledge the interconnections between water use, wastewater generation, and recycled water production, and how changes within the cycle will have implications.

Though indoor residential water use is a factor in water and wastewater flows and recycled water systems, impacts on utilities are also a function of the following factors:

- **Diverse utility characteristics and conditions**. Multiple characteristics influence a utility's vulnerability to adverse impacts, such as population served, age and condition of existing infrastructure, materials of construction, and utility rate structures.

- **Magnitude of effect**. If indoor residential water use is already low, overall effects of a changing standard may be minimal. Alternatively, a significant decrease in indoor residential water use to meet a changing standard may have more substantial adverse impacts.

- **Other water use sectors**. The COVID-19 pandemic has driven measurable increases in residential water use, along with a concurrent decrease in commercial, industrial, and institutional (CII) water use. The overall net effect for many utilities has been reduced system flows, even with increasing residential water use. During drought conditions, water use reductions are experienced in most water use sectors, which can further compound effects.

Because this study was a qualitative assessment and not intended to arrive at quantifiable thresholds for the R_i-gpcd, future studies to inform a new standard will need to take site-specific factors and unique characteristics into consideration. Summaries of this qualitative assessment on benefits and adverse impacts on water and wastewater utilities and impacts on recycled water projects from reduced R_i-gpcd are listed below in Tables 6-1, 6-2 a-c, and 6-3 a-c.

Public utilities across California have demonstrated their ability to adapt to adverse impacts of a changing R_i-gpcd through a variety of mitigation strategies. However, these adaptations require time and money, the extent of which will depend on utility-specific characteristics.

Existing literature and utility experience demonstrate real benefits from reduced per capita indoor residential water use, as well as significant adverse impacts to water, wastewater, and recycled water systems. These benefits and adverse impacts are summarized in Appendix I Tables 5.0a and ES-2 through ES-4, respectively.

Based on the research and case study interviews, specific utility characteristics can either increase a utility's resiliency or exacerbate adverse impacts from reduced R_i-gpcd. This is summarized in Appendix I Table ES-5 and discussed further in Section 5 of Appendix I. The utility characteristics described do not represent an exhaustive list, but rather a starting point for future research and quantifiable data collection.

The findings of this qualitative assessment are consistent with the quantitative analysis of impacts to wastewater and recycled water systems provided in the Nature Sustainability article, “Unintended consequences of water conservation on the use of treated municipal wastewater” (Shwabe et al., 2020). This Nature study found significant effects of conservation policies in 2015, 2016, and 2017 on wastewater flow and salinity, even when wastewater treatment plant characteristics, seasonal, monthly, or year-specific impacts are factored out. As expected, the magnitude of impact to the 34 southern California wastewater treatment plants analyzed was highly variable.

Table 6-1 Potential Benefits for Water and Wastewater Utilities from reduced R_i-gpcd

Effect	**Description**	**Benefit to Utility**
Adaptations to the effects of climate change	Enables existing supplies to support potential population growth without an immediate need for water treatment plant expansion or investments in supplemental supplies	Improved regional self-reliance, water service reliability, and cost savings
Decreased water treatment and pumping costs	Lower water demand decreases treatment chemical uses and associated costs to produce drinking water, and lowers energy required to pump water in distribution systems	Cost savings for water utilities through reduced chemical purchase and energy usage
Deferred capital investment	Remaining capacity can allow for deferral of capital investment costs to expand existing water or wastewater treatment plant	Deferred capital spent for water or wastewater utilities
Reduced energy usage for wastewater systems	Reduced water demand and wastewater production results in lower energy usage associated with reduced pumping and treatment process needs	Cost savings from reduced energy usage for pumping

Table 6-2.a Potential Adverse Impacts for Water Utilities from reduced R_i-gpcd

Effect	**Description**	**Potential Adaptation Strategies & Impact on Utility**
Deterioration of water quality	Increased retention time in the water distribution system creates treatment and potential public health and safety implications from increases in disinfectant by-product (DBP) formation, microbial activity, and change in aesthetic characteristics such as taste and odor	Increased operational costs from flushing, additional chemical usage or O&M, or possible increased risk to health and safety[1]
Stranded assets and stagnation in storage facilities	Reduced water demand may result in stranded assets such as underused water treatment plants or unused capacity in distribution systems and storage facilities	Economic impact from unused assets as well as operations and maintenance (O&M) labor and costs to continue maintaining underused infrastructure[1]
Reductions in revenue from reduced water sales	Reduced water demand can result in lower total water sales, which makes it challenging for utilities to cover baseline O&M costs	Economic impact from reduced revenue and need to increase customer rates to compensate

[1]Increased retention time results from systems oversized for current conditions. Utilities are updating demand projections, but there are considerations in water system sizing (e.g., peak hour, maximum day, and fire flows) that may limit a utility's ability to adapt through downsizing to match reduced water demand.

Table 6-2.b Potential Adverse Impacts for Wastewater Utilities from reduced R_i-gpcd

Effect	Description	Potential Adaptation Strategies & Impact on Utility
Increased sewer gas production	Increasing sewer gas production such as hydrogen sulfide (H_2S) concentrations can create public health and safety impacts from increase in odor production and build-up of noxious gasses	Increased costs from increased purchase of odor mitigation materials and associated O&M
Accelerated rate of corrosion in sewer pipes and manholes	Higher H_2S concentrations accelerate the rate of corrosion in sewer pipes, especially concrete, leading to faster rate of failure	Increased costs from additional O&M and accelerated need for capital improvement program (CIP) projects for infrastructure rehabilitation or replacement
Increased occurrence of sewer blockages and overflows	Increased solids concentrations exacerbate blockages in sewers, resulting in clogged pipes, loss of sewer serviceability, sanitary sewer overflows	Increased costs for additional O&M and public health & safety impacts if unaddressed
Degradation of wastewater influent quality	Increasing contaminant concentrations in wastewater influent such as higher ammonia, biological oxygen demand (BOD), and total suspended solids (TSS) can stress loading-based treatment processes and increase concentrations in wastewater effluent	Reduced treatment capacity and increased treatment costs to continue meeting discharge requirements

Table 6-2.c Potential Adverse Impacts for Recycled Water Projects from reduced R_i-gpcd

Effect	**Description**	**Potential Adaptation Strategies & Impact on Utility**
Reductions in recycled water quantity	Reductions in wastewater influent subsequently reduce the volumes of recycled water that can be produced, limiting a utility's ability to offset potable reuse with recycled water	Increased reliance on potable water instead of recycled water, reducing regional self-reliance
Deterioration of recycled water quality	Changes in wastewater effluent quality adversely affect recycled water quality, which has downstream impacts on recycled water users with specific water quality criteria	Increased costs of recycled water, particularly if supply needs to be supplemented with potable water or if additional pretreatment is needed

Table 6-3.a Water Utility Characteristics that can Contribute to Adverse Impacts from reduced R_i-gpcd

Adverse Impact	Utility Characteristics
Deterioration of water quality due to increased retention time in distribution system	• **Age of infrastructure.** Systems appropriately designed for higher historical flow rates can become oversized, resulting in longer retention times and higher water age. Design criteria that support higher flow rates (e.g., flat slopes, turns and pumping) may not work well for lower flow conditions and can exacerbate water quality. Older systems may also experience more corrosion and deterioration. In such systems, any changes in flow conditions may lead to water quality deterioration, including contaminant leaching. **Topography, size, and density of service area.** Systems that serve large, flat, and low-density areas require water to travel longer, increasing the potential for longer distribution system retention times. • **Infrastructure material.** Systems with pipes made of iron, lead, copper and other metals may be more susceptible to problematic metal release from increased retention time.
Stranded assets and stagnation challenges from reduced water quantity	• **Magnitude of change from initial design parameters.** Similar to the above, water treatment plants and storage facilities sized for historically greater water demands may become oversized, resulting in water stagnation or excess infrastructure that could exist as stranded assets.

Reductions in revenue from reduced water sales	• **Rate structure.** Utilities with rate structures tied to volumetric use may experience more financial volatility as customers reduce water use.

Table 6-3.b Wastewater Utility Characteristics that can Contribute to Adverse Impacts from reduced R_i-gpcd

Adverse Impact	Utility Characteristics
Increase in odors and accelerated corrosion from higher sewer gas concentrations	• **Age of infrastructure.** Utilities with older infrastructure may be more susceptible to odor, leakage, and accelerated corrosion as pipelines have deteriorated and corroded over time. • **Topography, size, and density of service area.** Long stretches of flat pipeline provide more time for H_2S production, exacerbating odor production and corrosion. • **Infrastructure material.** Sewer systems constructed of materials sensitive to corrosion, such as concrete, will experience adverse effects of accelerated corrosion most heavily.
Increase occurrence of sewer blockages and overflows	• **Pipeline diameters.** Pipelines with smaller diameters are more easily clogged and thus more susceptible to sanitary sewer blockages and associated overflows. • **Conveyance system design parameters.** Pipelines with more flow constraint conditions (turns, material roughness, use of lift stations, and other features) may be more susceptible to blockages.

Impacts on wastewater effluent quality and increased chemical use from degradation of wastewater influent quality	• **Customer demographic.** Utilities with large percentages of residential customers will experience larger changes in both wastewater quality and quantity. • **Wastewater Treatment Plant (WWTP) treatment process.** WWTPs that use treatment processes that have loading limitations, such as activated sludge, nutrient removal, and biosolids handling, will be more sensitive to increasing loads in influent wastewater. • **National Pollutant Discharge Elimination System (NPDES) permit requirements and discharge point.** WWTPs that discharge into sensitive water bodies with strict NPDES discharge limits may require more operational adjustments and may struggle to maintain margins of safety that enable consistent compliance with effluent requirements.

Table 6-3.c Recycled Water Utility Characteristics that can Contribute to Adverse Impacts

Adverse Impact	Utility Characteristics
Deterioration in recycled water quality from worsened wastewater effluent quality	• **Customer demographic and end-uses.** Systems that serve customers that require high water quality (e.g., industrial processes, golf courses, or potable reuse) could be more susceptible to the impacts of increasing concentrations in wastewater effluent. • **Existing or planned investments.** Changes in wastewater quality will more greatly impact projects that are actively in design or construction phases.
Limiting the offset of potable use from reductions in recycled water production volumes	• **Water supply source.** Utilities that use recycled water to supplement a sensitive or scarce source supply will be more impacted by reductions in recycled water production. • **Discharge requirements.** Production of recycled water could be limited where WWTP's must continue to discharge a minimum flow to the receiving water body.

7.0 KEY ANALYSIS CONSIDERATIONS AND LIMITATIONS

The scope of the study and analysis was limited by data availability and provides a best estimate of R_i-gpcd. In calculating R_i-gpcd, disaggregating indoor water use from total residential water use has many challenges, some of which are discussed below.

7.1 Data Limitations

7.1.1 Population Data

The indoor residential water use standard is developed on a per-person basis, meaning accurate population counts are essential for determining a more accurate R_i-gpcd. The most defensible population estimates would have come from the 2020 census; however, that data was not available until March 31, 2021 and is not included in the scope of this study.

7.1.2 Data Quality and Quantity

R_i-gpcd is inferred based on models which include: monthly customer-level data used to develop the Central Tendencies Analysis results and aggregate monthly data used to develop the Distribution Analysis results. Aggregate monthly data was gathered from 157 of the 408 Suppliers from the annual eAR data submitted to the State Water Board.

- Monthly data disaggregation methods used to infer indoor residential water use from monthly billing data work best where winter outdoor water use is minimal; that is not the case for many Suppliers.

- Estimated R_i-gpcd using monthly aggregated data for an entire service area does not produce as accurate an estimate as does using customer-level data.

- A prerequisite to using the LAM and RAM methods are acquiring customer-level billing data and parcel-level measurements of landscape areas. These methods also require the ability to work with large, customer-level datasets. Only the least robust disaggregation method, SAM, can be used with eAR Supplier-level monthly data; while the results are informative, they are imprecise.

- There are known input errors with the eAR data. While obvious errors can be resolved, unobvious errors cannot. After careful screening, 157 of the 408 Suppliers (38% of all Suppliers) reporting eAR data could be used in the Distribution Analysis.
- R_i-gpcd error and confidence intervals can only be developed from customer-level data. These intervals are unknown for the Distribution Analysis estimates.
- Projected 2030 R_i-gpcd estimates are based on assumptions of turnover and development at the county-level and may not reflect individual service area conditions.
- The analysis of multi-family R_i-gpcd estimates are limited because of the unknown number of dwelling units associated with each connection. Multi-family R_i-gpcd cannot be inferred from the eAR data because of populations in group quarters, residences served by commercial meters, and because meter misclassification may result in inaccurate residential water use volumes.
- Additional service areas for the customer-level analysis is warranted to characterize the diversity of Supplier service areas within California.

7.2 Unknown Efficiency and Efficiency Improvement Capability

Low or high estimates of R_i-gpcd derived from hourly, monthly, or aggregate Supplier data cannot be associated with efficient or inefficient household water use without a comprehensive End-Use study. Without knowing why a household's water use is low or high, it cannot be conclusively stated that indoor residential water use is efficient or inefficient. Reasoning for this can range from issues with the data provided, the analysis method not being suitable to the Supplier's situation, or other factors that may warrant a variance.

7.3 Potential Sector Water Use Shift

The majority of this study was conducted using pre-pandemic data but some water use data were collected during 2020. It is recognized that the increase in population at home due to stay-at-home orders may affect indoor residential water use. Several studies from across the globe have reported changes in residential water use that have resulted from increased work-at-home.[32]

During the statewide shelter-in-place orders in March 2020, indoor residential water use increased by approximately 3.0 to 12.2 gpcd from the limited analysis of six Suppliers in the Department's study. An analysis presented by Flume in early 2021 showed the dramatic impact of COVID-19 on water use by comparing indoor gpcd for every day of the year in 2019 to 2020. While not a representative sample of all California, this analysis shows how much indoor residential water use veered from a typical year versus 2020.[33] Significantly, the lingering impacts of COVID-19 are not known.

This increase in indoor residential water use due to COVID-19 is important because there is no CII indoor water use standard. When water use shifts from a sector for which there is no standard (CII) to a sector where there is a standard (indoor residential), this could affect a Supplier's ability to meet their water use objective even if their overall water use declines. The persistence of this increase and associated effects on CII and overall water use objectives is currently unknown.

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[32] "The average US home used nearly 729 additional gallons of water in April than it did in February, according to a new study from water-monitoring company Phyn". https://www.techrepublic.com/article/us-home-water-use-up-21-daily-during-covid-19-crisis/?mc_cid=203b67e30d&mc_eid=c3757b1ab4; Abu-Bakar, H. et. Al. 2021. Quantifying the impact of the COVID-19 lockdown on household water consumption patterns in England. npj Clean Water (2021) 4:13; https://doi.org/10.1038/s41545-021-00103-8

[33] Flume. 2021. Diving Deep Into Water Use Trends in 2020. Webcast - https://youtu.be/GqJrfP45w5Q

7.4 Unknown Effect on Affordability of Water and Human Right to Water

The studies did not analyze potential economic impacts. Implementation of programs to accelerate water conservation will cost money, which comes from the State (taxpayers) or customers (rate-payers). Some Suppliers are already struggling with lost revenue because of unrecoverable customer bills exacerbated by economic conditions arising from the pandemic. However, water use efficiency is often less expensive than developing new water supplies and may help to ensure equitable and affordable access to water.

7.5 Benefits and Impacts on Other Water Sectors

Water supply, wastewater, and recycled water systems could all be affected by changes to indoor residential water use standards. Public utilities can and will adapt to changing standards. However, planning and investments for changes in infrastructure and facilities take time and money. Quantification of specific benefits and impacts will depend on magnitude of change, utility of specific conditions and characteristics, and how the COVID-19 pandemic shifts where and how water is used. Quantitative benefit and impact analyses were not conducted for this study.

7.6 Implementation of Best Practices

Locally cost-effective programs still require initial investment for implementation which takes time. Suppliers may be limited in what more they can do or achieve and how quickly they can implement programs (see Section 6.2, above). For example, leaks cannot be completely eliminated, and appliances and fixtures can be efficient, but over time they may lose efficiency. Furthermore, many conservation practices are implemented by customers and there may be behavioral, cultural, or financial barriers to implementation.

For example, Metropolitan Water District of Southern California has continued to promote indoor incentives for its member agencies’ residential customers through rebate programs. Since the drought ended in 2016, the uptake of rebates by residential customers has dramatically declined (Figure 7.6-1). It is unknown whether this reduction is because of reduced interest, saturation of the area with efficient appliances, economic conditions that limit the ability of customers to contribute their cost-share, reduction in education and outreach programs by member agencies, or other factors. It is also unknown whether or not uptake can be increased to accommodate a changing standard.

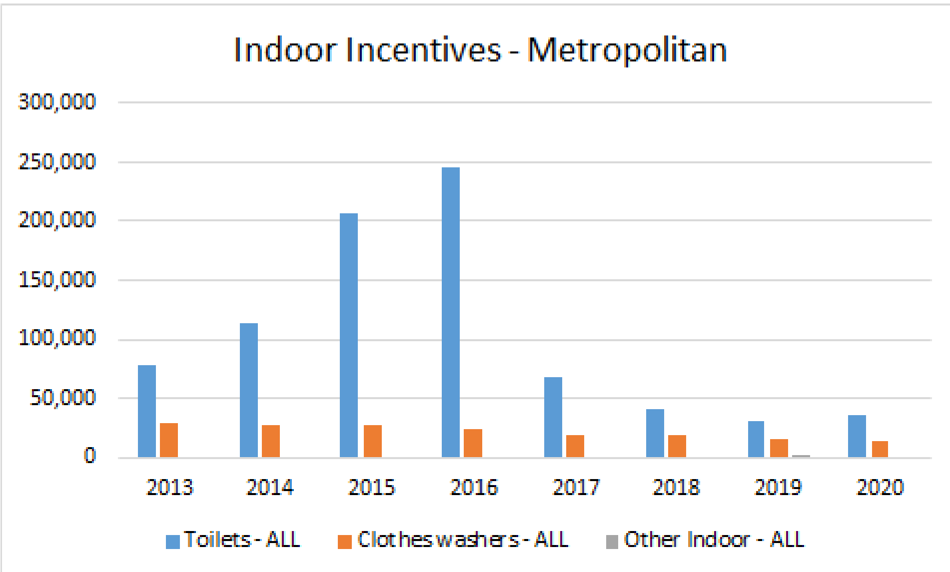

Figure 7.6-1. Fata for the Metropolitan Water District Incentive Program, Residential Installed Units (as of 12/14/2020)

8.0 RECOMMENDATIONS

The proposed joint recommendations for the indoor residential water use standards were presented at the April 22, 2021 Water Use Studies Working Group meeting for consideration and feedback from stakeholders. Table 8-1 lists the current standards in statute, the proposed standards in Assembly Bill 1434 (AB 1434, Freidman, as of April 26, 2021) for context, and the Department and State Water Board proposed joint recommendations.

Table 8-1. Comparison of Indoor Residential Water Use Standards (gpcd)

Starting Year	Current Statute	AB 1434	Joint DWR and Water Board Proposed Recommendation
2020	55	48	55
2025	52.5	45	47
2030	50	40	42

8.1 Rationale for Selecting the Proposed Joint Recommendations

Based on available information, the Department and State Water Board jointly believe the proposed recommendations reflect:

- That Californians have become more efficient over time. The current median water use of 48 gpcd is well below the 2020 standard in statute.[34]
- Efficient use.[35]
- Best practices.[36]
- That water use efficiency is often less expensive than developing new water supplies and may help to ensure equitable and affordable access to water.[37]

[34] The Department and the State Water Board's joint recommendations draw from the most robust analysis of indoor residential water use in California to date. See Appendix H.
[35] See the discussion of efficient indoor residential water use in Appendix J.
[36] See the discussion of best practices Section 1.8 and Appendix J.
[37] Water conservation programs have been shown to mitigate rate increases (Lee et al., 2011; Feinglas et al., 2013; Chesnutt et al., 2018). In some cases rate increases have disproportionately impacted lower income households (Mini et al., 2014 a,b).

- That water use efficiency reduces greenhouse gas emissions[38] and improves the resilience of urban areas to future water supply challenges.
- The need for a reasonable path to a feasible and impactful 2030 standard.
  - This standard recognizes the efforts, investments, and conservation achievements already made by California suppliers and their customers.
  - The overall water use objective is calculated by combining the indoor residential standard, the outdoor residential standard, the large landscape areas (CII) standard, the water loss standard, variances,[39] and a bonus incentive.[40] Suppliers retain discretion for how they will meet their overall water use objective.
  - Half of suppliers are on track to be at or below 44 gpcd by 2030 with passive conservation only. Estimates of Supplier water use are expected to be even lower when including active conservation.
  - Suppliers have time to plan, develop partnerships and programs, and support conservation as a way of life.

The Department and State Water Board recognize there are many factors affecting residents, suppliers, and related water utilities (wastewater and recycled water).

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[38] During the last drought, water conservation saved as much energy as all the energy efficiency initiatives offered by the state's major investor-owned utilities (Spang et al., 2018)
[39] Those suppliers that struggle to meet their objective specifically because of a unique circumstance that materially affects indoor residential water use rates (e.g., extensive use of evaporative coolers) may request a variance.
[40] For the amount of potable recycled water used the previous year.

2020: 55 gpcd (No Change in the Current Statute)

Our agencies do not recommend changing the 2020 standard. This is because a 2020 standard would be in effect for only one year (2024). In addition, this reflects our recognition of the financial strain the pandemic has created for many suppliers.

2025: 47 gpcd (5.5 gpcd Less than the Current Statute)

To assess the suitability of standards, it is important to estimate what water use will be in the future. When estimating future water use, it is informative to consider trends in water use over time. The main trend has been declining indoor residential water use at a rate of approximately 0.4 to 0.9 percent per year[41]. The lower end of this range reflects passive conservation and the higher end of this range reflect both active and passive conservation, where:

- "Active" conservation measures such as education and outreach, residential and commercial water audits, and rebates.
- "Passive" water use reductions such as those driven by plumbing codes, SB 407, and turnover given the expected lifetime of fixtures and appliances.

By 2025, 54 percent of Suppliers would be below the recommended standard of 47 gpcd considering only passive conservation. If indoor residential water use continues dropping with active conservation efforts, the number of suppliers below the 2025 recommended standard of 47 gpcd could be even higher. As noted above, suppliers retain discretion for how they will meet their overall water use objective. They may also be eligible for the bonus incentive or to pursue variances.

2030: 42 gpcd (8 gpcd Less than the Current Statute)

From 2030 onward, the Department and the State Water Board recommend an indoor residential standard of 42 gpcd. As with the recommendation for

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[41]Refer to Appendix F and the Residential End Use in United States, Version 2, which shows that indoor residential use decreased 15% between 1999 and 2016, suggesting a 0.9% per year decline (De Oreo et al., 2016).

the 2025 standard, the 2030 recommendation takes into consideration future use.

By 2030, 39 percent of Suppliers would be below the recommended standard of 42 gpcd considering only passive conservation. If indoor residential water use continues dropping with active conservation efforts, the number of suppliers below the 2030 recommended standard of 42 gpcd could be even higher. As noted above, suppliers retain discretion for how they will meet their overall water use objective. They may also be eligible for the bonus incentive or to pursue variances.

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