WaterSense® Technical Evaluation Process for Approving Home Certification Methods

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WaterSense Technical Evaluation Process for Approving Home Certification Methods

1.0 Introduction and Purpose

Under the *WaterSense Specification for Homes*, the U.S. Environmental Protection Agency (EPA) requires homes that earn the WaterSense label to be at least 30 percent more water-efficient than comparable homes with characteristics typical of new construction (i.e., meets national standards and follows common design and landscape practices). To confirm adherence to this requirement, homes must be certified under a Home Certification Organization's (HCO's) WaterSense Approved Certification Method (WACM), as described in the *WaterSense Home Certification System*. To become a WACM, WaterSense must confirm a proposed certification method (PCM) is able to differentiate homes that meet WaterSense's efficiency requirement from homes that do not.

This *WaterSense Technical Evaluation Process for Approving Home Certification Methods* (Technical Evaluation) describes WaterSense's process for assessing PCMs. The purpose of the evaluation is to provide reasonable assurance that in instances where the PCM's requirements are met, water savings of at least 30 percent can be expected. Only PCMs that are capable of consistently achieving WaterSense's required water efficiency criteria will be approved by the WaterSense program, thus becoming a WACM. The technical evaluation represents a protection of WaterSense's brand promise to only allow the WaterSense label to be associated with homes that demonstrate significant, quantifiable water savings and performance, as defined in the specification.

The purpose of this document is to explain EPA's process and assumptions used to evaluate the water efficiency level achieved by a PCM. Section 2.0 defines terminology used throughout the technical evaluation; Section 3.0 provides a brief overview of the technical evaluation process; Section 4.0 provides the details of the technical evaluation process and assumptions; and Section 5.0 discusses EPA's approval of PCMs that achieve at least 30 percent water efficiency, as determined by the technical evaluation.

2.0 Definitions

Definitions within the *WaterSense Home Certification System* are included by reference. Two definitions from the certification system are repeated here for convenience.

Proposed Certification Method (PCM): Methodology proposed by an HCO to evaluate a home's compliance with the water efficiency requirement in the *WaterSense Specification for Homes.* The PCM includes the technical requirements or criteria and the certification threshold homes must meet to demonstrate adherence to the water efficiency requirement in the *WaterSense Specification for Homes*.

WaterSense Approved Certification Method (WACM): A certification method that EPA has evaluated in accordance with the certification method technical evaluation process and has determined can effectively differentiate homes that meet the water efficiency requirement in the *WaterSense Specification for Homes.* In addition to the Mandatory Checklist, the WACM serves as the basis for certifying and labeling homes for the WaterSense program.

Other definitions applicable to this technical evaluation document include:

Reference Home/Reference Building: Set of assumed physical attributes of a home (e.g., lot size, number of bedrooms, number of bathrooms, minimum features installed) or multifamily building (e.g., landscape area, number of units, minimum features installed) EPA uses as a template for evaluating baseline water use and water efficiency gains across a range of homes that could be certified under a PCM. As part of this technical evaluation, EPA uses four single-family reference home and four multifamily reference building scenarios to represent a broad range of physical attributes that are realistic in new construction. These reference homes and buildings do not represent national or regional averages for these physical attributes. Instead they allow EPA to assess whether the PCM is able to meet the WaterSense water efficiency requirement across an array of physical home attributes.

Baseline Configuration: Term used to describe each reference home scenario that incorporates water use characteristics typical of new construction. Estimated water use from a home with characteristics typical of new construction assumes that the home is constructed to applicable national standards (e.g., plumbing fixture flush volumes and flow rates), as well as common design and landscape practices. These typical construction characteristics are applied to the relevant reference homes and/or buildings to create the baseline in the water use comparison. EPA's assumptions related to typical construction characteristics are discussed in Section 4.3 and Section 4.4.

Water-Efficient Configuration: Term used to describe each reference home scenario that incorporates features and assumptions that would be eligible for the WaterSense label under the PCM. Characteristics as defined by the PCM are applied to the relevant reference homes and/or buildings to create the water-efficient configuration used in the water use comparison. For the purposes of the evaluation, EPA assesses the least-efficient (i.e. highest water use) configuration that still meets the certification threshold for the specific PCM. EPA's assumptions related to water efficiency characteristics are discussed in Section 4.3 and Section 4.4.

3.0 Summary of the Technical Evaluation Process

Proposed Certification Method Scope Identification

As described in the *WaterSense Home Certification System*, an HCO shall supply EPA with a copy of its PCM and additional supporting documentation. The HCO's application to EPA must indicate the PCM's building eligibility (single-family and/or multifamily, new and/or existing construction) and geographic scope (i.e., national, regional, local). The HCO must also indicate the certification threshold (e.g., number of points, certification level, rating) it intends to designate for homes to earn the WaterSense label. EPA will use the HCO's stated scope to perform its technical evaluation. EPA will only approve the HCO's WACM for use with the stated building type and geographic region.

Determining "Least Efficient" Home and Landscape Design

Once the scope of the HCO's PCM is clearly defined, EPA will define one or more home and landscape designs to evaluate based on the minimum requirements a home must meet to achieve the PCM's stated certification threshold for WaterSense. EPA's goal is to determine the home and landscape designs that potentially result in the "least efficient" homes that could earn the WaterSense label. The features of the "least efficient" home and landscape designs will be incorporated into the assumptions and form the basis for the water-efficient home configurations. The process is intended to help EPA assess the minimum savings that are likely to be achieved by homes certified to the PCM.

The *WaterSense Specification for Homes* includes the Mandatory Checklist for WaterSense Labeled Homes (see Section 2.1 and Appendix B of the *WaterSense Specification for Homes*) that requires all homes that earn the WaterSense label to be equipped with WaterSense labeled toilets, lavatory faucets, and showerheads and be free of leaks. Therefore, the least efficient home design(s) that EPA evaluates will automatically include these features.

Water Savings, Technical Evaluation, and Approval

The technical evaluation will compare water use in a set of four predefined reference homes and/or reference buildings, as described in Section 4.2. Water use in each reference home and/or reference building will be compared between a baseline configuration with characteristics typical of new construction and a water-efficient configuration with characteristics of the "least efficient" home and landscape design expected to achieve certification under the PCM. Because some PCMs may provide flexibility in how homes can be configured to meet the requirements, EPA may define multiple "least efficient" home and landscape designs and repeat the technical evaluation across the reference homes. Homes must be able to meet EPA's water efficiency requirement across all reference home/reference building and "least efficient" home design scenarios in order for EPA to approve the PCM.

Sections 4.3 and 4.4 describe the assumptions and calculations EPA will use to evaluate water use from the baseline and water-efficient configurations. The features and water savings estimates included in the water use evaluation are those for which EPA has identified studies, research, or other data that suggest quantifiable water savings can be achieved from implementation of that feature. Wherever possible, EPA utilized industry recognized studies, such as the Water Research Foundation's *Residential End Uses of Water, Version 2,* to identify water use, water savings, or usage patterns of different water-using fixtures, appliances, or systems. Throughout, EPA's objective is to use the best available data and to evaluate a home's potential water use across a realistic range of scenarios.

Unless specifically included in Sections 4.3 and 4.4, all other requirements or features included in a PCM are not assessed for water savings in EPA's technical evaluation. This is not to suggest that other requirements or features that could be included in a PCM do not have the potential to provide water savings, energy savings, or other environmental benefit. The WaterSense label is meant to recognize homes that are assured to achieve the water efficiency requirement from the *WaterSense Specification for Homes;* therefore, features for which water savings cannot yet be reliably quantified are omitted. However, if an HCO believes that water use or savings from a requirement or feature of its PCM is not adequately accounted for, the HCO can submit technical justification to EPA for consideration. See Section 4.5 for more details.

4.0 Technical Evaluation Details and Assumptions

EPA's technical evaluation involves applying a series of calculations and assumptions to estimate baseline water use for several reference home scenarios intended to reflect a range of home and lot sizes, as well as common features. Similarly, the technical evaluation applies a series of calculations and assumptions to estimate water use associated with specific water efficiency features based on the criteria for the water-efficient configuration(s) in the same reference home scenarios. EPA will evaluate the water savings between the baseline and water-efficient configuration(s) under each reference home scenario.

The outdoor water use and savings assumptions vary depending upon the geographic scope of the PCM; therefore, EPA takes location into consideration when establishing the reference homes. Section 4.1 discusses this geographic scope factor. Section 4.2 provides a detailed explanation of the reference homes and Sections 4.3 and 4.4, respectively, describe the assumptions and methods for calculating indoor and outdoor water use for the baseline and water-efficient configurations of each reference home.

4.1 Scope

As identified in the *Application for Home Certification Organization (HCO) and Proposed Certification Method (PCM) Approval,* a prospective HCO submits its PCM's building eligibility (single-family and/or multifamily, new and/or existing construction) and geographic scope (i.e., national, regional, local) to EPA as part of its program application. EPA will evaluate the PCM based on the specific scope identified by the HCO applicant.

Geographic scope impacts the reference home's anticipated outdoor water use since climate has a well-documented impact on outdoor water use. For PCMs intended to certify homes at the local level (i.e., within a specific city or county), EPA will use local zip codes to determine a modified net evapotranspiration (NetET)[1] with effective rainfall ($ModNetET_o$, explained in more detail in Section 4.4) to include in the technical evaluation. For PCMs to be used to certify homes across a larger region, EPA will use a range of $ModNetET_o$ values to represent the geographic scope. For reference, values for $ModNetET_o$ across the continental United States range from approximately 20 inches per year to approximately 100 inches per year.[2] For national certification methods, EPA will use $ModNetET_o$ values toward both ends of this range to conduct the technical evaluation.

4.2 Reference Home Designs

EPA will analyze the expected differences in water use between a baseline and water-efficient configuration in a series of reference homes with the same physical attributes (e.g., lot sizes, number of bedrooms, number of bathrooms, minimum features installed). The series of basic reference homes serves as a template for evaluating water efficiency gains associated with homes that could be labeled under a PCM.

Both single- and multifamily homes can vary significantly in size and design. To avoid the need to develop an overly complex procedure to normalize all possible variations of home size and design, EPA has identified "reference home scenarios" that represent a broad range of typical home physical attributes. These reference home scenarios are intended to ensure that

[1] Evapotranspiration is a measurement of the amount of water a plant requires from optimal growth.
[2] See Section 4.4 for information on how EPA calculates $ModNetET_o$.

WaterSense labeled homes will be able to meet EPA's water efficiency requirements across a large range of likely home configurations that are possible under the PCM.

EPA identified features to include in the reference homes from the U.S. Department of Housing and Urban Development (HUD) 2017 Survey of Construction. U.S. Census data were reviewed to inform the range of typical design attributes—such as number of bedrooms, number of bathrooms, and lot size—that were included in the reference homes.[3,4]

EPA established the landscape area for single-family reference homes based on a best fit equation that was developed using observed field data from *Residential End Uses of Water, Version 2.* Where the lot size of the reference home is less than 7,000 square feet (sq. ft.), landscape area is calculated according to Equation 1. Where the lot size of the reference home is greater than or equal to 7,000 sq. ft., the landscape area is calculated according to Equation 2.[5]

Equation 1: Landscape Area for Single-Family Reference Homes With Lot Size Less Than 7,000 Square Feet

$$\text{Landscape area} = \text{Lot size} \times (0.002479 \times \text{Lot size}^{0.6157})$$

Equation 2: Landscape Area for Single-Family Reference Homes With Lot Size Greater Than or Equal to 7,000 Square Feet

$$\text{Landscape area} = \text{Lot size} \times 0.577$$

Landscape areas for the multifamily reference homes were established based on EPA's review of multiple data sources including the Fannie Mae Multifamily Energy and Water Market Research Survey[6] and entries in ENERGY STAR® Portfolio Manager® pertaining to EPA Water Score. These data sources indicate that, while it is extremely common for multifamily buildings to exhibit little to no outdoor water use, it is also observed that many properties have landscape areas several times larger than their floor area. As a result, EPA set the landscaped area for multifamily reference homes across a full range of values to capture all potential situations.

EPA assumes that an in-ground irrigation system is installed for each reference home. While this does not necessarily represent characteristics typical of new construction in all regions, EPA intends for the technical evaluation to assess homes with features likely to result in higher water use. Available data strongly indicate that a home constructed without an in-ground

[3] U.S. Census Bureau. Characteristics of New Single-Family Houses Completed. www.census.gov/construction/chars/completed.html

[4] U.S. Census Bureau. Characteristics of Units in New Multifamily Buildings Completed. www.census.gov/construction/chars/mfu.html

[5] American National Standards Institute (ANSI)/Residential Energy Services Network (RESNET)/International Code Council (ICC) 850-2020 *Standard Calculation and Labeling of the Water Use Performance of One- and Two-Family Dwellings Using the Water Rating Index*.

[6] Fannie Mae, 2012. Fannie Mae Multifamily Energy and Water Market Research Survey. www.fanniemae.com/multifamily/green-initiative-market-research-survey

irrigation system is likely to consume less water than a home with in-ground irrigation,[7] and therefore EPA is confident that a PCM that can effectively differentiate homes with in-ground irrigation could also do so where an in-ground irrigation system is absent.

Table 4-1 summarizes the attributes of the single-family reference homes. Table 4-2 summarizes the attributes of the multifamily reference buildings.

Through the technical evaluation, EPA will evaluate each reference home/reference building (that falls within the scope of the PCM) for baseline water use (both indoor and outdoor combined), as well as anticipated water use and savings (indoor and outdoor combined) from applying features of the water-efficient configurations(s) that could be certified under the PCM. Sections 4.3 and 4.4 explain the calculations and assumptions used to conduct this evaluation in more detail.

[7] Water Research Foundation (WRF), 2016. *Residential End Uses of Water, Version 2*.

Table 4-1. Single-Family Reference Homes

Attribute/ Feature	Single-Family Reference Home 1: Small Footprint and Large Lot	Single-Family Reference Home 2: Small Footprint and Small Lot	Single-Family Reference Home 3: Large Footprint and Large Lot	Single-Family Reference Home 4: Large Footprint and Small Lot
Bedrooms	2	2	5	5
Bathrooms	1.5	1.5	4	4
Footprint (sq. ft.)	1,000	1,000	2,500	2,500
Number of stories	1	1	2	2
Total square footage (sq. ft.)	1,000	1,000	5,000	5,000
Lot size (sq. ft.)	22,000	4,440	22,000	4,440
Landscaped area (sq. ft.)	12,694	1,938	12,694	1,938
Number of toilets	2	2	4	4
Number of showerheads	1	1	4	4
Number of lavatory faucets[8]	3	3	6	6
Number of kitchen faucets	1	1	1	1
Number of clothes washers	1	1	1	1
Number of dishwashers	1	1	1	1
Irrigation season[9]	Determined based on climate data	Determined based on climate data	Determined based on climate data	Determined based on climate data

[8] The number of lavatory faucets exceeds the number of toilets based on EPA's assumption that dual vanities will be installed in some of the home's bathrooms.
[9] EPA uses a value for $ModNetET_o$ as an indicator of irrigation season. See Section 4.4 for more information.

Table 4-2. Multifamily Reference Buildings

Attribute/ Feature	Multifamily Reference Home 1: Small Building and No Irrigated Area	Multifamily Reference Home 2: Small Building With Irrigated Area	Multifamily Reference Home 3: Large Building and No Irrigated Area	Multifamily Reference Home 4: Large Building With Irrigated Area
Units and Bedrooms	20 units x 1 bedroom/unit = 20	20 units x 1 bedrooms/unit = 20	300 units x 2.5 bedrooms/unit = 750	300 units x 2.5 bedrooms/unit = 750
Bathrooms	1 bathroom per unit	1 bathroom per unit	2 bathrooms per unit	2 bathrooms per unit
Landscaped area (sq. ft.)	None	40,000	None	600,000
Number of toilets	20 units x 1 bathroom/unit = 20	20 units x 1 bathroom/unit= 20	300 units x 2 bathrooms/unit = 600	300 units x 2 bathrooms/unit = 600
Number of showerheads	20 units x 1 bathroom/unit = 20	20 units x 1 bathroom/unit = 20	300 units x 2 bathrooms/unit = 600	300 units x 2 bathrooms/unit = 600
Number of lavatory faucets	20 units x 1 bathroom/unit = 20	20 units x 1 bathroom/unit = 20	300 units x 2 bathrooms/unit = 600	300 units x 2 bathrooms/unit = 600
Number of kitchen faucets	20 units x 1 kitchen/unit = 20	20 units x 1 kitchen/unit = 20	300 units x 1 kitchen/unit = 300	300 units x 1 kitchen/unit = 300
Number of clothes washers	20 units x 1 machine/unit = 20	20 units x 1 machine/unit = 20	300 units x 1 machine/unit = 300	300 units x 1 machine/unit = 300
Number of dishwashers	20 units x 1 machine/unit = 20	20 units x 1 machine/unit = 20	300 units x 1 machine/unit = 300	300 units x 1 machine/unit = 300
Irrigation season[10]	Determined based on climate data	Determined based on climate data	Determined based on climate data	Determined based on climate data

[10] EPA uses a value for $ModNetET_o$ as an indicator of irrigation season. See Section 4.4 for more information.

4.3 Evaluating Indoor Water Use

Generally, indoor water use is heavily influenced by occupancy in addition to the efficiencies of its technology and design features. Therefore, the technical evaluation estimates indoor water use under each reference home scenario for a baseline configuration, with features and efficiencies typical of new construction, and a water-efficient configuration, with features and efficiencies based on the water-efficient home design(s) from the PCM.

The indoor water use reduction is considered with the outdoor water use reduction, discussed in Section 4.4, to determine the total water savings for the home over the baseline, which must meet EPA's water efficiency requirement across all reference home scenarios.

The subsections below describe how EPA estimates indoor water use within its technical evaluation.

4.3.1 Establishing Occupancy

Indoor water use is largely influenced by home occupancy. Generally, the more occupants in a home, the more water is used within the household, since most major end uses of water in homes (e.g., toilet flushes, showers) rise proportionally with the number of occupants.

To maintain a focus on the physical home or building as opposed to future occupants, EPA uses the number of bedrooms to predict occupancy. For the technical evaluation, EPA determines occupancy based on Equation 3 and Equation 4, which were derived from the Residential Energy Consumption Survey (RECS) and presented in the Florida Solar Energy Center's *Estimating Daily Domestic Hot-Water Use in North American Homes.*[11]

Equation 3: Single-Family Occupancy

$$\text{Occupants} = 1.09 + 0.54 \times \text{Number of bedrooms}$$

Equation 4: Multifamily Occupancy

$$\text{Occupants} = (1.49 + 0.45 \times \text{Number of bedrooms per unit}) \times \text{Number of units}$$

Where:

- Number of bedrooms is determined by the respective single-family and multifamily reference homes discussed in Section 4.2.
- Number of units is determined by the respective multifamily reference homes discussed in Section 4.2.

[11] Parker, Danny S. and Philip W. Fairey. Florida Solar Energy Center, 2015. *Estimating Daily Domestic Hot-Water Use in North American Homes.* FSEC-PF-464-15. June 30, 2015. www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-464-15.pdf

4.3.2 Establishing Water Use for Indoor Baseline and Water-Efficient Configurations

The annual baseline indoor water use for each reference home is determined based on Equation 5. The baseline water use is intended to represent the anticipated water use from a home constructed using typical design practices and standard plumbing fixture, fitting, and appliance efficiencies.

Equation 5: Annual Indoor Water Use for Baseline Configuration

$$\begin{aligned}\text{Annual indoor water use for baseline configuration (gallons)} \\ = [&\text{daily toilet use} + \text{daily shower use} + \text{daily lavatory faucet use} \\ &+ \text{daily kitchen faucet use} + \text{daily clothes washer use} \\ &+ \text{daily dishwasher use} + \text{daily bathtub use} \\ &+ \text{daily structural water waste from hot water delivery} \\ &+ \text{daily use from household leaks} + \text{other use (if applicable)}] \\ &\times 365 \text{ days}\end{aligned}$$

Where:

- Daily toilet use is established using Equation 7.
- Daily shower use is established using Equation 8.
- Daily lavatory faucet use is established using Equation 10.
- Daily kitchen faucet use is established using Equation 12.
- Daily clothes washer use is established using Equation 14.
- Daily dishwasher use is established using Equation 15.
- Daily bathtub use is established using Equation 16.
- Daily structural water waste from hot water delivery is established using Equation 17.
- Daily use from household leaks is established based on Section 4.3.2.9.
- Daily other use (if applicable) is determined based on information supplied by the HCO and reviewed by EPA, as explained in Section 4.5.

Annual indoor water use for each water-efficient reference home configuration is determined based on Equation 6. This is intended to represent the anticipated water use from a water-efficient home constructed using practices and efficiency measures adopted from the PCM.

Equation 6: Annual Indoor Water Use for Efficient Configuration

$$\begin{aligned}
&\text{Annual indoor water use for efficient configuration (gallons)}\\
&\quad = [\text{daily toilet use} + \text{daily shower use}\\
&\quad - \text{daily savings from thermostatic shutoff valves}\\
&\quad + \text{daily lavatory faucet use} + \text{daily kitchen faucet use}\\
&\quad + \text{daily clothes washer use} + \text{daily dishwasher use} + \text{daily bathtub use}\\
&\quad + \text{daily structural water waste from hot water delivery}\\
&\quad - \text{daily savings from hot water recirculation}\\
&\quad + \text{daily use from household leaks} + \text{other use (if applicable)}]\\
&\quad \times 365 \text{ days}
\end{aligned}$$

Where:

- Daily toilet use is established using Equation 7.
- Daily shower use is established using Equation 8.
- Daily savings from thermostatic shutoff valves is established using Equation 9.
- Daily lavatory faucet use is established using Equation 11.
- Daily kitchen faucet use is established using Equation 13.
- Daily clothes washer use is established using Equation 14.
- Daily dishwasher use is established using Equation 15.
- Daily bathtub use is established using Equation 16.
- Daily structural water waste from hot water delivery is established using Equation 18.
- Daily savings from hot water recirculation is established using Equation 19.
- Daily use from household leaks is established based on Section 4.3.2.9.
- Daily other use (if applicable) is determined based on information supplied by the HCO and reviewed by EPA, as explained in Section 4.5.

4.3.2.1 Toilet Water Use

Toilet water use for each baseline and water-efficient configuration of a reference home is determined based on Equation 7.

Equation 7: Daily Toilet Water Use

$$\text{Daily toilet water use (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Toilet flush volume}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 5.0 flushes per person per day.[12]
- Toilet flush volume (gallons per flush [gpf]) is dependent on whether the daily toilet water use is being determined for the baseline or the water-efficient configuration.
    - For baseline configurations, assume a toilet flush volume of 1.6 gpf. The Energy Policy Act of 1992 (EPAct 1992) established this as the maximum allowable flush volume for all gravity, flushometer-tank, and flushometer-valve toilets.[13]
    - For the water-efficient configurations, flush volume is determined based on requirements or features included in the water-efficient home(s) under the PCM; however, the flush volume cannot exceed 1.28 gpf. To earn the WaterSense label, homes must meet the Mandatory Checklist, as discussed in the *WaterSense Specification for Homes*, which requires all toilets installed within a home to be WaterSense labeled. WaterSense labeled tank-type and flushometer-valve toilets are required to have a flush volume of 1.28 gpf or less.[14,15]

[12] Water Research Foundation (WRF), 2016. *Residential End Uses of Water, Version 2*. Table 6.7.
[13] The maximum flush volume for toilets is codified in the Code of Federal Regulations (CFR) at 10 CFR Part 430.32.
[14] EPA, 2014. *WaterSense Specification for Tank-Type Toilets, Version 1.2.* June 2, 2014. www.epa.gov/sites/production/files/2017-01/documents/ws-products-spec-toilets.pdf
[15] EPA, 2015. *WaterSense Specification for Flushometer-Valve Water Closets, Version 1.0*. December 17, 2015. www.epa.gov/sites/production/files/2017-01/documents/ws-products-spec-fv-toilets.pdf

4.3.2.2 Shower Water Use

Shower water use for each baseline and water-efficient configuration for a reference home is determined based on Equation 8.

Equation 8: Daily Shower Water Use

$$\text{Daily shower water use (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Minutes per use} \times \text{Shower compartment flow rate}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 0.69 showers per person per day.[16]
- Minutes per use = 7.8 minutes per shower.[17]
- Shower compartment flow rate (gallons per minute [gpm]) is dependent on whether the daily shower water use is being determined for the baseline or the water-efficient configuration.
    - For baseline configurations, a shower compartment flow rate of 2.5 gpm is used, as EPAct 1992 established this as the maximum allowable flow rate for all showerheads.[18]
    - For the water-efficient configurations, the shower compartment flow rate(s) is determined based on requirements or features included in the water-efficient home(s) under the PCM; however, the flow rate cannot exceed 2.0 gpm per showerhead within a shower compartment. To earn the WaterSense label, homes must meet the Mandatory Checklist, which requires all showerheads installed within a home be WaterSense labeled. WaterSense labeled showerheads are required to have a flow rate of 2.0 gpm or less.[19]

Multiple spray showers (individual shower compartments with either multiple showerheads, supplemental body sprays, or supplemental hand wands) are frequently observed in homes and can substantially increase shower water use. A PCM may fail to appropriately account for multiple spray showers, specifically when incentive measures (i.e. points or credits) are awarded on a per product basis or when calculations do not account for the full shower compartment flow rate. In instances where this may be the case, WaterSense may increase the estimated flow rate for one shower compartment of the water-efficient configuration (by up to 2.0 gpm) to recognize this practice and ensure it does not result in erroneous home certification. In its technical evaluation, EPA will not increase the flow rate input if a PCM has measures in place to limit the total flow rate of all devices. EPA will not assume an increased flow rate for the

[16] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.9.
[17] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.9.
[18] The maximum water use (i.e., flow rate) for showerheads is codified in 10 CFR Part 430.32.
[19] EPA, 2018. *WaterSense Specification for Showerheads, Version 1.1.* July 26, 2018. www.epa.gov/sites/production/files/2018-07/documents/ws-products-specification-showerheads-v1-1.pdf

shower compartment if the measures of the PCM are at least as stringent as the requirements included in the Plumbing Manufacturers International (PMI) and Alliance for Water Efficiency (AWE) Memorandum of Understanding (MOU), which requires the total combined flow rate from all shower outlet devices controlled by one shower valve to not exceed 2.0 gpm. Where a second shower valve is installed in a shower compartment designed for two persons in residences, shower valves shall be installed not less than 96 inches apart, as measured horizontally.[20]

While EPA recognizes the MOU between PMI and AWE as an important industry agreement and has identified it as the preferred path to limit multiple spray showers, it is important to note that it is recent (at the time of publication of this document). As a result, EPA will not apply this penalty to PCMs for which stakeholder engagement has occurred prior to release of this technical evaluation process document and have otherwise established some level of control for the flow rate from multiple spray showers.

4.3.2.2.1 Savings From Thermostatic Shutoff Valves

There are two types of water waste associated with hot water distribution and use: structural waste and behavioral waste. Structural waste, which is discussed further in Section 4.3.2.8, represents the cooled-off hot water that often must be cleared from the hot water pipe that connects the water heater to the plumbing fitting (e.g., showerhead, faucet) or other end use. Behavioral waste constitutes water that has reached the desired temperature, but that runs down the drain before the occupant uses the water (e.g., gets into the shower).[21] Bathers could walk away from the shower or tub while the water heats up, performing other tasks prior to entering the shower. Any hot water that flows down the drain in the period after the water arriving at the point of use is hot and before the user begins their activity is considered behavioral waste.

Thermostatic shutoff valves (TSVs) can be used to eliminate behavioral waste from showering events. TSVs shut off (or greatly reduce) the flow of water to the tub spout or showerhead when water reaches a temperature hot enough for bathing. When the user is ready to enter the shower, the TSV can be reopened to allow the flow of water.

For baseline configurations for each reference home, no water savings are applied for TSVs, since these devices are not required by code and WaterSense does not have any information to suggest these devices are typically installed in new construction. Water savings are applied only if a PCM requires or credits for installation of TSVs and EPA has included it as part of the water-efficient configuration(s). Water savings to be applied to the water-efficient configuration for each reference home are determined using Equation 9.

[20] Plumbing Manufacturers International and Alliance for Water Efficiency, 2019. Memorandum of Understanding. November 7, 2019. www.allianceforwaterefficiency.org/sites/www.allianceforwaterefficiency.org/files/assets/AWE_PMI_MOU_Multi-Showerhead_Signed.pdf

[21] Lutz, Jim, 2011. *Water and Energy Wasted During Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems.* Lawrence Berkeley National Laboratory. LBNL-5115E. September 2011.

Equation 9: Daily Water Savings from TSVs for Efficient Configuration

$$\text{Daily water savings from TSVs for efficient configuration (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Volume saved per use}$$

Where:
- “Occupants” is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 0.69 showers per person per day.[22]
- Volume saved per use = 1.13 gallons per showering event.[23]

4.3.2.3 Lavatory Faucet Water Use

Daily lavatory (bathroom) faucet water use for the baseline configuration for each reference home is determined based on Equation 10.

Equation 10: Daily Lavatory Faucet Water Use for Baseline Configuration

$$\text{Daily lavatory faucet water use for baseline configuration (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Gallons per use}$$

Where:
- “Occupants” is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 5.7 lavatory faucet uses per person per day.[24]
- Gallons per use = 0.5 gallons.[25]

Faucet flow rate cannot be directly used to estimate water use because of user behavior. Frequently, a faucet is not turned entirely open during use, but is adjusted to meet the end user’s needs for hand washing, teeth brushing, or other behaviors. *Residential End Uses of Water, Version 2,* found a volume per faucet use of 0.5 gallons. EPA uses this value, along with expected uses per person per day, to establish water use for a baseline configuration.

To estimate lavatory faucet savings for the water-efficient configuration, EPA utilizes the same information that was examined during the development of WaterSense’s *High-Efficiency Lavatory Faucet Specification.* EPA reviewed two retrofit studies prepared by Aquacraft Inc.,

[22] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.9.
[23] Sherman, Troy, 2014. *Disaggregating Residential Shower Warm-Up Waste: An Understanding and Quantification of Behavioral Waste Based on Data from Lawrence Berkeley National Labs.* August 11, 2014.
[24] Because WRF’s *Residential End Uses of Water, Version 2* does not differentiate between lavatory faucet and kitchen faucet uses, EPA assumes that the number of lavatory faucet uses per occupant per day is equal to the number of toilet flushes per occupant (5.0) plus the number of showers per occupant (0.69), as determined by *Residential End Uses of Water, Version 2.*
[25] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.10.

one in Seattle, Washington in 2000,[26] and one in the service area of East Bay Municipal Utility District (EBMUD) in 2003,[27] where 1.5 gpm aerators were installed in place of existing faucet aerators. Post-faucet retrofit, the weighted average daily per capita reduction in water consumption achieved was 0.6 gallons per capita per day (gcpd).[28] For a lavatory faucet flow rate below 1.5 gpm, EPA intends to extrapolate these savings linearly, so additional savings in the technical evaluation are proportionally applied to a flow rate reduction beyond 1.5 gpm. Therefore, the daily lavatory faucet water use for an efficient configuration is determined based on Equation 11.

Equation 11: Daily Lavatory Faucet Water Use for Efficient Configuration

$$\text{Daily lavatory faucet water use for efficient configuration (gallons)} = \text{Baseline daily lavatory faucet water use} - [\text{Occupants} \times (\text{Standard lavatory faucet flow rate} - \text{Efficient lavatory faucet flow rate}) \times (\frac{\text{Post–retrofit savings}}{\text{Retrofit flow rate reduction}})]$$

Where:

- Daily lavatory faucet water use for baseline configuration is established using Equation 10.
- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Standard lavatory faucet flow rate = 2.2 gpm.[29]
- Efficient lavatory faucet flow rate = 1.5 gpm or less, as determined based on the requirements or features of the water-efficient home(s) under the PCM.
- Post-retrofit savings = 0.6 gallons per person per day.
- Retrofit flow rate reduction = 0.7 gpm, based on faucet flow rate reduction from the Seattle and EBMUD retrofit studies from 2.2 gpm to 1.5 gpm.

For the water-efficient configurations, the efficient lavatory faucet flow rate is determined based on requirements or features included in the water-efficient home(s) under the PCM; however, the flow rate cannot exceed 1.5 gpm. To earn the WaterSense label, homes must meet the Mandatory Checklist, which requires all lavatory faucets installed within a home to be WaterSense labeled. WaterSense labeled lavatory faucets are required to have a flow rate of 1.5 gpm or less.[30]

[26] Mayer, Peter W., William B. DeOreo, and David M. Lewis. 2000. *Seattle Home Water Conservation Study: The Impacts of High-Efficiency Plumbing Fixture Retrofits in Single-Family Homes*. December 2000.
[27] Mayer, Peter W., William B. DeOreo, Erin Towler, and David M. Lewis, 2003. *Residential indoor Water Conservation Study: Evaluation of High-Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area*. July 2003.
[28] EPA, 2007a. *WaterSense High-Efficiency Lavatory Faucet Specification Supporting Statement.* October 1, 2007. www.epa.gov/sites/production/files/2017-01/documents/ws-products-support-statement-faucets.pdf
[29] The maximum water use (i.e., flow rate) for lavatory faucets is codified in 10 CFR Part 430.32.
[30] EPA, 2007b. *WaterSense High-Efficiency Lavatory Faucet Specification, Version 1.0.* October 1, 2007. www.epa.gov/sites/production/files/2017-01/documents/ws-products-spec-faucets.pdf

4.3.2.4 Kitchen Faucet Water Use

Daily kitchen faucet water use for the baseline configuration for each reference home is determined based on Equation 12.

Equation 12: Daily Kitchen Faucet Water Use for Baseline Configuration

$$\text{Daily kitchen faucet water use for baseline configuration (gallons)} \\ = \text{Occupants} \times \text{Daily use} \times \text{Gallons per use}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 14.3 kitchen faucet uses per person per day.[31]
- Gallons per use = 0.5 gallons.[32]

As with lavatory faucets, kitchen faucet flow rate cannot be directly used to estimate water use because of user behavior. In addition, a kitchen faucet could only be turned entirely open for pot filling or other volumetric-based needs. In this case, flow rate would have an impact on run time, but not total water use.

For the water-efficient configurations, EPA estimates kitchen faucet savings based on a similar methodology it uses for lavatory faucets in Section 4.3.2.3; however, the methodology is modified to apply a ratio of kitchen faucet uses to lavatory faucets, accounting for increased daily uses of kitchen faucets compared to lavatory faucets. EPA is using this method because it is not aware of any field studies to suggest estimated daily, annual, or per capita water savings from reducing the flow rate of kitchen faucets.

[31] Because WRF's *Residential End Uses of Water, Version 2* does not differentiate between lavatory faucet and kitchen faucet uses, EPA assumes that the number of kitchen faucet uses per occupant per day is equal to the total number of faucet uses per occupant (20) minus the number of lavatory faucet uses estimated from Section 4.3.2.3. Information on total daily faucet uses was determined in *Residential End Uses of Water, Version 2,* Table 6.10.
[32] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.10.

The daily kitchen faucet water use for an efficient configuration is determined based on Equation 13.

Equation 13: Daily Kitchen Faucet Water Use for Efficient Configuration

$$\text{Daily kitchen faucet water use for efficient configuration (gallons)} = \text{Daily kitchen faucet water use for baseline configuration} - [\text{Occupants} \times (\text{Standard kitchen faucet flow rate} - \text{Efficient kitchen faucet flow rate}) \times (\frac{\text{Kitchen faucet daily use}}{\text{Lavatory faucet dail use}}) \times (\frac{\text{Post-retrofit savings}}{\text{Retrofit flow rate reduction}})]$$

Where:

- Daily kitchen faucet water use for the baseline configuration is established using Equation 12.
- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Standard kitchen faucet flow rate = 2.2 gpm.[33]
- Efficient kitchen faucet flow rate = 2.2 gpm or less, as determined based on the requirements or features of the water-efficient home(s) under the PCM.
- Kitchen faucet daily use = 14.3 uses per person per day.
- Lavatory faucet daily use = 5.7 uses per person per day.
- Post-retrofit savings = 0.6 gallons per person per day.[34]
- Retrofit flow rate reduction = 0.7 gpm, based on faucet flow rate reduction from the Seattle and EBMUD retrofit studies from 2.2 gpm to 1.5 gpm.

For the efficient configurations, unless a more efficient flow rate is required or credited under a PCM, EPA defaults the kitchen faucet flow rate at 2.2 gpm (the national standard flow rate) and assumes no water savings are achieved. WaterSense does not currently label kitchen faucets but could in the future.

[33] The maximum water use (i.e., flow rate) for kitchen faucets is codified in 10 CFR Part 430.32.

[34] The post-retrofit savings are based on the per capita per day water savings from retrofitting lavatory faucets, as explained in Section 4.3.2.3; however, EPA is not aware of comparable savings data specific to kitchen faucets.

4.3.2.5 Clothes Washer Water Use

Clothes washer water use for each baseline and water-efficient configuration for a reference home is determined based on Equation 14.

Equation 14: Daily Clothes Washer Water Use

$$\text{Daily clothes washer water use (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Clothes washer capacity} \times \text{Clothes washer integrated water factor}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 0.3 loads per person per day.[35]
- Clothes washer capacity = 3.9 cubic feet.[36]
- The clothes washer integrated water factor is dependent on whether the daily clothes washer water use is being determined for the baseline or the water-efficient configuration.
    - For baseline configurations, EPA uses an integrated water factor of 6.5 gallons per cycle per cubic foot, based on the federal requirements for top-loading clothes washers with a capacity of 1.6 cubic feet or greater, as codified in 10 CFR § 430.32.
    - For the water-efficient configurations, the clothes washer integrated water factor is determined based on requirements or features included in the water-efficient home(s) of the PCM. If the PCM requires or provides credit for ENERGY STAR certified clothes washers, EPA uses an integrated water factor of 4.3, as this is the ENERGY STAR requirement for top-loading clothes washers with a capacity greater than 2.5 cubic feet.[37]

[35] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.14.
[36] Based on the average capacity (cubic feet) of clothes washers from U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy (EERE) Compliance Certification Database. Accessed March 6, 2019.
[37] ENERGY STAR Clothes Washers Program Requirements, Version 8.0. Effective February 5, 2018. www.energystar.gov/products/appliances/clothes_washers/partners

4.3.2.6 Dishwasher Water Use

Dishwasher water use for each baseline and water-efficient configuration for a reference home is determined based on Equation 15.

Equation 15: Daily Dishwasher Water Use

$$\text{Daily dishwasher water use (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Dishwasher gallons per cycle}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 0.1 loads per person per day.[38]
- Dishwasher gallons per cycle is dependent on whether the daily dishwasher water use is being determined for the baseline or the water-efficient configuration.
    - For baseline configurations, EPA uses 5.0 gallons per cycle, based on the federal requirements for dishwashers codified in 10 CFR § 430.32.
    - For the water-efficient configurations, the dishwasher gallons per cycle are determined based on requirements or features included in the water-efficient home(s) under the PCM. If the PCM requires or provides credit for ENERGY STAR certified dishwashers, EPA uses 3.5 gallons per cycle.[39]

[38] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.15.

[39] ENERGY STAR Program Requirements for Residential Dishwashers, Version 6.0. Effective January 29, 2016. www.energystar.gov/products/appliances/dishwashers/partners

4.3.2.7 Bathtub Water Use

Bathtub water use for each baseline and water-efficient configuration for a reference home is determined based on Equation 16.

Equation 16: Daily Bathtub Water Use

$$\text{Daily bathtub water use (gallons)} = \text{Occupants} \times \text{Daily use} \times \text{Volume per bath}$$

Where:
- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily use = 0.07 baths per person per day.[40]
- Volume per bath = 20.2 gallons.[41]

Because bath consumption is a fixed, volumetric use, EPA uses Equation 16 and the associated inputs to generate water use for the baseline and water-efficient configurations for each reference home. Under the technical evaluation, there is not a means to reduce water use from baths.

Although it may not be significant, water use from baths is accounted for, since it is a likely use of water within a home. Therefore, to ensure WaterSense labeled homes are able to reduce water use by the requisite amount based on the water efficiency requirement from the *WaterSense Specification for Homes*, EPA must establish a realistic baseline against which to compare water savings, even if it means accounting for uses for which there are not options to achieve savings.

[40] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.17.
[41] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.17.

4.3.2.8 Water Waste From Hot Water Delivery

In a home with characteristics of typical new construction, there is potential for significant water waste while a user waits for hot water to reach the showerhead or faucet. By improving hot water distribution system design or installing an on-demand hot water recirculation system, the amount of water wasted while waiting for hot water can be substantially reduced.

EPA establishes water waste from hot water delivery for the baseline configuration for each reference home based on Equation 17.

Equation 17: Daily Water Waste From Hot Water Delivery for Baseline Configuration

$$\text{Daily water waste from hot water delivery for baseline configuration (gallons)} \\ = \text{Occupants} \times \text{Daily useful hot water draws} \\ \times \text{Standard volume wasted per hot water draw}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily useful hot water draws = 1.22 useful hot water draws per person per day.[42,43]
- Standard volume wasted per hot water draw = 1.77 gallons.[44]

The technical evaluation can estimate water savings from two methods for reducing water waste from hot water delivery: 1) efficient design that reduces the piping distance and/or diameter between the hot water heater and the point of use, thus reducing the amount of water that needs to be cleared from the system before hot water arrives; or 2) inclusion of a hot water recirculation system. EPA assigns savings for the water-efficient configuration(s) based on the hot water delivery requirements of the PCM from either approach, but not both.

[42] A useful hot water draw is characterized as an instance where the user waits for hot water to reach the plumbing fitting (e.g., showerhead) prior to performing a task (e.g., showering).

[43] EPA estimates the number of useful hot water draws per person per day to be the number of showers per person per day (0.69; based on WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.9) and the number of long faucet draws per person per day (0.53, based on Lutz, James, 2005. *Estimating Energy and Water Losses in Residential Hot Water Distribution Systems*).

[44] Based on Lutz, James, 2005. *Estimating Energy and Water Losses in Residential Hot Water Distribution Systems*. The study estimated household daily water waste at 6.35 gallons, with an average occupancy of 2.8 persons per household and 1.28 faucet and shower draws per capita per day.

To account for efficient design that reduces the piping distance and/or diameter between the hot water heater and point-of-use, EPA establishes water waste from hot water delivery for the water-efficient configurations for each reference home using Equation 18.

Equation 18: Daily Water Waste From Hot Water Delivery for Efficient Configuration

$$\text{Daily water waste from hot water delivery for efficient configuration(gallons)} \\ = \text{Occupants} \times \text{Daily useful hot water draws} \\ \times \text{Efficient home volume wasted per hot water draw}$$

Where:

- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily useful hot water draws = 1.22 useful hot water draws per person per day.[45,46]
- Efficient configuration volume wasted per hot water draw is determined based on requirements or features included in the water-efficient home(s) under the PCM. For example, if a program requires or provides credit for designing a hot water delivery system such that the volume of water stored in the piping must be less than 0.5 gallons, then 0.5 gallons would be used.

Alternatively, if a reduction in hot water delivery water waste is accounted for in a water-efficient home(s) through installation of a hot water recirculation system, EPA applies water savings to the water-efficient configurations for each reference home, as determined by Equation 19.

[45] A useful hot water draw is characterized as an instance where the user will wait for hot water to reach the plumbing fitting (e.g., showerhead) prior to performing a task (e.g., showering).
[46] EPA estimates the number of useful hot water draws per person per day to be the number of showers per person per day (0.69; based on WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.9) and the number of long faucet draws per person per day (0.53, based on Lutz, James, 2005. *Estimating Energy and Water Losses in Residential Hot Water Distribution Systems*).

Equation 19: Savings From Hot Water Recirculation System for Efficient Configuration

$$\text{Daily water savings from hot water recirculation for efficient configuration (gallons)} = \text{Occupants} \times (\text{Daily faucet savings attributable to recirculation} + \text{Daily showerhead savings attributable to recirculation})$$

Where:
- "Occupants" is established using Equation 3 or Equation 4, depending on the reference home.
- Daily faucet savings attributable to recirculation = 0.97 gallons per person per day.[47]
- Daily showerhead savings attributable to recirculation = 1.11 gallons per person per day.[48]

Savings calculated in Equation 19 are subtracted from the overall indoor water use for the water-efficient configuration for each reference home.

4.3.2.9 Water Waste From Household Leaks

Household water leaks are a reality in many homes, including those that are newly constructed. According to *Residential End Uses of Water, Version 2,* only 5 percent of existing homes included in the study were completely free of leaks during the data collection period.[49] A similar study completed in 2011 by Aquacraft that assessed the water use patterns of new homes designed and constructed to be high-efficiency (considered to be roughly equivalent to homes built to the *WaterSense Specification for New Homes, Version 1.0)* found a median daily leak rate of 2.8 gallons of water across the study homes.[50] Therefore, to properly account for all anticipated water uses in a home, EPA is including water waste from leaks in its technical evaluation of baseline and water-efficient configurations for each reference home.

For baseline configurations, EPA assumes that each reference home has a daily leak rate of 4.3 gallons of water, based on the median daily household leak volume identified in *Residential End Uses of Water, Version 2*.[51] In contrast to other information cited from *Residential End Uses of Water, Version 2,* where the mean value is used, EPA uses the median daily household leak volume. This is because some study homes had cases of extreme water leaks, therefore contributing disproportionately to the average leak rate. *Residential End Uses of Water, Version 2* noted that 80 percent of homes in the study had daily leak volumes of 20 gallons or less, contributing to only 17 percent of the total leaked volume identified in the study. EPA is also using a per household leak rate rather than a per capita leak rate. While most indoor water uses are largely dependent on occupants and their daily behaviors (e.g., toilet flushes, showers),

[47] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.29.
[48] WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.29.
[49] WRF, 2016. *Residential End Uses of Water, Version 2*. Page 130.
[50] DeOreo, William B, 2011. *Analysis of Water Use in New Single-Family Homes.*
[51] Based on the median daily household leak volume identified in WRF, 2016. *Residential End Uses of Water, Version 2*. Table 6.18.

leaks are independent of occupancy. Therefore, the 4.3 gallons for household water leaks is applied across the baseline configuration for all reference homes.

The Mandatory Checklist requires homes earning the WaterSense label to be free of leaks at all fixtures, fittings, and appliances and throughout the plumbing system and irrigation system (if applicable). Therefore, EPA has assurance that homes are leak-free at the time of final completion and certification. While this process is intended to identify and correct for any leaks before certification, it would be unrealistic to expect these actions will impact all subsequent leaks. To account for this verification, EPA's technical evaluation assumes the amount of water waste from leaks is reduced by 50 percent (2.15 gallons per day) for the water-efficient configurations for all reference homes.

While the technical evaluation assumes the actions included in the Mandatory Checklist reduce water waste from leaks by 50 percent, the remaining 50 percent (2.15 gallons per day) can be influenced if a leak detection and/or flow sensing system is required or credited for in the water-efficient home(s) under a PCM. Leak detection or flow-sensing systems are used to monitor water flows and detect if a household leak is occurring. The system will then either alert the homeowner or shut off the water until the issue is resolved.

EPA is aware that there are data needs associated with this new type of technology. It is difficult to estimate daily or annual water savings from leak detection devices, because actual water savings are dependent on instances where significant water leaks are prevented; however, EPA wants to recognize the benefits of these technologies and encourage their use by accounting for savings in its technical evaluation. As better data become available, the technical evaluation can be updated to reflect the best available data.

4.4 Evaluating Outdoor Water Use

Generally, outdoor water use is influenced by climate, irrigated area, irrigation (type of technology and irrigation schedule/maintenance), and landscape features (e.g., plant type). EPA uses this information within its technical evaluation to establish outdoor water use for each baseline and water-efficient configuration, using the results from each reference home scenario to compare the reduction in outdoor water use from installing water-efficient features and implementing water-efficient practices. The outdoor water use reduction is considered with the indoor water use reduction discussed in Section 4.3 to determine the total water savings for the home compared to the baseline, which must meet EPA's water efficiency requirement across all reference home scenarios for each PCM-specific, water-efficient design evaluated.

EPA uses a theoretical irrigation requirement (TIR) method to determine landscape water use, for both the baseline (Section 4.4.1) and water-efficient landscape scenarios (Section 4.4.2). The TIR accounts for factors such as irrigated area, plant types, reference evapotranspiration (ET_o), and allowance for irrigation inefficiencies. TIR is meant to determine how much water is required for optimum plant growth. This method is based, with modification, on *Residential End Uses of Water, Version 2.*[52] As acknowledged in *Residential End Uses of Water, Version 2*,

[52] WRF, 2016. *Residential End Uses of Water, Version 2.* (Note: The methodology is based on the landscape coefficient method described in the University of California Cooperative Extension's *A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California,* which itself was derived from standard water engineering techniques such as the U. S. Department of Agriculture, *SCS Technical Release 21* and the American Society of Civil Engineers, *Evapotranspiration and Irrigation Water Requirements.*)

these methods have been used for many years. Additionally, *Residential End Uses of Water, Version 2* reiterates that it is important to acknowledge that the TIR is a "theoretical number designed to optimize plant growth by fully supplying all of the water requirements as if for a commercial or agricultural operation." It is not a predictive value and should not be used as such; however, EPA intends to use it as a starting point to evaluate potential reduction in water use.

The calculation employed in the technical evaluation uses Equation 20[53] to determine the TIR:

Equation 20: Theoretical Irrigation Requirement

$$TIR = 0.6233 \times ModNetET_o \times \sum_{i=1}^{n}\left[\frac{A_i}{Eff_i} \times K_{species}\right]$$

Where:

- TIR = theoretical irrigation demand (gallons per year).
- 0.6233 = conversion factor for inches of $ModNetET_o$ to gallons per square foot.
- $ModNetET_o$ = Modified net ET_o based on effective rainfall (inches), explained in more detail below.
- n = number of irrigated zones in the landscape.
- i = individual zone.
- A_i = irrigated area of individual zone (sq. ft.).
- Eff_i = irrigation efficiency allowance of individual zone (taken from Table 3-3).
- $K_{species}$ = species coefficient (taken from Table 3-3).

Key TIR inputs are further described in the subsections below. Sections 4.4.1 and 4.4.2 describe how TIR is applied to estimate outdoor water use for a baseline and water-efficient configuration, respectively.

Modified Net ET_o Based on Effective Rainfall

The purpose of this calculation is to determine the theoretical amount of water a reference plant needs in the form of irrigation. It is calculated using monthly ET_o and rainfall data. EPA uses reference ET (ET_o) and rainfall data from the *World Water and Climate Atlas*, a project of the International Water Management Institute (IWMI).[54] EPA processed data from 1961 to 1990 to determine monthly ET_o and rainfall for each zip code in the United States. For additional information on data processing, please visit the WaterSense Water Budget Data Finder webpage[55] for details on converting IWMI data into monthly values.

ET_o is the rate of evapotranspiration from an extensive surface of cool-season grass cover of uniform height of 12 centimeters, actively growing, completely shading the ground, and not short

[53] Note that this equation is a modified version of Equation 3 in *Residential End Uses of Water, Version 2.*
[54] International Water Management Institute (IWMI). *World Water & Climate Atlas*. www.iwmi.cgiar.org/resources/world-water-and-climate-atlas/
[55] WaterSense Water Budget Data Finder. www.epa.gov/watersense/water-budget-data-finder

of water.[56] Theoretically, ET_o minus effective rainfall is the amount of supplemental water the reference crop needs for optimum growth.

Annual modified $NetET_o$ based on effective rainfall ($ModNetET_o$) is calculated according to Equation 21.

Equation 21: Annual Modified Net ET_o Based on Effective Rainfall

Where (Monthly ET_o – Monthly effective rainfall) is greater than 0:

$$\text{Annual ModNetET}_o = \sum(\text{Monthly ET}_o - \text{Monthly effective rainfall})$$

Where:

- Only positive values of (Monthly ET_o – Monthly effective rainfall) are used as an indicator for the irrigation season.
- ET_o = Reference ET_o (inches).
- Monthly effective rainfall = 25 percent of rainfall for a given month (inches).

Equation 21 modifies rainfall to acknowledge that not all the rain that falls is available to the plant. EPA determined the effective rainfall to be 25 percent of total rainfall as a conservative estimate to prevent underestimating the TIR in parts of the country with sustained rainfall during the growing season.[57] Then, effective rainfall is subtracted from ET_o. The months with positive values are then summed to determine annual modified $NetET_o$ based on effective rainfall.

Note that only months with positive values of ET_o minus effective rainfall are included in the sum, as these months more likely correspond to the irrigation season. Theoretically, during months where effective rainfall exceeds ET_o, a household's landscape should not require irrigation. Therefore, EPA assumes that irrigation is only applied in months where ET_o exceeds the effective rainfall. Months with negative values of ET_o minus effective rainfall are assumed to be zero.

Irrigation Efficiency Allowance and Species Coefficient

Both the efficiency of an irrigation system and plant water needs impact the theoretical amount of water required by a landscape. In the technical evaluation, EPA uses the values included in

[56] Food and Agriculture Organization (FAO). 1998. *Crop evapotranspiration—Guidelines for computing crop water requirements—FAO Irrigation and drainage paper 56*; and ASCE, 1990. *ASCE Manual and Reports on Engineering Practice 70*. American Society of Civil Engineering in Irrigation Association. 2005. *Landscape Irrigation Scheduling and Water Management*.

[57] The Irrigation Association's "Landscape Irrigation Scheduling and Water Management" (2005) states that effective rainfall should not exceed 50 percent for planning purposes. EPA selected 25 percent to remain consistent with the *WaterSense Water Budget Approach* (2014; www.epa.gov/sites/production/files/2017-01/documents/ws-homes-water-budget-approach.pdf), so as to not underestimate the amount of irrigation required.

Residential End Uses of Water, Version 2 in order to remain consistent with peer reviewed literature. The values used are displayed in Table 4-3.

Table 4-3. Landscape Parameters[58]

Landscape type	Species Coefficient ($K_{species}$)	Irrigation Efficiency Allowance (Eff_i)	Combined Factor
Entire lot	NA	NA	NA
Non-turf plants with spray irrigation[a]	0.65	71%	0.92
Pool or fountain	1.25	100%	1.25
Cool season turf	0.8	71%	1.13
Warm season turf[b]	0.6	71%	0.85
Vegetable garden	0.8	71%	1.13
Xeriscape[b]	0.3	90%	0.33
Non-turf plants with microirrigation[c]	0.65	90%	0.72
Non-irrigated ground	0	0%	0

[a] EPA modified this row to clarify that the combination is for non-turf plants irrigated with spray irrigation.
[b] EPA is reserving these species coefficients for regions where these plant types are most viable. EPA is reserving the species coefficient for xeriscape plants for regions in warm, arid climates; EPA is reserving the species coefficient for warm season turf for regions in warm climates.
[c] EPA added this row to the table. This type of landscape (non-turf plants) watered with microirrigation is not included in *Residential End Uses of Water, Version 2*. EPA incorporated this additional combination because it is a common practice in irrigated landscapes. While *Residential End Uses of Water, Version 2* includes xeriscape with an irrigation efficiency allowance assumed to be equated with microirrigation (90 percent), EPA is reserving the species coefficient associated with xeriscape plants for only those regions in warm, arid climates, and therefore needed a combination representing other non-turf plants that are watered with microirrigation. EPA selected 0.65 as the species coefficient and 90 percent as the irrigation efficient allowance to remain consistent with *Residential End Uses of Water, Version 2.*

The species coefficient allows the TIR to account for the different plant water requirements. For example, some plants require consistent irrigation, resulting in a higher species coefficient, while others can exist on little, if any, irrigation.[59] These values were developed as a percentage of ET_o. Additional information on how the species coefficients were determined is included in *Residential End Uses of Water, Version 2*.

Irrigation efficiency allowance allows the TIR to account for inefficiencies in irrigation systems and the fact that not all water that is distributed from the system is usable by plants, as some is lost to evaporation, wind or overspray. The irrigation efficiency allowances included in *Residential End Uses of Water, Version 2* are based on well-designed irrigation systems, not those typically found in the field. Spray irrigation is typically the lowest efficiency form of irrigation (assigned 71 percent in *Residential End Uses of Water, Version 2*), due to factors such as evaporation and runoff, whereas microirrigation is typically more efficient (assigned 90 percent in *Residential End Uses of Water, Version 2*) due to slower water delivery that is

[58] Modified from WRF, 2016. *Residential End Uses of Water, Version 2*. Table 2.1.
[59] WRF, 2016. *Residential End Uses of Water, Version 2*.

targeted to plants' roots. *Residential End Uses of Water, Version 2* assigned each ground cover an irrigation efficiency based on whether it was expected to have spray or microirrigation. Additional information regarding how these values were determined is included in *Residential End Uses of Water, Version 2.* As explained in the footnotes of Table 4-3, EPA created an additional combined value to account for a common combination of plant type and irrigation type found in many water-efficient homes programs (i.e., non-turf plants watered with microirrigation).

4.4.1 Establishing Outdoor Water Use for Baseline Configuration

Baseline outdoor water use is determined for each reference home using Equation 22:

Equation 22: Annual Outdoor Water Use for Baseline Configuration

$$\text{Annual outdoor water use for baseline configuration (gallons)} = \text{Baseline TIR} \times \text{Actual irrigation factor}$$

Where:

- Baseline TIR = theoretical irrigation requirement for the baseline scenario (assume 100 percent cool season turfgrass watered with spray irrigation) (gallons per year).
- Actual irrigation factor = 0.58.[60]

For the baseline outdoor water use estimate, EPA assumes the entire landscaped area, as determined according to Section 4.2, is comprised of cool season turfgrass irrigated with spray irrigation. This assumption allows EPA to account for the highest likely water use. As described in Section 4.1, EPA uses a specific, or range of, $ModNetET_o$(s) within the TIR equation to account for the geographic area and the climate where the reference home(s) are located.

EPA acknowledges that homeowners do not typically irrigate landscapes to their full water plant demand. Therefore, EPA applies a factor of 58 percent to the baseline TIR to account for actual anticipated irrigation. This factor is based on results generated in *Residential End Uses of Water, Version 2,* which indicated that, on average, homeowners watered landscapes to 58 percent of their TIR.

4.4.2 Establishing Outdoor Water Use for Efficient Configuration

There are several different approaches that PCMs could implement to encourage water savings outdoors. In general, these approaches fall into two categories: 1) an approach based on landscape type and irrigation features (i.e., requiring or rewarding for more efficient plant choices and/or irrigation systems, and/or promoting other water-efficient practices associated with outdoor water use); and 2) an approach that promotes irrigation system capacity control (i.e., limiting irrigation system flow rate and/or irrigated area).

[60] Based on WRF, 2016. *Residential End Uses of Water, Version 2.* Page 157. Average actual water use by residents in the study was 58 percent of their TIR.

The technical evaluation can assess both approaches. EPA will select Option 1 or Option 2, explained in more detail below, to evaluate the water-efficient configurations' outdoor water use based on the PCM's outdoor requirements.

4.4.2.1 Option 1: Landscape Type and Irrigation Feature-Based Approach

Several home certification programs in the marketplace aim to impact outdoor water use by influencing decisions made about landscape and/or irrigation features. There are two common approaches that intend to reach the same goal. The first is a water budget, which aims to influence design decisions about plant type (e.g., turf or shrubs/ornamentals) and irrigation type (e.g., spray irrigation or microirrigation). The budget is typically developed using landscape area and climate data (ET_o and rainfall), as well as plant type and irrigation type. The second approach is a more prescriptive approach that either limits plants that typically consume more water, limits certain types of irrigation, and/or rewards efficient design practices, such as hydrozoning or head-to-head coverage for spray irrigation. Option 1 of the technical evaluation is designed to determine outdoor water savings for PCMs that either implement the water budget or use a prescriptive approach to encourage reductions in outdoor water use.

The following steps and calculations establish the outdoor water use for water-efficient configurations using the landscape and irrigation feature-based approach. For purposes of this next section, the TIR for water-efficient configurations will be indicated as TIR_{eff} to differentiate it from the baseline TIR.

- **Step 1:** Calculate the TIR_{eff}, using Equation 20, based on the plant types and irrigation type for the water-efficient landscape design(s) included in a PCM (see Section 4.2 for information on determining the water-efficient landscape design for the reference home).

A TIR_{eff} is calculated for each zone and summed to calculate the TIR_{eff} for the total landscaped area for each reference home.

- **Step 2:** Calculate the outdoor water use for the water-efficient landscape design for each reference home using Equation 23.

Equation 23: Annual Outdoor Water Use for Water-Efficient Landscape Design

$$\text{Annual outdoor water use for efficient configuration (gallons)} \\ = \text{TIR}_{eff} \times \text{Actual irrigation factor}$$

Where:

- TIR_{eff} = theoretical irrigation requirement for the water-efficient landscape design (gallons per year).
- Actual irrigation factor = 0.58.[61]

[61] Based on WRF, 2016. *Residential End Uses of Water, Version 2.* Page 157. Average actual water use by residents in the study was 58 percent of their TIR.

- **Step 3:** Subtract water savings associated with efficient irrigation technologies and efficient practices from the outdoor water use for the water-efficient landscape design (from Equation 23), which is based on the technologies included in the water-efficient landscape design(s) included for the PCM.

In addition to placing requirements on plant type and irrigation type to achieve savings, many PCMs require or provide credit for efficient irrigation technologies and/or practices. The technical evaluation includes these requirements or credits by subtracting potential water savings for each technology or practice included in the water-efficient configurations from the outdoor water use for the water-efficient landscape design.

Technologies and practices for which additional savings are accounted for in the technical evaluation are discussed in in the subsections below. Throughout the technical evaluation, EPA considered technologies and practices with proven, quantifiable water savings.

4.4.2.1.1 Savings From Pressure Regulation

Landscape irrigation sprinklers are often installed at sites where the system pressure is higher than what is recommended for the sprinkler nozzle. This can lead to excessive flow rates, misting, fogging, and uneven coverage, all of which results in inefficient irrigation and water waste. In irrigation systems, pressure can either be regulated at the valve or at the sprinkler body, providing a consistent flow rate at the sprinkler nozzle. Additionally, when a sprinkler is operating at its optimal pressure, the nozzle is better able to generate the right amount of water spray and coverage for more uniform distribution of water across the landscape. For PCMs that require or credit for installation of pressure-regulating valves or WaterSense labeled spray sprinkler bodies[62] in the water-efficient configuration(s), EPA applies 22 percent water savings to the outdoor water use for the water-efficient landscape design (from Equation 23). The water savings estimate of 22 percent is based on the reduction in flow calculated in the *WaterSense Specification for Spray Sprinkler Bodies Supporting Statement.*[63] In either case, the water savings only apply to areas irrigated with spray irrigation, as the 22 percent savings identified by EPA only applies to spray sprinklers. Savings are not applied to areas irrigated with microirrigation, since pressure regulation for microirrigation/drip irrigation systems is typical practice.

4.4.2.1.2 Savings From Irrigation Scheduling Technologies

The most common method used to schedule irrigation is a manually programmed clock timer that irrigates for a specified amount of time on a preset schedule the user programs. In these systems, the responsibility of changing the irrigation schedule to meet landscape water needs lies with the end user or a contracted irrigation professional. Clock timer controllers can be a significant source of wasted water because irrigation schedules are often set to water at the height of the growing season, and the homeowner is unlikely to adjust the schedule to reflect seasonal changes or changes in plant watering needs. For example, plant water requirements decrease in the fall, but many homeowners forget to adjust their irrigation schedules to reflect this change. Therefore, a homeowner could be watering in October as if it were July. As an

[62] Spray sprinkler bodies that have earned the WaterSense label are required to have integral pressure regulation.
[63] EPA, 2017. *WaterSense Specification for Spray Sprinkler Bodies Supporting Statement*. September 21, 2017. www.epa.gov/sites/production/files/2017-09/documents/ws-products-support-statement-ssb.pdf

alternative to a clock timer controller, “smart” scheduling technology, such as weather-based irrigation controllers and soil moisture-based irrigation controllers (also known as soil moisture sensors), can make irrigation schedule adjustments automatically by tailoring the amount, frequency, and timing of irrigation events based on landscape conditions and either current weather data or soil moisture levels. To a lesser extent, rainfall shutoff devices (also known as rain sensors) can also provide a level of savings by interrupting the irrigation schedule during periods of rain.

Within the technical evaluation, for PCMs that require or provide credit for one or more of these technologies, EPA subtracts applicable water savings from the outdoor water use for the water-efficient landscape design (from Equation 23, after savings from pressure regulation are subtracted, if applicable), as follows:

- Soil moisture-based irrigation controllers make irrigation schedule adjustments by automatically tailoring the amount and/or frequency and timing of irrigation events based on the moisture content of the soil in the landscape. The technical evaluation applies 30 percent water savings to the outdoor water use for the water-efficient landscape design (from Equation 23) if soil moisture-based irrigation controllers are required or provided credit for in a PCM. The savings value of 30 percent is based on the water savings estimates included in the *WaterSense Specification for Soil Moisture-Based Irrigation Controllers Supporting Statement.*[64]
- WaterSense labeled weather-based irrigation controllers create or modify irrigation schedules based on landscape attributes and real-time weather data, applying water only when the landscape needs it. The technical evaluation applies 15 percent water savings to the outdoor water use for the water-efficient landscape design (from Equation 23) if WaterSense labeled weather-based irrigation controllers are required or provided credit for in a PCM. The savings value of 15 percent is based on the water savings estimates calculated in the *WaterSense Specification for Weather-Based Irrigation Controllers Supporting Statement.*[65,66]
- Rain shutoff devices are products designed to interrupt a scheduled irrigation event when a certain amount of rain has fallen. The technical evaluation applies a 6.7 percent water savings to the outdoor water use for the water-efficient landscape design (from Equation 23) if rainfall shut devices are required or provided credit for in a PCM. The savings value of 6.7 percent is based on the water savings estimates included in the *Landscape Irrigation Controllers* document developed by the Codes and Standards Enhancement (CASE) Initiative in California.[67]

Each of these technologies functionally accomplish the same thing—using some indicator of weather conditions (i.e., local weather data, soil moisture, rain) to alter the irrigation schedule. Therefore, savings from these technologies are not additive. Thus, for PCMs that require or

[64] EPA, 2021. *WaterSense Specification for Soil Moisture-Based Irrigation Controllers Supporting Statement.* February 2021. www.epa.gov/watersense/soil-moisture-based-control-technologies

[65] EPA, 2011. *WaterSense Specification for Weather-Based Irrigation Controllers Supporting Statement.* November 3, 2011. www.epa.gov/sites/production/files/2017-01/documents/ws-products-support-statement-irrigation-controllers.pdf

[66] Note that 15 percent water savings is based on data that WaterSense collected as part of the specification development process for weather-based irrigation controllers prior to 2011. This estimate was later supported by research conducted by Lawrence Berkeley National Laboratory (LBNL, 2014).

[67] Codes and Standards Enhancement (CASE) Initiative, 2017. Landscape Irritation Controllers. September 18, 2017.

provide credit for more than one of these technologies in the water-efficient home(s), only the greatest water savings will be applied to the water-efficient configurations. For example, if a PCM requires or provides credit for installation of a rainfall shutoff device and a WaterSense labeled weather-based irrigation controller, the technical evaluation will only apply a water savings of 15 percent to the outdoor water use for the water-efficient landscape design (from Equation 23).

4.4.2.1.3 Savings From Professional Irrigation Design, Installation or Audit

As much as half of water used outdoors is wasted due to evaporation, wind, or runoff, often caused by improper irrigation system design, installation, maintenance, or scheduling. Proper commissioning of a system through efficient design, correct installation, and/or an audit done by an irrigation professional can all reduce water wasted in an irrigation system. EPA provides water savings within its technical evaluation to PCMs that require or provide credit for an irrigation system that is designed, installed, and/or audited by an irrigation professional certified by a WaterSense labeled program. These certified professionals are familiar with WaterSense and the best practices for designing, installing, or maintaining an irrigation system.[68] EPA based the inclusion of professionally designed, installed, and/or audited systems on a research project based in Colorado that examined pre/post audit usage of more than 2,000 participants. While the study has limitations, results suggest that irrigation audits can save approximately 5 percent.[69] EPA conservatively assumes that savings from professional irrigation design and installation are commensurate. Therefore, in instances where the PCM requires a professional irrigation design, installation, and/or audit, water savings of 5 percent is applied within EPA's technical evaluation to the outdoor water use for the water-efficient landscape design (from Equation 23, after savings from pressure regulation and irrigation scheduling technologies are applied).

4.4.2.2 Option 2: Irrigation System Capacity Control

Research suggests that irrigation system flow rate and irrigated area significantly impact outdoor water use, and can be used as a method to reduce outdoor water use in place of prescriptive or water budget approaches that focus of specific plant types or irrigation equipment.[70] Therefore, some PCMs may be designed to influence outdoor water use by limiting capacity (i.e., irrigation flow rates and irrigated area) instead of implementing a water budget or more prescriptive approach.

The following calculations establish the outdoor water use for water-efficient configurations in certification methods using the capacity control approach:

- **Step 1:** Apply capacity adjustment to the baseline configuration's annual outdoor water use (from Equation 22).

[68] For more information, visit the WaterSense Irrigation Professionals webpage: www.epa.gov/watersense/irrigation-pro
[69] The Center for ReSource Conservation. 2014. Water Conservation Impact Assessment 2013 Final Report.
[70] Sovocool, Kent, 2018. *Estimating Annual Water Demands from Irrigation Flow Rates.* Southern Nevada Water Authority (SNWA). www.irrigation.org/IA/FileUploads/IA/Resources/TechnicalPapers/2018/Estimating_Annual_Water_Demands_SOVOCOOL.pdf

Irrigation capacity can be determined by calculating a Residential Irrigation Capacity Index (RICI) score, as described in *Estimating Annual Water Demands from Irrigation Flow Rates,* prepared by Kent Sovocool from the Southern Nevada Water Authority (SNWA). A RICI score is based on the flow rate for each irrigation valve and the corresponding irrigated area. In the most basic sense, RICI demonstrates that higher water use is associated with the higher capacity of the irrigation system (e.g., higher flow rates and larger areas result in higher outdoor water use).

RICI is calculated in Equation 24.

Equation 24: Residential Irrigation Capacity Index

$$\text{RICI} = \frac{\text{Sum of flows for all irrigation valves}}{\text{Irrigation area}} \times 1{,}000$$

Where:

- Sum of flows for all irrigation valves (gpm).
- Irrigation area (sq. ft.).

As part of the research study, during the standard development process for ANSI/RESNET/ICC 850-2020 *Standard Calculation and Labeling of the Water Use Performance of One- and Two-Family Dwellings Using the Water Rating Index,* the author evaluated data from *Residential End Uses of Water, Version 2* and established a baseline RICI of 5. During this evaluation, the author also determined that a 20 percent reduction in irrigation system flow rate (equivalent to a RICI score reduction of 1) resulted in outdoor water savings of approximately 10 percent.[71] Therefore, to determine outdoor water use for a water-efficient configuration, EPA applies 10 percent water savings to the baseline outdoor water use for every RICI score reduction of 1.

If a PCM requires or provides credits for capacity reduction, EPA will convert capacity reduction to an applicable RICI score using Equation 24. EPA will then use Equation 25 to calculate the outdoor water use for the water-efficient configurations considering the certification method's reduction in RICI.

[71] *Ibid.*

Equation 25: Annual Outdoor Water Use for Efficient Configuration Based on Capacity Adjustment

$$\text{Annual outdoor water use for efficient configuration (gallons)} = \text{Annual outdoor water use for baseline configuration} - [\text{Annual outdoor water use for baseline configuration} \times (\text{RICI}_{\text{Baseline}} - \text{RICI}_{\text{Eff}}) \times 10 \text{ percent}]$$

Where:

- Annual outdoor water use for baseline configuration is calculated based on Equation 22.
- $\text{RICI}_{\text{Baseline}}$ = 5.
- RICI_{Eff} is the RICI score of the water-efficient configuration, based on the capacity reduction required or provided credit for in the water-efficient home(s) under the PCM.

- **Step 2:** Similar to Step 3 of Option 1, subtract water savings for the technologies and practices listed in Sections 4.4.2.1.2 and 4.4.2.1.3 from the baseline TIR to determine the final use for the water-efficient landscape.

EPA is not including savings from irrigation technologies that impact irrigation system flow rate, such as microirrigation, WaterSense labeled spray sprinkler bodies, or pressure regulation at the valve. These savings are already accounted for in the capacity reduction captured by reduction in RICI, since RICI is a ratio that includes the total flow rate of the system.

4.5 Other Water Uses

While EPA's technical evaluation is meant to assess all quantifiable water uses (and respective savings) expected for a home, it is possible that there are other potential water uses and/or savings for which EPA has not accounted. If an HCO believes that water use or savings from a requirement or feature of its PCM is not adequately accounted for, the HCO can submit technical justification to EPA for consideration. Technical justification shall include, but is not limited to:

- The expected impact on water use per household per day or per occupant per day for standard models or standard design.
- The expected water savings per household per day or per occupant per day from incorporation of more efficient product models or system design.
- Studies, data, and other supporting materials on the use of the specific design or technology in the field that supports the HCO's claims.
- For systems that supply alternative water sources (such as rainwater or greywater systems), the temporal resolution with which water collection and use is calculated.
- For systems that supply alternative water sources (such as rainwater or greywater systems), the percentage of useful water that the system is anticipated to yield after treatment.

EPA will review the technical merits of an HCO's request on a case-by-case basis. If sufficient technical justification is provided and approved, EPA will incorporate anticipated water use and/or savings for the baseline and water-efficient configuration for each reference home in the technical evaluation, as applicable.

4.6 Generating Total Water Efficiency Percent Savings

As the last step of the technical evaluation, EPA combines the indoor and outdoor water use generated for the respective baseline and water-efficient configuration for each reference home to establish a total water use. Total water use for each water-efficient reference home configuration, representing the least efficient home design(s) for the PCM, is compared to its respective baseline reference home configuration to establish a percent savings. If the water efficiency requirement from the *WaterSense Specification for Homes* is achieved across each reference home scenario, EPA will approve the PCM, as discussed in Section 5.0.

5.0 EPA Response to HCOs

Upon technical evaluation, EPA shall issue an evaluation report to the HCO to indicate whether its PCM demonstrated the ability to consistently differentiate homes that meet the water efficiency requirements compared to a home with characteristics typical of new construction (as required in the *WaterSense Specification for Homes*).

As part of the evaluation process, EPA may submit comments or recommendations to the HCO for consideration during future revisions to the certification method to further enhance the water efficiency and/or performance requirements. Upon request from the HCO, EPA may also provide recommendations for PCMs that do not consistently differentiate homes that meet EPA's water efficiency requirements. Following revision to its certification method, an HCO can resubmit a PCM for technical evaluation.

EPA will license HCOs whose PCMs are capable of consistently achieving WaterSense's efficiency requirements for homes in accordance with the *WaterSense Home Certification System.* The PCM will subsequently be designated as a WACM.

As discussed in the *WaterSense Homes Certification System*, EPA's intent is to recognize a WACM for a period of five (5) years, as long as it is not revised by the HCO such that the revisions could impact its ability to differentiate homes that meet EPA's water efficiency requirement.

6.0 Amendments, Modifications and Revisions

As required under the *WaterSense Home Certification System,* an HCO shall notify EPA in writing of any changes to its WACM that could materially affect its performance under EPA's technical evaluation. Notification shall be made at least 60 days prior to the implementation of such changes and with sufficient time to allow for EPA to evaluate the changes and determine if the WACM will continue to meet the efficiency requirements of the *WaterSense Specification for Homes.* EPA shall evaluate revisions to the HCO's WACM using the latest version of the *WaterSense Technical Evaluation Process for Approving Home Certification Methods.*

EPA also reserves the right to revise the technical evaluation process, as described in the *WaterSense Home Certification System*. EPA will consider revisions should: 1) national product and appliance efficiency standards or typical construction characteristics change in the future such that it affects baseline water use estimates; 2) better data on water use by products, appliances, systems, and/or the whole household become available; and/or 3) technological and/or market changes affect its usefulness to consumers, industry, or the environment.

As described in the *WaterSense Home Certification System,* EPA will only make major revisions to the technical evaluation process following an open public process, including discussion with builders, HCOs, verifiers, and other interested stakeholders. Major revisions will typically require re-approval of existing WACMs to the new technical evaluation or the *WaterSense Home Certification System*. Minor revisions or technical clarifications will generally be editorial in nature and serve to clarify vague or unclear requirements and will not require reapproval.

7.0 More Information

For inquiries or other questions related to this technical evaluation process document, the *WaterSense Specification for Homes*, or the WaterSense Labeled Homes Program, please contact the WaterSense Helpline at (866) WTRSENS (987-7367) or watersense@epa.gov.