# Recommendations for Variance for Significant Water Use of Evaporative Coolers, Methods of Calculation, and Supporting Data Requirements

**WUES-DWR-2021-05**

## A Report to the State Water Resources Control Board Prepared Pursuant to California Water Code Section 10609.14

## September 2022

California Department of Water Resources
Water Use Efficiency Branch

Note: This report is part of the package of reports developed by the California Department of Water Resources to meet the requirements of Senate Bill 606 and Assembly Bill 1668 of 2018 for urban water use efficiency.

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**Acknowledgements**

The California Department of Water Resources (DWR) would like to acknowledge the collaboration and coordination with the staff of State Water Resources Control Board in developing the recommendations and supporting content. In particular, DWR would like to recognize the input and constructive feedback from members of the Water Use Studies Working Group and Standards, Methodologies, and Performance Measures Working Group throughout the process, and their extensive time commitments for supporting this effort. Additional input and comments from other stakeholders, interested parties, and the public are also greatly appreciated. DWR would like to extend its gratitude to Mojave Water District, Joshua Basin Water District, and Phelan Piñon Hills Community Services District that assisted DWR in sharing information for development of the methodologies and recommendations. DWR also would like to extend its gratitude for the valuable services from the consultant team that supported DWR in the needed studies, investigations, and analytical work.

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## Abbreviations and Acronyms

| | |
|---|---|
| 2018 Legislation | 2018 Legislation on Water Conservation and Drought Planning (Senate Bill 606 [Hertzberg] and Assembly Bill 1668 [Friedman], as amended) |
| AC | air conditioner |
| APN | Assessor's Parcel Number |
| CFM | cubic feet per minute |
| CII | commercial, industrial, and institutional |
| CII-DIMWUS | Commercial, Industrial, and Institutional Outdoor Irrigation of Landscape Areas with Dedicated Irrigation Meters Water Use Efficiency Standard |
| CWEE | University of California, Davis, Center for Water-Energy Efficiency |
| DIM | dedicated irrigation meter |
| DWR | California Department of Water Resources |
| EC | evaporative cooler (Note: Acronym as used in WUES-DWR-2021-01B, WUES-DWR-2021-04, WUES-DWR-2021-05) |
| IRWUS | Indoor Residential Water Use Efficiency Standard |
| MWA | Mojave Water Agency |
| N/A | not applicable |
| ORWUS | Outdoor Residential Water Use Efficiency Standard |
| Recommendation Package | Urban Water Use Efficiency Recommendation Package |
| SB | Senate Bill |
| SFR | Single-Family Residence |
| State | State of California |
| State Water Board | State Water Resources Control Board |
| UWUO | urban water use objective |
| UWUO_SB | urban water use objective without any variances |
| WC | California Water Code |
| WLS | Water Loss Standard |

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# Executive Summary

The California State Legislature passed the 2018 Legislation on Water Conservation and Drought Planning (Senate Bill 606 [Hertzberg] and Assembly Bill 1668 [Friedman], as amended; hereinafter referred to as the "2018 Legislation"), which included provisions for advancing urban water use efficiency through developing and implementing various water use efficiency standards, variances, and performance measures. This report provides the purpose and details of review and development, and the recommendations for a variance for "significant use of evaporative coolers," consistent with the directives under California Water Code (WC) Section 10609.14.

WC Section 10609.14 directs the California Department of Water Resources (DWR), in coordination with the State Water Resources Control Board (State Water Board), to conduct necessary studies to recommend appropriate variances for unique uses of water that could have a material effect on an urban retail water supplier's urban water use objective (UWUO). A variance for "significant use of evaporative coolers" is one of the eight potential variances identified in the legislation. For each variance, the recommendations include a threshold of significance and guidelines and methodologies for calculating efficient water use allowable under the variance.

DWR conducted topic-specific research and investigations to answer three critical questions prior to developing recommendations for a variance for significant use of evaporative coolers (EC):

1. Is this water use outside of the scope of the UWUO? In other words, is this water for non-urban use or part of the commercial, industrial, and institutional water uses other than irrigating landscape with dedicated irrigation meters? If so, the water use is either not subject to the provisions of urban water use efficiency in the 2018 Legislation or excluded from the UWUO and, thus, there is no need for a variance.
2. Is this water use unique within the context of the UWUO? If no, it is not eligible. If yes, the water use is potentially eligible for a variance, and the following two questions need to be answered "yes" to be determined eligible:
    a. Is this water use shared by only some urban retail water suppliers or needed in unusual circumstances, but not commonly used enough to be included in one of the standards?
    b. Is this water use excluded from all urban water use efficiency standards and other variances?
3. Could this unique water use have a material effect on the UWUO of some urban retail water suppliers? If so, the water use is warranted for variance development.

After confirming the above in collaboration with stakeholders and the State Water Board, DWR proceeded with variance development with a clarified scope, whereby significant use of water for ECs can be appropriately estimated and incorporated in an urban retail water supplier's UWUO.

Consistent with the legislative directive, DWR used a public process involving a diverse group of stakeholders in the review and development of the variance for significant use of ECs. The Water Use Studies Working Group and the Standards, Methods, and Performance Measures Working Group that DWR established to assist in implementing the 2018 Legislation were the primary stakeholders involved in the variance development process. Additional stakeholders included State of California agencies, cities, counties, urban retail water suppliers, environmental organizations, and other interested parties. Working group members and stakeholders were provided with many opportunities to comment on and inform the appropriateness of recommending a variance for significant use of ECs. Additionally, they were able to comment on and inform the development and refinements for the applicable scope, specifications, and methodologies for estimating the efficient water use volume for such a purpose. The resource requirements for administering the variance and associated supporting data requirements, accessibility, and quality were considered in the evaluation.

Through investigation of available data and stakeholder input, DWR has concluded that establishing a variance to accommodate efficient water use for significant use of ECs is appropriate, as that water use is unique, excluded from other standards and variances, and can have a material effect on an urban retail water supplier's UWUO. Furthermore, to draw a clear connection between the title of this proposed variance and significant water use, DWR refined the variance title to "significant water use of evaporative coolers." DWR worked with University of California, Davis, Center for Water-Energy Efficiency to develop methods for identifying EC usage rates and for quantifying associated water use based on available data. However, the research was not conclusive enough to support the variance design for implementation. Therefore, in the recommendations, DWR focuses on a consistent and repeatable method to calculate the efficient water use of ECs using weather information and results from an EC use survey that should be conducted by urban retail water suppliers. Implementation considerations, including the need for technical assistance, are included with the recommendations.

The recommendations for a variance for significant water use of ECs are part of the *Recommendations for Urban Water Use Efficiency Standards, Variances, Performance Measures, and Annual Water Use Reporting* (WUES-DWR-2021-01A). The recommendations were prepared per the requirements of the 2018 Legislation and are to be transmitted to the State Water Board for adoption.

# 1.0 Introduction

Senate Bill (SB) 606 (Hertzberg) and Assembly Bill 1668 (Friedman) of 2018, as amended (hereinafter referred to as the "2018 Legislation"), established a new foundation for long-term improvements in water conservation and drought planning to adapt to climate change and the resulting longer and more intense droughts in the State of California (State). These two bills provide expanded and new authorities and requirements to enable permanent changes and actions for those purposes, thereby improving the State's water future for generations to come. Details of these provisions are summarized in *Making Water Conservation a California Way of Life: Primer of 2018 Legislation on Water Conservation and Drought Planning, Senate Bill 606 (Hertzberg) and Assembly Bill 1668 (Friedman)* (DWR and State Water Board, 2018).

## 1.1 New Approach to Urban Water Use Efficiency

Among other things, the 2018 Legislation contains provisions for advancing urban water use efficiency through developing and implementing various water use efficiency standards, variances, and performance measures per California Water Code (WC) Section 10609. The new water conservation framework is different than SB X7-7, which was established in 2009. The focus of SB X7-7 was to reduce statewide urban water use by 20 percent in 2020 compared to the baseline calculated in 2010. The 2018 Legislation requires a bottom-up estimate from urban retail water suppliers of the urban water use objective (UWUO) based on the aggregated efficient water use volume by considering four urban water use efficiency standards and appropriate variances. The four standards are:

- Indoor Residential Water Use Efficiency Standard (IRWUS).
- Outdoor Residential Water Use Efficiency Standard (ORWUS).
- Commercial, Industrial, and Institutional Outdoor Irrigation of Landscape Areas with Dedicated Irrigation Meters Water Use Efficiency Standard (CII-DIMWUS).
- Water Loss Standard (WLS).

Commercial, industrial, and institutional (CII) water use not associated with dedicated irrigation meters (DIM) (or equivalent technologies) for outdoor irrigation of landscape areas is excluded from the UWUO.

Each of the procedural requirements to formalize these four standards for implementation is different. The 2018 Legislation includes a default progressively reduced IRWUS (WC Section 10609.4(a)). In November 2021, in collaboration with the State Water Resources Control Board (State Water Board), the California Department of Water Resources (DWR) submitted the joint recommendations for IRWUS to the

California State Legislature for further consideration per WC Section 10609.4(b). Separately, the State Water Board is currently conducting a rulemaking process to adopt the proposed WLS, which was originally authorized by SB 555 of 2015. For ORWUS and CII-DIMWUS, the 2018 Legislation requires DWR, in coordination with the State Water Board, to conduct necessary studies and investigations and develop recommendations to the State Water Board by October 1, 2021 (WC Sections 10609.6 and 10609.8).

Another major difference between the SB X7-7 requirements and those of the 2018 Legislation is that the anticipated outcome was measured on a statewide level per SB X7-7 and on an individual urban retail water supplier level per the 2018 Legislation. Recognizing the diversity of water use to support local economic, social, and environmental needs and varying climate conditions in the State, the 2018 Legislation requires DWR, in coordination with the State Water Board, to conduct necessary studies and investigations. It also requires DWR to develop recommendations for adoption by the State Water Board by October 1, 2021, for appropriate variances for unique uses and the corresponding thresholds of significance, that can have a material effect on an urban retail water supplier's UWUO (WC Section 10609.14). In this context, DWR interpreted that a material effect means that this unique water use, although used in an efficient manner, could unfairly jeopardize an urban retail water supplier's ability to meet the UWUO when not explicitly addressed and calculated separately from the volume based on the four water use efficiency standards.

As a supporting recommendation, the 2018 Legislation requires DWR to develop accompanying guidelines and methodologies for calculating the UWUO (WC Section 10609.16) and provide the recommendation to the State Water Board for adoption, along with DWR's recommendations on ORWUS, CII-DIMWUS, and appropriate variances by June 30, 2022 (WC Section 10609.2). The 2018 Legislation further requires DWR and the State Water Board to solicit broad public participation throughout the development and adoption processes (WC Section 10609(b)(3)).

# 1.2 Appropriate Variances

Per the 2018 Legislation, appropriate variances **may include, but are not limited to,** the following eight identified in WC Section 10609.14(b):

1. Significant use of evaporative coolers.
2. Significant populations of horses and other livestock.
3. Significant fluctuations in seasonal populations.
4. Significant landscaped areas irrigated with recycled water having high levels of total dissolved solids.

5. Significant use of water for soil compaction and dust control.

6. Significant use of water to supplement ponds and lakes to sustain wildlife.

7. Significant use of water to irrigate vegetation for fire protection.

8. Significant use of water for commercial or noncommercial agricultural use.

The eight identified potential variances were subject to further review to affirm the unique use and the likelihood of a material effect on an urban retail water supplier's UWUO before DWR engaged in additional efforts in variance development. Through stakeholder engagement, additional potential variances could also be identified. Additional potential variances may emerge in the future due to changes in water use to meet economic, social, and environmental needs.

When a recommended variance is adopted by the State Water Board, the variance becomes available to urban retail water suppliers. However, before a variance can be included in an urban retail water supplier's UWUO, the urban retail water supplier is required to request, with supporting data, and receive approval from the State Water Board (WC Section 10609.14(d)). This procedural requirement is urban retail water supplier–specific and variance-specific. The State Water Board is required to post on its website a list of approved variances, the specific variances approved for each urban retail water supplier, and the data supporting the approval of each variance for individual urban retail water suppliers (WC Section 10609.14(e)).

### Refinement to the Water Code List

Based on research and stakeholder input, it was decided to draw a clear connection between the title of this proposed variance and significant water use. Therefore, DWR refined the variance title to "significant water use of evaporative coolers."

## 1.3 Purpose of the Report

Per legislative requirements, DWR conducted studies and investigations to determine if the legislatively identified potential variances and others suggested by stakeholders should be developed and recommended for adoption. This report is one of the variance-specific reports that focuses on the potential variance for "significant use of evaporative coolers" identified in the legislation.

Through communication and input from working group members and stakeholders, additional home use devices that could potentially use significant amount of water were explored. Medical devices were identified as another class of home use devices which could have potential significant use of water. For details on home use medical devices, see *Recommendations for Deferring Variance for Significant Water Use of Home Use*

*Medical Devices* (WUES-DWR-2021-06). The remaining discussion in this report focuses on ECs only.

### Efficient Water Use of Evaporative Coolers

An EC is a device that cools air through the evaporation of water. The cooling ability of ECs is increased in hot and dry conditions in which there is high potential in the climate for evaporation of water. EC use is relatively cost-efficient and requires less electricity than other forms of cooling. Therefore, EC use is common for thermal comfort in buildings in many areas in the State. In the context of urban water use efficiency in the 2018 Legislation, the focus of the variance for ECs that contribute to indoor residential water use is in residential properties, since this specific water use is not considered in IRWUS. Therefore, EC water use could be recognized as a variance, and – if satisfying all the requirements – a proper calculation method to identify associated efficient water use would be needed for implementation purposes.

### Relationship to California Department of Water Resources' Urban Water Use Efficiency Recommendation Package

DWR has completed a significant body of work to meet the requirements of the 2018 Legislation and provide recommendations on different topics to the State Water Board for adoption. To streamline document development and recognize the inherent interrelationship among different topics and the need for overall consistency, DWR organized the various reports in an Urban Water Use Efficiency Recommendation Package (Recommendation Package) that allows mutual referencing and incorporates content by reference. All reports in this Recommendation Package are given a serial number in the form of "WUES-DWR-2021-xx." For each report, Appendix A includes the list of documents within the Recommendation Package that are incorporated by reference.

Specifically, this report, *Recommendations for Variance for Significant Water Use of Evaporative Coolers, Methods of Calculation, and Supporting Data Requirements* (WUES-DWR-2021-05), provides the detailed documentation for the review and subsequent variance development for specifications, guidelines, and methodologies for the potential variance for significant water use of ECs. The recommendations for this variance are summarized in the report, *Summary of Recommendations for Variances* (WUES-DWR-2021-04), and the corresponding guidelines and methodologies for calculating efficient water use for this variance are summarized in *Recommendations for Guidelines and Methodologies for Calculating Urban Water Use Objective* (WUES-DWR-2021-01B). The additional context, variance development process and approach, evaluation of options, and stakeholder input included in this document are incorporated by reference. Key terms and their definitions used in this report, along with abbreviations and acronyms, are included in *Urban Water Use Efficiency Recommendation Package: Glossary and Abbreviations and Acronyms* (WUES-DWR-2021-21).

### Effects on Existing Law and Regulations

DWR developed this variance per legislative directive. The resulting variance, when adopted, does not set, rescind, or modify existing or future requirements for using ECs in residential properties.

# 1.4 Report Organization

This report is organized into six sections:

- **Section 1 – Introduction** provides the background and purpose of this document.
- **Section 2 – Scope Definition** provides the process and rationales used in confirming the scope for this potential variance that reflects unique water use and with potential material effects on an urban retail water supplier's UWUO.
- **Section 3 – Approach to Variance Design** describes the technical approach and stakeholder engagement that DWR conducted to support the variance development. Options for different coverages and methods for calculating efficient water use for this variance are discussed and evaluated for technical feasibility, reasonableness, and ability to be implemented.
- **Section 4 – Recommendations** provides DWR's recommendations on this variance, including the specifications, guidelines, and methodologies for calculating efficient water use for this variance and the supporting data and information requirements.
- **Section 5 – Glossary** provides a list of key terms and their definitions used in this document.
- **Section 6 – References** provides a list of references used in this document.

This report includes two appendices:

- **Appendix A** provides the list of documents in DWR's Recommendation Package that are incorporated by reference.
- **Appendix B** provides a template for calculating the efficient water use for significant water use of ECs based on the recommendations. This template is provided for illustrative purposes and subject to update after the State Water Board's adoption of the variance.

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# 2.0 Scope Definition

In accordance with the legislative directive, DWR conducted studies and investigation to develop the information necessary to determine if a variance for significant water use of ECs was needed and, if so, to support any recommendation made to the State Water Board on the guidelines and methodologies pertaining to the calculation of an urban retail water supplier's UWUO.

The goals of these studies and investigation were to achieve the following:

- Confirm whether significant use of water for ECs is a unique use that could have a material effect on the UWUO of urban retail water suppliers.
- Inform the recommendations for variance specifications, including the threshold of significance.
- Provide the basis for developing guidelines and methodologies for urban retail water suppliers to use in calculating the aggregated efficient water use allowable under this variance.

The first study goal provided a clarified scope for variance development, which was to be accomplished by addressing the remaining two study goals. The process and findings for scope definition are provided in Section 2. Section 3 contains additional variance development and option evaluation to inform the recommendations in Section 4.

## 2.1 Interpretation of Significant Water Use of Evaporative Coolers Nexus

ECs are used frequently in warehouses and data centers as supplemental cooling devices as well as in residential properties due to the lower cost of operation and availability of the potable units. ECs vary in size, application, and amount of water required to operate properly. ECs used in residential properties consume indoor residential water. However, the indoor residential water use accounted for in IRWUS only includes common water use practices, such as drinking, bathing, food preparation, washing clothes and dishes, and flushing toilets. Indoor water use by other less-common water-consuming home devices, such as ECs, is not accounted for in IRWUS, although it could significantly affect the amount of indoor residential water use. The legislative directive pertains to significant use of water for ECs as a variance consideration, which may be included in the UWUO of urban retail water suppliers. Therefore, the consideration of EC water use in this variance focuses on residential use only, because water use of ECs in warehouses, data centers, and other CII facilities are CII water use. CII water use is excluded from the UWUO, although it remains subject to

CII water use performance measures (see *Recommendations for Performance Measures for Commercial, Industrial, and Institutional Water Use* [WUES-DWR-2021-15]).

## 2.2 Process for Scope Refinement

In the context of the 2018 Legislation, the four water use efficiency standards cover types of water use commonly shared by most, if not all, urban retail water suppliers. The variances are effectively the less common uses that may be important for only some urban retail water suppliers due to geographic location, local climate, and other local conditions. In concept, the scopes of standards and those of variances are mutually exclusive. However, local water use, facility connection, and account management can be complex due to years of development and implementation of practices without the structure suggested in the 2018 Legislation. Therefore, DWR needed to examine different scenarios associated with significant water use of ECs against three questions in sequence prior to developing variance recommendations:

1. Is this water use out of the scope for the UWUO? In other words, is this water for non-urban use or part of the CII water uses other than irrigating landscape with DIMs? If so, the water use is either not subject to the provisions of urban water use efficiency in the 2018 Legislation or excluded from the UWUO and thus, there is no need for a variance.

2. Is this water use unique in the context of the UWUO? If no, it is not eligible. If yes, the water use is potentially eligible for a variance, and the following two questions need to be answered “yes” to be determined eligible:

    a. Is this water use shared by only some urban retail water suppliers or needed in unusual circumstances, but not commonly used enough to be included in one of the standards?

    b. Is this water use excluded from all urban water use efficiency standards and other variances?

3. Could this unique water use have a material effect on the UWUO of some urban retail water suppliers? If so, the water use is warranted for variance development.

The following summarizes the results of the above process of elimination for clarifying the scope of the variance

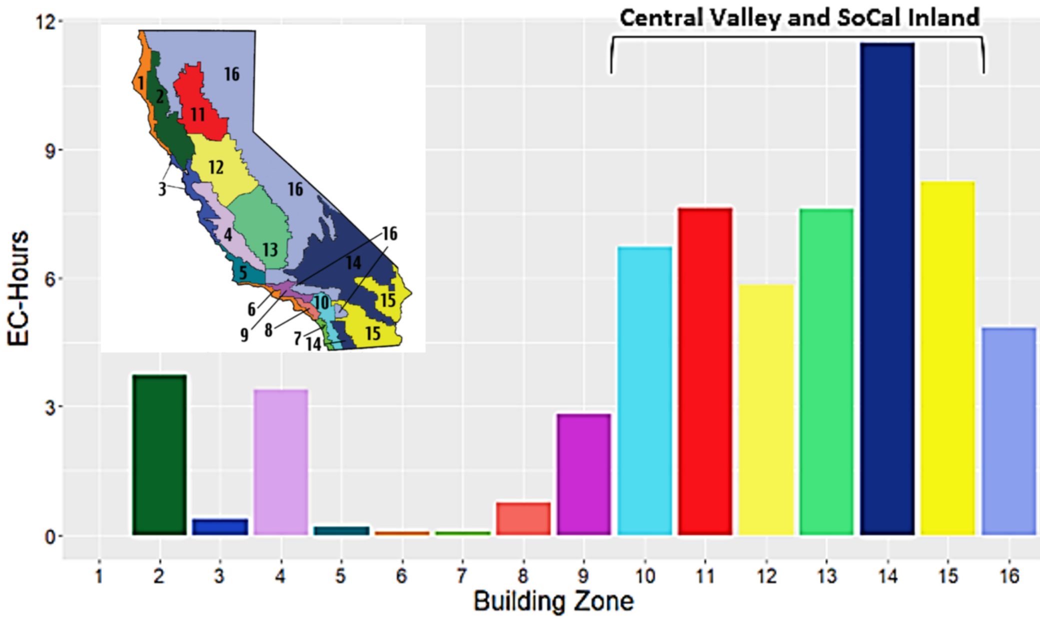
### Unique Use

The unique use for variance consideration was established by addressing the first two questions listed above.

In April 2021, DWR conducted a survey regarding potential concerns over significant water use for using ECs at residential properties. The survey was completed by 68 urban retail water suppliers in the State. About 13 percent of the participants mentioned that use of water to operate ECs at homes might be significant to their utilities. Mostly urban retail water suppliers located in the San Francisco Bay and the Colorado River regions expected that this specific use would be relatively significant compared to their total water use.

The popularity of ECs is largely dependent on climate conditions in which the system will operate, among other variables. In areas with extremely hot and dry climate conditions, and in certain rural communities in the State, the use of ECs is more prevalent than other cooling methods. ECs operate by absorbing the ambient temperature to evaporate the available water in the system; therefore, these devices are not effective in cold and humid environments. However, based on this specific operational design, even in a hot and dry climate, ECs can operate efficiently only during part of the day.

Data from the Pacific Energy Center (2006) (see Figure 2-1) show that ECs have a higher potential for use in the Central Valley and Southern California inland areas because of the hotter and dried climate conditions that allow for more evaporative cooling. Note that the California climate zones shown in this map are not the same as what are commonly called climate areas, such as "desert" or "alpine" climates. These climate zones are based on energy use, temperature, weather, and other factors, as described in California Code of Regulations, Title 24 Energy Efficiency Standards' glossary section. In certain communities, the cost of electricity far exceeds the cost of water, making air cooling by ECs more popular than air cooling using air conditioners (AC).




*Source: Pacific Energy Center, 2006*
Key:
EC = evaporative cooler
SoCal = southern California

**Figure 2-1 Average Daily Summer Hours Appropriate to Use Evaporative Cooling in the 16 California Building Climate Zones (Summer 2017)**

The results of the April 2021 survey, combined with climate conditions that limit EC effectiveness and the popularity of ECs in some specific parts of the State, suggested that this water use could be considered unique due to its use in only some urban retail water suppliers' service areas.

As mentioned in Section 2.1, this variance only includes use of ECs at residential properties. ECs used in CII settings, including warehouses, data centers, and other similar facilities, and their associated water use are part of CII water use that is not included in the scope of the UWUO. However, CII water use is subject to CII water use performance measures (see *Recommendations for Performance Measures for Commercial, Industrial, and Institutional Water Use* [WUES-DWR-2021-15]).

### Potential for a Material Effect

In the process of studying this variance, DWR collaborated with University of California, Davis, Center for Water-Energy Efficiency (CWEE) for exploration of methods to identify the number of ECs used in the service areas of urban retail water suppliers and their associated water use. A thorough literature review by CWEE suggested that the estimated water use for EC systems in different climates across the State could range from 52 to 132 gallons per day. Knowing that indoor residential efficient water use is 52 gallons per day per person, the EC water use is equivalent to approximately 1 to greater than 2.5 extra people in the household (see technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-*

*Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]). According to the CWEE study, varying types and ages of ECs may require various additional water for maintenance and removal of mineral buildups. This process could increase the water requirements of ECs by 10 to 50 percent (see technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]).

Analysis of data from Joshua Basin Water District confirmed that people could use ECs even when the house has AC (see technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]). Therefore, having an AC does not necessarily mean that the house is not using an EC. Due to economic benefits of using ECs compared to ACs, it is likely that EC use continues and could increase in the future. Therefore, the resulting water use could result in a material effect on the urban retail water supplier's UWUO.

## 2.3 Clarified Scope for Variance Development

Based on the analysis, the variance for significant water use of ECs only applies to use of ECs at residential properties that are supplied from indoor residential meters; therefore, the variance is against IRWUS.

Water use for EC operation in CII facilities is excluded from the UWUO and, therefore, is not included in this variance consideration.

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# 3.0 Approach to Variance Design

DWR's approach to variance design was an iterative process in collaboration with stakeholders and the State Water Board to assist DWR in refining options and associated specifications and data needs. Taking into consideration findings from the studies, research, and input and feedback from the collaborative process, DWR formulated the recommendations.

## 3.1 Stakeholder Process

Consistent with the legislative directive, DWR used a public process involving diverse stakeholders in the review and development of the variance for significant water use of ECs. The stakeholder process was part of the larger engagement process to implement the provisions of urban water use efficiency in the 2018 Legislation (see *Stakeholder Outreach Summary for Developing Urban Water Use Efficiency Standards, Variances, and Performance Measures* [WUES-DWR-2021-20]). More focused stakeholder engagements, specifically for variances, started in November 2020, with periodic meetings and workshops held through early 2022.

DWR established two working groups to assist in implementing the 2018 Legislation, and these groups formed the base of the stakeholder involvement process that included State agencies, cities, counties, urban retail water suppliers, environmental organizations, professionals, and other stakeholders and interested parties. The Water Use Studies Working Group was established in July 2019 to inform DWR in developing water use studies for setting up standards, variances, and performance measures. Concurrently, the Standards, Methods, and Performance Measures Working Group was also established to provide input to DWR on developing the structure and specifications of water use efficiency standards, variances, methodologies, and performance measures. However, due to the close relationship between research and variance design, members of both working groups were invited to participate in the same stakeholder meetings and workshops. DWR also opened the working group meetings and workshops to the public to allow for broader participation in and input from other stakeholders, interested parties, and individuals.

Working group members and other participants had ample opportunities to learn about the variance design process and provide feedback on the appropriateness of this specific variance being developed and the scope, specifications, and methodologies for estimating efficient water use. They provided input on variance implementation, such as resource needs (staff), supporting data requirements, and accessibility considerations.

DWR also conducted and responded to requests for additional meetings and public outreach and engagement activities with both individuals and groups of stakeholders to learn from their experiences, understand their specific concerns, and receive other feedback. For this variance, three urban retail water suppliers provided data to DWR for research purposes under confidential agreements, namely Mojave Water District, Joshua Basin Water District, and Phelan Piñon Hills Community Services District. In collaboration with CWEE, DWR used the information to develop indicators and information necessary for the variance design (see technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]). Separate consultation sessions with these participating agencies were also conducted to review the results of the analyses using their data.

## 3.2 Considerations for Variance Design

As stated in Section 2.3, the clarified scope for the variance for significant water use of ECs is limited to water use for running ECs in residential properties. The resulting variance could be against water use under IRWUS. DWR proceeded with variance development after confirming this clarified scope with stakeholders and working group members.

In variance design, DWR needed to determine what would constitute water use efficiency for significant water use of ECs, what level of estimated water use (i.e., significance threshold) should be achieved before an urban retail water supplier could claim the variance in its UWUO, and how to calculate the aggregated water use under the variance with credible data and supporting information. Based on the research and stakeholder input, DWR considered the following factors:

- Operation efficiencies of ECs vary based on climate conditions. They operate most effectively in arid and dry climate with high ambient temperatures.

- Theoretically, water use by ECs can be calculated following a three-dimentional chart based on psychrometric principles that require detailed information on a specific EC system. Practically, using the chart to estimate the EC water use is a significanlty complex process. Therefore, the design of this variance needs to be generalized and less complex.

- ECs use a cooling process by which thermal energy is transferred from hot, dry air to liquid water, causing some of that water to vaporize and create cool, moist air. Therefore, the amount of water consumed by any given EC can be expressed using an evaporation rate. However, there are variations in the size and technology used in different EC systems for the cooling process. The variation in technology affects evaporation rate and, therefore, the water use and operational efficiency of the ECs.

- In addition to evaporation rate, the number of operating hours and days per year is needed to calculate total water use of a given EC.

- Urban retail water suppliers would need to idenfity or estimate the total number of EC units in their service areas and their corresponding specifications and characteritics in order to calculate the total water use associated with EC use.
- DWR recognized that specific data are needed to calculate water use for this variance. Many urban retail water suppliers expressed concerns over the potential burden and costs to pursue a variance in addition to compliance with many other requirements under the provisions of urban water use efficiency in the 2018 Legislation. Therefore, DWR considered the following to be reasonable:
  - The methodology for calculating aggregated water use under this variance should, to the extent reasonable, stay consistent with existing water use efficiency laws and regulations or build on existing methodologies used by urban retail water suppliers in SB X7-7 compliance.
  - The data and information required to support a variance and calculated amount need to be credible and reasonably accessible to urban retail water suppliers or reasonably obtainable by urban retail water suppliers.
  - Necessary technical assistance from DWR related to implementation should be also incorporated into the variance recommendation.

## 3.3 Variance Options

As discussed earlier, ECs operate based on a water evaporation process, but the evaporation rate varies significantly among different units depending on the technology, size, ambient air temperature, and other controlling factors. Most of the necessary details required to calculate EC water use may not be readily available to urban retail water suppliers. Before the options can be presented, certain basic parameters for ECs need to be established for the purpose of the variance.

The purpose of considering options with different specifications were to explore pros and cons for different settings and solicit input from stakeholders regarding their corresponding reasonableness and ability of urban retail water suppliers to implement them. DWR considered different options for calculating efficient water use under this variance and discussed all options with stakeholders in working group meetings on May 13 and July 21, 2021. Based on the resultant findings and insights, DWR then developed the recommendations (Section 4), which were also shared with the stakeholders and working group members during the workshop held on November 17, 2021.

### Estimating Water Use of an Evaporative Cooler Unit

Estimating water use of an EC unit can be accomplished through a formula established using physical characteristics of the EC unit. However, for variance design purposes, this would require a defined representative condition for operation, including the range of air temperatures for operation and EC efficiency for each EC unit. DWR considered that it may not be practical for an urban retail water supplier to calculate water use under this variance on a unit-by-unit basis and, therefore, representative conditions are necessary for an estimate on the urban retail water supplier level. The following provides additional discussions on these topics.

### *Water Use of an EC Unit*

EC water use can be estimated based on principles of evaporative cooling, which is based on the evaporation rate. Therefore, the water use can be calculated as follows:

> EC Unit Water Use per Day (gallons) = *Number of Operating Hours per Day* (hours) x *Evaporation Rate* (gallons per hour)

The EC evaporation rate can be determined using the following equation:

$$EC\ Evaporation\ Rate = \frac{CFM \times \Delta T \times efficiency\ rate}{8700}$$

where,

- *CFM* is the cubic feet per minute of air exchange, which is the EC-unit-specific information provided by the manufacturer.
- *ΔT* is the difference between ambient air wet-bulb temperature and dry-bulb temperature in degrees Fahrenheit.
- *Efficiency rate* is EC-unit-specific information that varies by technologies, types, and media uses.
- 8,700 is the unit conversion factor that is based on 8.34 pounds of water per gallon.

If wet-bulb temperature is unknown, it can be calculated as follows:

$$\begin{aligned} Tw = T \times \arctan\left[0.151977 \times \sqrt{(rh + 8.313659)}\right] \\ + \arctan(T + rh) - arctan(rh - 1.676331) \\ + 0.00391838 \times rh^{1.5} \times \arctan(0.023101 \times rh) - 4.686035 \end{aligned}$$

where,

- *Tw* is the wet-bulb temperature in degrees Fahrenheit (the equation is an approximation method based on dry-bulb temperature and relative humidity).
- *T* is the dry-bulb temperature.

- arctan is the mathematical operation to calculate Arc Tangent.
- *rh* is the relative humidity in percent.

If the number of operating hours and evaporation rate (i.e., water use rate) in gallons per hour is known, the EC unit water use per day can be determined. However, as seen from the equation above, the evaporation rate of an EC depends on the ambient air temperature and efficiency of the EC system, in addition to the EC-specific characteristics, such as *CFM*. By knowing the total number of ECs in the service areas, urban retail water suppliers would then be able to determine total water use by ECs in their service areas. As previously mentioned, representative conditions are needed for an aggregate water use estimate on the urban retail water supplier level, because DWR does not believe that calculating water use based on unit-by-unit data, specifications, and individual user behavior is feasible for the calculation of this variance.

#### *Representative Range of Air Temperature for EC Operation*

ECs are not effective in cold and humid environments because they cool air by water evaporation. Evaporation rates are less in humid conditions because the air is already full of water; thus, humid conditions discourage evaporation. Cold air holds less moisture, and it takes energy (heat) to induce evaporation; therefore, evaporation rates are lower in cold conditions. Without some intrusive methods, an urban retail water supplier cannot know the temperature threshold when an individual decides to use ECs for cooling. However, it will not actually use as much water through evaporation, even if water users choose to try and operate ECs during suboptimal evaporation conditions. Nonetheless, it is necessary to define a general temperature threshold for calculating efficient water use volume used by ECs on the urban retail water supplier level.

References for the temperature threshold for water users' behavior in using cooling devices may be found in literature. According to the Pacific Energy Center's Guide to California Climate Zones and Bioclimate Design (Pacific Energy Center, 2006), humans are comfortable within a relatively small range of temperature (between 68 and 80 degrees Fahrenheit). Energy Star recommends that for energy saving purpose, the setpoint temperature of programmable thermostats be at 78 degrees Fahrenheit for cooling, with additional increase in set temperature during different times of a day.[2] DWR recognized that the recommendation is close to the upper bound of the comfortable range and for the purpose of achieving significant energy savings. It is also recognized that this temperature may not be suitable for everyone. ECs usually do not have a programmable thermostat for such precise control, and EC users have achieved the cost-saving goal of using less energy by using ECs. Therefore, additional information is required for setting a reasonable temperature threshold for EC use.

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[2] https://www.energystar.gov/products/heating_cooling/programmable_thermostats

Using Pacific Energy Center (2006) as a guide, DWR explored the concept of setting the temperature threshold at 72 degrees Fahrenheit with working group members and stakeholders. While there was no specific input on this point, the working group members and stakeholders encouraged additional field verification, if possible.

Based on stakeholder input, DWR further explored field data from the study that was conducted by CWEE. Using data from County Accessor's Office by Assessor's Parcel Number (APN) and water use data, the CWEE analysis showed that water use increases along a similar pattern in homes with ECs and those with ACs as temperature increases (Figure 3-1) (see technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]).

Figure 3-1 shows water use at the same air temperature among homes with ECs and those with ACs. The disparities in water consumption are likely due to the following factors: (1) the two types of devices (i.e., ACs and ECs) use water differently for cooling, and (2) the consumption rates differ when the air temperature is below 60 degrees Fahrenheit.

Important to note is that, in many cases, water users utilize both EC and AC units for cooling in a single home. As a result, there is no immediate way to distinguish the water consumption for only an AC unit versus water consumption for only an EC unit. Therefore, because the consumption rates shown on Figure 3-1 may or may not be mutually exclusive, no conclusion regarding actual EC water use can be made using this data. Section 4 provides further discussion of this issue.

Nonetheless, the pattern of the two trends may provide additional insight into residential water use behaviors relative to ECs. As shown in Figure 3-1, the pattern of the observed difference is roughly the same until the air temperature reaches around 72 degrees Fahrenheit; at that point, there is a more prominent increase in water use in homes with ECs. The observed temperature threshold around 72 degrees Fahrenheit, as discussed above, is within comfort range, slightly less than mid-point. Although it is lower than the recommended temperature setpoint by Energy Star, which is considered a goal to achieve energy savings, DWR considered that 72 degrees Fahrenheit is representative and supported by the field data and, therefore, can be used as the temperature threshold for calculating ECs' efficient water use volume.

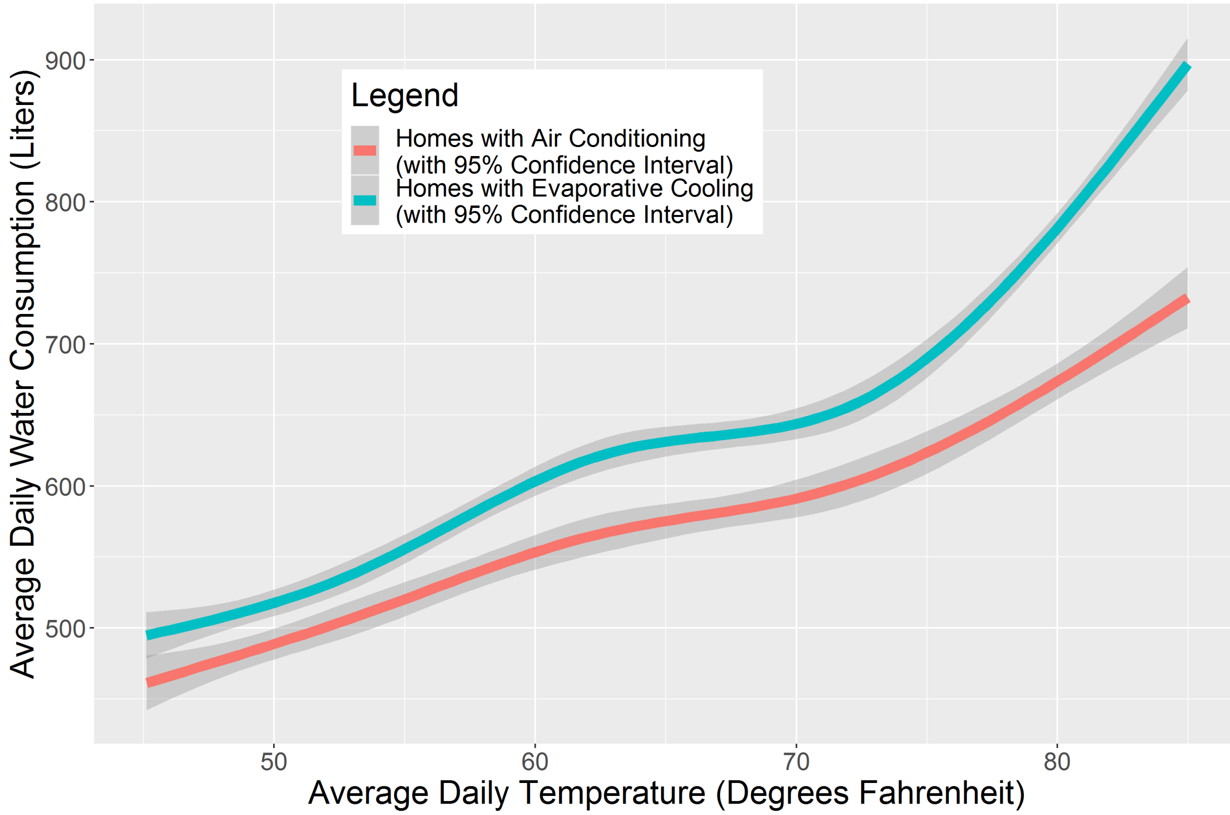


**Figure 3-1 Average Daily Water Use of Homes with Air Conditioners vs. Homes with Evaporative Coolers with Respect to Air Temperature**

***Representative Efficiency of ECs***

ECs pass outdoor air through water-saturated pads and the water in the pads evaporates, reducing the air temperature before the air is directed into the home. If the evaporation process was 100 percent efficient, the leaving dry-bulb temperature would equal the entering wet-bulb temperature. However, the efficiency of the evaporation process is often less than perfect, depending on the system configuration and material type.

The efficiency of an EC unit is the ratio of the actual cooling produced to the energy required to supply it relative to the theoretical maximum that could be produced, expressed in percentage. When discussing the efficiency of evaporative cooling, the focus is often on the actual temperature drop as the air passes through the pad.[3] It is worth noting that a more efficient EC means a faster cooling process, which means a higher rate of water use for evaporative cooling purposes.

The efficiency of ECs is improving over time. CWEE research shows that the average efficiency rate of ECs used at residential properties is between 0.8 and 0.95 (see

[3] https://phoenixmanufacturing.com/efficiency-numbers-what-they-mean-and-how-they-relate-to-our-various-products/

technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]). The higher range refers to the advanced technologies and later generations of ECs. The information from the U.S. Department of Energy also confirms that newer ECs have pads with an efficiency rate between 0.75 and 0.93.[4]

DWR considered that the installed EC units can vary significantly based on their age, design, and other specifications. Since the use of ECs for cooling is often driven by economic reasons, stakeholders and DWR agreed that modern, high efficiency ECs may not be representative of residential use. Therefore, after consultation with stakeholders and review of literature, DWR considered 0.8 as a reasonable efficiency rate that could be representative of residential use ECs for the purpose of this variance.

### Identification of Evaporative Cooler Units and Water Use on Urban Retail Water Supplier Level Through Data Analysis

As previously mentioned, DWR collaborated with CWEE to develop methodologies for identifying EC units and their associated water use on the aggregate urban retail water supplier level through data analysis. Refer to technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* (WUES-DWR-2021-05.T1) for details on the technical analysis. The following summary of the analysis and findings provide the basis for the development of options.

The regression analysis shown in Figure 3-1 was performed based on EC units identified in the APN data. The original hypothesis of this regression analysis was that the water use trend for homes with ECs would represent EC water use, which was expected to vary by air temperature. The original regression analysis was conducted using (1) only water data, and (2) both water and energy data. Depending on the data availability, a relationship could be generated from a sample set of homes and extrapolated for use in the entire service area. While additional errors may be introduced into the analysis, DWR nonetheless considers this approach to be reasonable due to limited data availability. This is especially the case when electricity use data were used. However, considering that most urban retail water suppliers cannot access energy use data, the approach of using only water data would most likely be preferred by most urban retail water suppliers. More granular water use data could also be beneficial for the water use estimation. Hourly weather data are easily available from multiple sources. However, it is also recognized that many urban retail water suppliers only have access to monthly water use data. Using an example dataset, the CWEE analysis suggested that an average water use of EC units is about 3.59 liters (0.95 gallons) per day per cooling-degree, with a standard error of 1.23 liters (0.32 gallons).

[4] https://basc.pnnl.gov/resource-guides/evaporative-cooling-systems#edit-group-description

CWEE proceeded with designing methodologies to identify the number of EC units in a service area, assuming that the APN data were accurate. The approach and techniques used to develop the identification methods are included in the technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* [WUES-DWR-2021-05.T1]). Overall, the recommended methodologies could identify approximately 70 to 75 percent of the total EC units in the service area under study, based on APN data.

Feedback from working group members and stakeholders on the above methodologies were mixed. They mostly agreed that APN data are not reliable, and users' behaviors cannot be properly characterized in the methodologies. They mentioned it would make sense to obtain information from APN data, but the accuracy of the data will depend on how often a property changes hands and whether it would show up in the records. Also, the quality of the data may be low because APN data often covers only master parcels rather than sub parcels, such as condominiums. However, stakeholders did not provide any additional reliable sources for identifying EC units other than proposing to conduct surveys throughout their service areas.

In addition to the technical difficulties in finding the number of EC units, user behavior is another complex factor that should be considered when analyzing EC-related data. On one hand, EC use may be underestimated if the corresponding community's predominant labor force spends long hours away from home. On the other hand, EC use in homes that also have ACs was reported to be a common practice due to economic reasons. Depending on the installed EC unit, the cooling could be for the entire house or just a portion of it. Based on the CWEE water use estimate, it was identified that cooling the entire house using ECs is not the norm. Additionally, portable EC units make it possible to use the system only for specific areas in the property during specific hours. It was agreed that identifying one pattern of use for all regions would not be reasonable using limited data that are currently available, and that this is a topic that may be best addressed by urban retail water suppliers for their service areas' local conditions. The working group members and stakeholders were not able to provide suggestions on how to address this issue due to a lack of comprehensive knowledge on this topic at this point in time.

Feedback also was received about the complexity of the equations for performing the calculation. Urban retail water suppliers voiced the concerns that they would not be able to conduct the analysis for this variance if no additional technical assistance is provided by DWR for implementation.

### Options for Evaporative Coolers Identification and Water Use Calculation

DWR formulated three options to differentiate the procedures, methodologies, and data requirements for calculating water use. Options 1 and 2 both used CWEE methodologies, but they were different in terms of data requirements. Option 1 included the use of electricity usage data, and Option 2 used only monthly water use records. In both options, DWR assumed that an urban retail water supplier could access its Single-Family Residence (SFR) customers' monthly water use records and the APN data for those SFRs to derive information on EC units. DWR recognized that APN data may not have EC unit information for all homes in a service area, and the data may be outdated or inaccurate. However, the dataset is the initial point of CWEE methodologies described above for EC water use estimation. If the APN data do not contain information for EC units, urban retail water suppliers could use the identification methodologies provided in the technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* (WUES-DWR-2021-05.T1) to identify the number of EC units in their service areas.

- **Option 1 –** Option 1 required following information to run the regression analysis: monthly water use data, energy data, daily weather data, property information, and account-level hourly energy consumption data for a sample of SFR homes in the service region known to have EC systems and for a sample of SFRs known to have AC systems.

  The urban retail water suppliers must first calculate a series of variables using the weather, property, water, and energy use data from their service areas. The variables would then be passed through two generic statistical tools to generate total water use by ECs in an urban retail water supplier's service area. Technical details for constructing the variables for each of the two methodologies are given in technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* (WUES-DWR-2021-05.T1).

- **Option 2 –** Option 2 required following information to run the regression analysis: monthly water use data, daily weather data, and property information for a sample of SFR homes in the service region known to have EC systems and for a sample of SFRs known to have AC systems. Similar to option 1, urban retail water suppliers would need to run the statistical analyses to determine the EC water use in their service areas.

The difference between Option 1 and Option 2 was that the lack of energy data decreased the accuracy of estimations, as fully discussed in technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* (WUES-DWR-2021-05.T1).

DWR included a third option that relies upon the on-the-ground information collected by urban retail water suppliers. This option provided a necessary contrast to Option 1 and Option 2, which relied only on data analyses.

- **Option 3 –** Option 3 required following information: hourly weather data (dry- and wet-bulb air temperature or dry-bulb temperature and relative humidity), EC indicator (whether a home uses EC or AC or both), average number of EC operation hours, and *CFM* of reported EC systems. Contrary to Options 1 and 2, Option 3 did not need statistical or regression analysis to determine EC water use in an urban retail water supplier's service area. However, it did require that a survey be conducted by urban retail water suppliers to obtain information regarding the number of EC units and SFR-specific information, such as the *CFM* associated with each EC unit, typical room size for use, and their operation hours.

A summary of different options and sources of data for each option are provided in Table 3-1. Each option, along with important characteristics, including data requirements, data source, and threshold of significance, are shown in the table. This comparison was presented to the stakeholders during the workshop held on July 21, 2021, and the feedback received is explained below.

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**Table 3-1 Summary of the Three Options for Variance for Significant Water Use of Evaporative Coolers**

| Items | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| Significance threshold | More than 5% of the aggregated efficient water use volume based on the four standards without a variance. | More than 5% of the aggregated efficient water use volume based on the four standards without a variance. | More than 5% of the aggregated efficient water use volume based on the four standards without a variance. |
| Data needed for calculation | For a sample of SFR homes in the service region known to have ECs and for a sample of SFRs known to have ACs:<br>• Monthly water use data.<br>• Energy data.<br>• Daily weather data.<br>• Property information.<br>• Account-level hourly energy consumption data. | For a sample of SFR homes in the service region known to have ECs and for a sample of SFRs known to have ACs:<br>• Monthly water use data.<br>• Daily weather data.<br>• Property information. | • Hourly weather data (dry- and wet-bulb air temperature or dry-bulb temperature and relative humidity).<br>• EC indicator (whether a home uses EC or AC or both).<br>• Average number of EC operation hours.<br>• *CFM* of reported EC systems based on customer surveys. |
| Equation | Statistical analyses provided in technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* (WUES-DWR-2021-05.T1). | Statistical analyses provided in technical report, *Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data* (WUES-DWR-2021-05.T1). | *EC Unit Water Use per Day* (gallons) = *Number of Operating Hours per Day* (hours) x *Evaporation Rate* (gallons per hour) |
| Evaporation rate | N/A | N/A | $\frac{CFM \times Operating\ Day\ Average\ \Delta T \times efficiency\ rate}{8700}$<br>where,<br>• *CFM* is cubic feet per minute of air exchange, which is the EC-unit-specific information provided by the manufacturer.<br>• *ΔT* is the difference between ambient air wet-bulb temperature and dry-bulb temperature in degrees Fahrenheit.<br>• *Efficiency rate* is EC-unit-specific information that varies by technologies, types, and media uses.<br>• 8,700 is the unit conversion factor that is based on 8.34 pounds of water per gallon. |
| Wet-bulb temperature | N/A | N/A | $Tw = T \times \arctan\left[0.151977 \times \sqrt{(rh + 8.313659)}\right] + \arctan(T + rh) - arctan(rh - 1.676331) + 0.00391838 \times rh^{1.5} \times \arctan(0.023101 \times rh) - 4.686035$<br>where,<br>• *Tw* is the wet-bulb temperature in degrees Fahrenheit (the equation is an approximation method based on dry-bulb temperature and relative humidity).<br>• *T* is the dry-bulb temperature.<br>• arctan is the mathematical operation to calculate Arc Tangent.<br>• *rh* is relative humidity, which is assumed to be 0.8 for these variance calculations. |

Key:
AC = air conditioner
CFM = cubic feet per minute
EC = evaporative cooler
N/A = not applicable

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The discussion of these options was conducted concurrently with the presentation of CWEE methodologies and findings. In addition to the feedback on CWEE findings, working group members and stakeholders agreed that on-the-ground information may be more reliable. However, they expressed concerns over the resource needs for conducting such a survey and the required tactics to keep them up to date. The stakeholders acknowledged that it is difficult to determine this variance water use without direct data from customers. Therefore, it will be incumbent on them to validate that they have significant water use related to ECs. Stakeholders discussed the use of budget-based rates as an approach to solicit customer information about their EC use. However, this idea was criticized due to lack of fairness and the potential for significant difference between water use in different climate zones. In this case, the key question to address is how the urban retail water supplier could establish a record to support this variance specific water use.

During the variance design process, Mojave Water Agency (MWA) completed its own study on EC water use in its service area (MWA, 2022). The study was based on field measurements of EC water use in 2020, and it showed that, in its service area, the average water use for each EC unit was about 52 gallons per day operating from 71 days to 101 days during 2020. More importantly, this study confirmed the importance of individual user behaviors regarding when and how ECs were used for cooling purposes. The study also confirmed that the use of ECs is not exclusive for those residents without AC installation; in fact, many residents with AC would use ECs for cooling purposes. The latter MWA measurement findings support CWEE findings using regression analysis methodologies.

## 3.4 Summary of Findings

Based on research and input from working group members and stakeholders, DWR concluded that significant water use of ECs in residential properties is a unique use and should be recognized as a variance. Different options to estimate the number of EC units and their water use across service areas of urban retail water suppliers were designed using APN data. However, it was concluded that installation of AC and EC units was not mutually exclusive. Many people would use both ECs and ACs in their residential properties due to cost benefits associated with using EC units for cooling purposes. The research analysis showed that behavioral patterns of people would also significantly affect the water use of ECs. Therefore, development of an identification method for the number of EC units and their water use remained inconclusive.

DWR considered that the on-the-ground data collection is the most reliable, repeatable, and transferrable means to develop necessary EC unit identification data and user behaviors to facilitate the water use volume calculation based on the available data, research findings, and stakeholder input. The temperature threshold for EC use on the aggregate urban retail water supplier level was set at 72 degrees Fahrenheit, and the representative EC efficiency was set at 0.8. Although it has not been a major topic for discussion, the consistent use of the threshold of significance at 5 percent of the water use of the four established standards was considered reasonable by stakeholders and working group members.

# 4.0 Recommendations

This section provides DWR's recommendations for the variance for significant water use of ECs, including guidelines and methodologies, reporting requirements and implementation considerations.

These recommendations and the resulting varaince adopted by the State Water Board do not set, rescind, or modify existing or future requirements for significant water use of ECs.

## 4.1 Summary of Recommendations

Based on the analysis and stakeholder input, DWR's recommendations are as follows.

### Recommendations for the Variance for Significant Water Use of Evaporative Coolers

DWR recommends that a variance should be established for significant water use of ECs in residential parcels that are served by residential meters. In this context, residential parcels mean that property parcels have a residential land use designation under the governing general plans of counties and cities. DWR's recommended variance against IRWUS should have the specifications detailed in Section 4.2. The calculation of aggregated efficient water use for significant use of ECs (Variance Efficient Water Use Volume) as part of an urban retail water supplier's UWUO should be subject to the guidelines and methodologies detailed in Section 4.3.

## 4.2 Specifications

DWR recommends that a variance be established for "significant water use of evaporative coolers" with the following specifications.

- Only EC water use at residential properties is allowed under this variance.
- The Variance Efficient Water Use Volume is calculated based on total number of customers using EC units in a service area, the average evaporation rate, and total number of operation hours per day for EC units.

$$\text{Variance Efficient Water Use Volume (gallons)} = \sum_{customers} \left[ \sum_{i=1}^{operating\ days} Number\ of\ Operating\ Hours \times Operating\ Day\ Average\ EC\ Evaporation\ Rate\left(\frac{gallons}{hour}\right) \right]$$

- EC evaporation rate depends on dry-bulb temperature, wet-bulb temperature, EC performance efficiency rate, and *CFM*.
- A representative EC performance efficiency is set at 0.8 (80 percent) for calculating the estimated EC water use, which is used to determine the *Operating Day Average EC Evaporation Rate*.
- The Variance Efficient Water Use Volume calculation is based on the desired air temperature in a specific room of 72 degrees Fahrenheit. Therefore, weather-related information is needed only when the ambient air temperature is above 72 degrees Fahrenheit.
- The estimated Variance Efficient Water Use Volume should be greater than 5 percent of the total aggregated efficient water use volume based on the four established standards, namely IRWUS, ORWUS, CII-DIMWUS, and WLS.
- The calculation of estimated water use under this variance should follow the guidelines and methodologies provided by DWR (detailed later in this section).

# 4.3 Guidelines and Methodologies

DWR recommends the following guidelines and methodologies for variance for “significant water use of evaporative coolers.”

- An urban retail water supplier will be allowed to include the variance for significant use of ECs in calculating its UWUO when all the following conditions are satisfied.
    1. The use of this variance by the urban retail water supplier is previously approved by State Water Board. (Reminder: The State Water Board’s approval is for using the variance, but not for the quantity, which varies every year.)
    2. The Variance Efficient Water Use Volume is greater than 5 percent of the sum of the aggregated estimates of efficient water uses based on four

established standards: IRWUS, ORWUS, CII-DIMWUS, and WLS (UWUO_SB).

- This condition should be verified by the urban retail water supplier every other year before using the variance to calculate the UWUO.

- The Variance Efficient Water Use Volume should be calculated based on data applicable to the conditions of the previous year.
- DWR, in coordination with the State Water Board, may recommend revisions of the guidelines and methodologies in the future, as needed.
- Use of alternative data and methodology is allowed if the urban retail water supplier can provide evidence that the alternative data and methodology are equal to or superior to DWR-provided data and methodology or DWR-suggested referenced data. Refer to "*Use of Alternative Data and Methodology for Calculating Variance Efficient Water Use Volume*" in the following sections.
- Urban retail water suppliers should provide all necessary data and information to support the use of this variance and associated calculated amount of estimate water use to be included in the UWUO. The data and information should be made publicly available. Where applicable, DWR will specify validation and certification requirements for certain data use.

For general guidelines and methodologies for using variances for calculating the UWUO, refer to *Recommendations for Guidelines and Methodologies for Calculating Urban Water Use Objective* (WUES-DWR-2021-01B, Section 6.2).

### Methodology for Estimating Variance Efficient Water Use Volume on Urban Retail Water Supplier Level

The urban retail water supplier will base its analysis on use of ECs information collected from its customers. DWR recommends that urban retail water suppliers make the information publicly accessible and periodically verify the data with follow-up surveys or update requirements for its customers.

DWR recommends that the urban retail water supplier establish a report form or a survey to obtain the required information. DWR will provide a template that can be tailored or directly used by urban retail water suppliers to collect the necessary information.

The calculation is based on hourly weather information, because temperatures may fluctuate throughout a day. Calculating the water use will require the urban retail water supplier to obtain and maintain a substantial amount of data. The urban retail water supplier should consider the system requirements to store that information.

DWR will develop an Excel-based utility program for use by urban retail water suppliers to assist with calculations. Appendix B provides a template for calculating the efficient use of water for EC use. This template is provided for illustrative purposes and is subject to revision after the State Water Board's adoption.

An urban retail water supplier with a significant water use that is in the scope of this variance must follow the required development steps to apply for the variance using one of the two calculation options, provided it meets the requirements and threshold.

***Data Needed for Calculation***

- Hourly weather data (dry- and wet-bulb air temperature or dry-bulb temperature and relative humidity).
- EC indicator (does a home use EC or AC, or both?).
- Number of EC operation hours (Operating Hours).
- Air exchange rate in *CFM* of reported EC systems (*CFM* is usually marked on the front of the cooler and would need to be reported to the urban retail water supplier by customers).
- EC evaporation rate (gallons per hour) is calculated as follows:

$$EC\ Evaporation\ Rate = \frac{CFM \times \Delta T \times efficiency\ rate}{8700}$$

where,

- *CFM* is cubic feet per minute of air exchange (to be reported by customers to the urban retail water supplier).
- *ΔT* is the difference between wet-bulb temperature and dry-bulb temperature.
- *Efficiency rate* is 0.80 (80 percent).

If the wet-bulb temperature is unknown, it can be calculated as follows:

$$Tw = T \times \arctan\left[0.151977 \times \sqrt{(rh + 8.313659)}\right] + \arctan(T + rh) - arctan(rh - 1.676331) + 0.00391838 \times rh^{1.5} \times \arctan(0.023101 \times rh) - 4.686035$$

where,

- *Tw* is the wet-bulb temperature in degrees Fahrenheit (the equation is an approximation method based on dry-bulb temperature and relative humidity; DWR will provide a tool to calculate this parameter).

- *T* is the dry-bulb temperature.
- *rh* is relative humidity as a percent.

***Variance Efficient Water Use Volume***

The urban retail water supplier should follow these two steps and their corresponding calculations to determine the Variance Efficient Water Use Volume,

**Step 1**. Using weather data, determine:

- Number of days temperature was greater than 72 degrees Fahrenheit (Operating Days).
- Number of hours per Operating Day the temperature was greater than 72 degrees Fahrenheit (*Maximum Operating Hours per Operating Day*).

**Step 2**. This method uses an average EC evaporation rate calculation. The Variance Efficient Water Use Volume estimation will need to be conducted on a daily basis for each operating day and for each customer account based on the information the customer provided.

i. Determine the *Operating Day Average ΔT*:

Calculate *ΔT* (dry-bulb temperature – wet-bulb temperature) for each hour, with dry-bulb temperature greater than 72 degrees Fahrenheit, and calculate the average *ΔT* for the operating day (*Operating Day Average ΔT*).

ii. For each customer, average EC evaporation rate per hour (gallons/hour) per Operating Day is then:

*Operating Day Average EC Evaporation Rate =*

$$\frac{CFM \times Operating\ Day\ Average\ \Delta T \times efficiency\ rate}{8700}$$

iii. For each customer, determine actual operating hours per *Operating Day* (*Daily Maximum Operating Hours*).

If the average operating hours provided by the customer was greater than the *Daily Maximum Operating Hours* in an operating day, the *Daily Maximum Operating Hours* is used in the calculations for that Operating Day.

iv. For each customer account, efficient EC use per Operating Day is:

Efficient Operating Day EC Customer Water Use = *Maximum Operating Hours per Operating Day* x *Operating Day Average EC Evaporation Rate* (gallons per hour)

- If multiple EC units are used by a customer, an average EC evaporation rate can be used with the combined total number of operating hours.

Efficient Operating Day EC Customer Water Use = *Sum of Maximum Operating Hours per Operating Day* x *Operating Day Average EC Evaporation Rate* (gallons per hour)

v. Variance Efficient Water Use Volume is then summed up for all operating days and all customers with ECs:

$$\text{Variance Efficient Water Use Volume (gallons)} = \sum_{customers}\left[\sum_{i=1}^{operating\ \ days} Number\ of\ Operating\ Hours \times Operating\ Day\ Average\ EC\ Evaporation\ Rate(\frac{gallons}{hour})\right]$$

### *Significance Test*

For this variance, the Variance Efficient Water Use Volume must be equal to or greater than the minimum volume established below.

Minimum Variance Volume (gallons) = 5% x UWUO_SB

## Data Provided by Urban Retail Water Supplier

- EC indicator (does a home use EC or AC, or both?).
- Total number of EC Operating Hours per customer.
- Air exchange factor of ECs (*CFM*).

### *EC Data*

The number of ECs and operation factors are variable, since they are based on the urban retail water supplier's service area. Urban retail water suppliers will need to gather data on the number, capacity (*CFM*), and operating hours of each EC in their service area. Data can be gathered through a survey sent to residential water users or when a user registers for water use or goes through a recertification process, or other information-gathering process. Required data includes:

- Whether an EC is present and used.

- If an EC is present and used, additional data are required, including:
  - Air exchange rate in *CFM* of reported EC systems. (*CFM* is usually marked on the front of the cooler and would need to be reported to the urban retail water supplier by customers.)
  - Number of EC operation hours (Operating Hours)

### Summary of Guidelines and Methodologies to Calculate the Variance Efficient Water Use Volume

A summary of guidelines and methodologies for the calculation methodology is presented in Tables 4-1.

#### *Data Accuracy*

To ensure data accuracy, urban retail water suppliers must also provide a detailed description of the method(s) used to obtain EC data. This description must include data collection and verification process or procedures, including, but not limited to, documentation and records retention, follow-up procedures (if necessary), and verification process and associated statistics if not verifying all data.

Urban retail water suppliers do not have to verify all survey information. A statistical sample for verification (i.e., random sample of a certain percentage of customers responding positively to a survey) may be used so long as the process is properly described and documentation is provided. DWR recommends that the statistical sampling meet the following minimum requirements:

- Verify a random sample of accounts identified with ECs.
  - At least a minimum of 10 percent of these accounts, but no less than 5 percent.
  - A maximum of 100 verfied accounts.
- Verification can include pictures, site visits, or other methods to be described in the application documentation of number of identified ECs.

Documentation on individual surveys or other records, statistical sample results, and any other data supporting the methods and verification should be available upon request and retained for the period the data are used in this process, plus three years.

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**Table 4-1 Summary of Guidelines and Methodologies for Calculating the Variance Efficient Water Use Volume for Significant Water Use of Evaporative Coolers**

| Guidelines and Methodologies | Calculation for 5 Percent Significance Threshold |
|---|---|
| Data needed for calculation | • Hourly weather data (dry-bulb/wet-bulb air temperature, relative humidity, and dew point temperature).<br>• EC indicator (does a home use EC or AC, or both?).<br>• Number of EC Operating Hours<br>• *CFM* of reported EC systems. (*CFM* is usually marked on the front of the cooler and would need to be reported to the urban retail water supplier by customers.) |
| Wet-bulb temperature | $Tw = T \times \arctan\left[0.151977 \times \sqrt{(rh + 8.313659)}\right] + \arctan(T + rh) - acrtan(rh - 1.676331) + 0.00391838 \times rh^{1.5} \times \arctan(0.023101 \times rh) - 4.686035$<br>where,<br>• *Tw* is wet-bulb temperature in degrees Fahrenheit (the equation is an approximation method based on dry-bulb temperature and relative humidity; DWR will provide a tool to calculate this parameter).<br>• *T* is dry-bulb temperature in degrees Fahrenheit (from CIMIS).<br>• *rh* is relative humidity as a percent (from CIMIS). |
| Operating Day Average EC Evaporation Rate (gallons per hour) | $\frac{CFM \times Operating\ Day\ Average\ \Delta T \times efficiency\ rate}{8700}$<br>where,<br>• *CFM* is cubic feet per minute (to be reported by customers to the urban retail water supplier).<br>• *ΔT* is the difference between wet-bulb temperature and dry-bulb temperature for each hour, with dry-bulb temperature greater than 72 degrees Fahrenheit.<br>• Representative efficiency rate is 0.80 (80%). |
| Equation | $\text{Variance Efficient Water Use Volume (gallons)} = \sum_{customers}\left[\sum_{i=1}^{operating\ days} Number\ of\ Operating\ Hours \times Operating\ Day\ Average\ EC\ Evaporation\ Rate\left(\frac{gallons}{hour}\right)\right]$ |
| Source(s) of data | **National Weather Service and others (to be determined):**<br>• Hourly dry-bulb air temperature.<br>• Hourly relative humidity.<br>• Hourly dew point temperature.<br>**CIMIS** (when used, recognize that the gauge setting for CIMIS data collection may not reflect the conditions of individual houses):<br>• Hourly dry-bulb air temperature.<br>• Hourly relative humidity.<br>• Hourly dew point temperature.<br>**To be obtained/developed by urban retail water supplier:**<br>• Hourly wet-bulb temperature (to be calculated based on the DWR tool).<br>• EC indicator (does a home use EC or AC, or both?).<br>• Total number of EC Operating Hours per residential property.<br>• Air exchange factor of ECs (*CFM*). |

**Table 4-1 Summary of Guidelines and Methodologies for Calculation of the Variance Efficient Water Use Volume for Significant Water Use of Evaporative Coolers (contd.)**

| Guidelines and Methodologies | Calculation for 5 Percent Threshold Use |
|---|---|
| Reporting requirements (provided to DWR by urban retail water supplier) | • Hourly weather data (dry-/wet-bulb air temperature, relative humidity, dew point temperature, vapor pressure).<br>• EC indicator (does a home use EC or AC, or both?).<br>• Total number of EC operating hours per residential property.<br>• Air exchange factor of ECs (*CFM*).<br>• All other supporting data and documentation used to calculate the Variance Efficient Water Use Volume. |

Key:
AC = air conditioner
CFM = cubic feet per minute
CIMIS = California Irrigation Management Information System
DWR = California Department of Water Resources
EC = evaporative cooler

### Data Obtained by the Urban Retail Water Supplier

Urban retail water suppliers will also need to obtain weather information from a reliable source where data must be published and conform to normal standards for weather data collection such as the Western Regional Climate Center Remote Automated Weather Stations USA Climate Archive.[5]

- Hourly dry-bulb air temperature.
- Hourly wet-bulb air temperature or hourly relative humidity if wet-bulb temperature is not available.

### Data and Resources Provided by the California Department of Water Resources

- DWR will develop an Excel-based utility program for use by urban retail water suppliers using the formulas presented in this section.
- CIMIS data may be used, but may not well represent the urban climate; and wet-bulb temperature will need to be estimated from relative humidity:
  - Hourly dry-bulb air temperature.
  - Hourly relative humidity.

### Use of Alternative Data and Methodology for Calculating Variance Efficient Water Use Volume

Alternative data and methodology for determining hourly wet-bulb temperature and EC evaporation rate can be used if the urban retail water supplier provides evidence that the alternative data are superior to DWR-provided data or DWR-suggested referenced data. Alternative methods from studies to determine the Variance Efficient Water Use Volume also can be used if the urban retail water supplier provides evidence that the study is specifically developed for the calculation of this variance water use and meets the acceptable criteria as follows.

#### *Alternative Variance Efficient Water Use Volume Calculation*

To request the use of an alternative approach to calculate the Variance Efficient Water Use Volume, the urban retail water supplier must demonstrate that the alternative methodology or study meets or exceeds the quality and accuracy of the methodology DWR provided in this Recommendation Package by submitting a package to DWR for approval containing the following:

[5] https://wrcc.dri.edu

1. Description of why the alternative method meets or exceeds the quality and accuracy of the guidelines and methodologies.
2. Description of the methodology used, including calculations and data.
3. Verification of the methodology through literature reviews, models, measurements, or other processes.
4. Credentials (such as licenses, certifications, education, training, or professional background of staff) for the entity/party that conducted the analysis or provided the data.
5. Affidavit or certification of the alternative methodology by a qualified urban retail water supplier staff member responsible for developing the UWUO and Annual Water Use Report.
    a. Certification of the alternative methodology by the entity/party that produced it, if not produced by the urban retail water supplier's staff.
    b. Referenced, published research reports do not require certification, but must be cited.
6. A public process to provide the public an opportunity to review the alternative methodology and understand the purpose of the request to use alternative data.
7. A request to DWR signed by the General Manager of the urban retail water supplier.

***Alternative Evaporation Rate Calculation or Wet-Bulb Temperature***

To request the use of alternative EC climate data or evaporation rate calculation, the urban retail water supplier must demonstrate that the alternative data or methodologies meet or exceed the quality and accuracy of the data DWR provides or references by submitting a package to DWR for approval containing the following:

1. Description of why the alternative data meets or exceeds the quality and accuracy of the DWR data.
2. Description of the methodology used for determining wet-bulb temperature or EC evaporation rate, including data sources and any locally applicable research and literature.
3. Verification that the ECs considered in the variance are for residential uses, which are categorically excluded from ORWUS and IRWUS.

4. Credentials (such as licenses, certifications, education, training, or professional background of staff) for the entity/party that conducted the analysis or provided the data.

5. Affidavit or certification of the alternative data by a qualified urban retail water supplier staff member responsible for data quality.

    a. Certification of the alternative data by the entity/party that produced it if not produced by the urban retail water supplier’s staff.

    b. Referenced, published research reports do not require certification, but must be cited.

6. A public process to provide the public an opportunity to review the alternative data and understand the purpose of the request to use alternative data.

7. A request to DWR signed by the General Manager of the urban retail water supplier.

***Temperature and Climate Data***

To request the use of alternative data or method to determine wet-bulb temperature, dry-bulb temperature, or relative humidity, the urban retail water supplier must demonstrate that the alternative data or methodologies meet or exceed the quality and accuracy of the data and method DWR provides or references by submitting a package to DWR for approval containing the following:

1. Description of why the alternative data or method meets or exceeds the quality and accuracy of the DWR data or referenced data.

2. Description of the methodology and data used, including data sources and any locally applicable research and literature.

3. Credentials (such as licenses, certifications, education, training, or professional background of staff) for the entity/party that conducted the research or analysis and verification.

4. Affidavit or certification of the alternative data by a qualified urban retail water supplier staff member responsible for data quality.

    a. Certification of the alternative data by the entity/party that produced it, if not produced by the urban retail water supplier’s staff.

    b. Referenced, published research reports do not require certification, but must be cited.

5. A public process to provide the public an opportunity to review the alternative data or methodology and understand the purpose of the request to use alternative data.

6. A request to DWR signed by the General Manager of the urban retail water supplier.

## 4.4 Implementation Considerations

Specific considerations to prepare for this variance application are as follows:

- The urban retail water supplier will calculate the Variance Efficient Water Use Volume based on the information collected from its customers. DWR recommends that urban retail water suppliers make the information publicly accessible, where applicable, and in accordance with data privacy laws and regulations, and periodically verify the data with follow-up surveys or updated requirements for its customers.
  - Data and documentation should be kept for the duration the data is in use and at least three years following.
- DWR recommends that the urban retail water supplier establish a report form or a survey to obtain the required information from customers.
- The calculation is based on hourly weather information, as temperatures may fluctuate throughout a day.
  - Calculating water use will require the urban retail water supplier to obtain and maintain a substantial amount of data. The urban retail water supplier should consider the system requirements to store that information.
  - Alternative data for hourly dry-bulb temperature, hourly wet-bulb temperature, and relative humidity can be used if the urban retail water supplier provides evidence that the alternative data are equal to or superior to DWR-provided data or DWR-suggested referenced data.
  - DWR will develop an Excel-based utility program for urban retail water supplier use, because the underlying calculations and formula are relatively complicated.

## 4.5 Reporting Requirements

Official documentation to verify the accuracy of the data must be submitted with the package. All data used by an urban retail water supplier in its calculation(s), regardless of whether they were obtained by the urban retail water supplier or provided by DWR, must be reported with the variance application as listed below. Urban retail water suppliers will need to report their variance water use each year in their Annual Water Use Report. Each year, the urban retail water supplier will have to calculate its UWUO based on the efficient water use standards and conduct the threshold test in order to allow for addition of the approved variance volume in its UWUO.

- Total number of ECs.
- Total number of *Operating Days.*
- Total number of *Maximum Operating Hours.*
- Range and average air exchange rate in *CFM*.
- Average *EC Evaporation Rate.*
- Number of EC operation hours (Operating Hours).
- Variance Efficient Water Use Volume.
- Description of verification process and results.
- DWR approval to use alternative data or methodology, as applicable.

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# 5.0 Glossary

The following key terms are listed below for easy reference. Where applicable, existing definitions from statutes and regulations are provided.

**commercial, industrial, and institutional water use**. Water used by commercial water users, industrial water users, institutional water users, and large landscape water users, as defined in California Water Code Section 10608.12(d).

**commercial water user**. A water user that provides or distributes a product or service, as defined in California Water Code Section 10608.12(e).

**dedicated irrigation meter**. A meter used only for irrigation of outdoor landscape areas. However, a mixed-use meter with no more than five percent of total delivered water serving non-landscape irrigation purposes can also be considered a dedicated irrigation meter for the purpose of the urban water use objective and actual water use calculations and reporting.

**dew point temperature**. The temperature at which water vapor in the air condenses into liquid water at the same rate at which it evaporates.

**dry-bulb temperature**. The ambient temperature, measured by a thermometer freely exposed to the air but shielded from radiation and moisture.

**evaporative cooler**. A device that cools air through the evaporation of water.

**evaporative cooling**. The process by which thermal energy transfers from hot, dry air to liquid water, causing some of that water to vaporize and create cool, moist air.

**industrial water user**. A water user that is primarily a manufacturer or processor of materials as defined by the North American Industry Classification System code sectors 31 to 33, inclusive, or an entity that is a water user primarily engaged in research and development, as defined in California Water Code Section 10608.12(i).

**institutional water user**. A water user dedicated to public service. This type of user includes, among other users, higher education institutions, schools, courts, churches, hospitals, government facilities, and nonprofit research institutions, as defined in California Water Code Section 10608.12(j).

**material effect**. Having real importance or great consequences. In the context of California Department of Water Resources' recommendations regarding the urban water use objective and variances, a material effect is an effect on the urban water use objective that could influence the compliance status of an urban retail water supplier.

**performance measures**. Actions to be taken by urban retail water suppliers that will result in increased water use efficiency by commercial, industrial, and institutional water users. Performance measures may include, but are not limited to, educating commercial, industrial, and institutional water users on best management practices, conducting water use audits, and preparing water management plans. Performance measures do not apply to process water, as defined in California Water Code Section 10608.12(n).

**relative humidity**. The amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature.

**threshold of significance**. A minimum volume of unique water use in an urban retail water supplier's service area that could have a material effect on that urban retail water supplier's urban water use objective.

**urban retail water supplier**. A water supplier, either publicly or privately owned, that directly provides potable municipal water to more than 3,000 end users or that supplies more than 3,000 acre-feet of potable water annually at retail for municipal purposes, as defined in California Water Code Section 10608.12(t).

**urban water use efficiency standards**. The standards effective through California Water Code Section 10609.4 (indoor residential use) or adopted by the State Water Resources Control Board (outdoor residential, water loss, and commercial, industrial, and institutional outdoor irrigation of landscape areas with dedicated meters) pursuant to California Water Code Section 10609.2.

**urban water use objective**. An estimate of aggregate efficient water use for the previous year based on adopted water use efficiency standards and local service area characteristics for that year, as described in California Water Code Section 10609.20, as defined in California Water Code Section 10608.12(u).

**water loss**. The total of apparent loss and real loss (California Code of Regulations, Title 23, Section 638.1(a) and Section 638.1(k), respectively) in an urban retail water supplier's system. Apparent loss means loss due to unauthorized consumption and/or nonphysical (paper) loss attributed to inaccuracies associated with customer metering or systematic handling errors. Real loss means the physical water loss from the pressurized potable water system and the urban retail water supplier's potable water storage tanks, up to the point of customer consumption.

**wet-bulb temperature**. The lowest temperature to which air can be cooled by the evaporation of water into the air at a constant pressure. It is measured by wrapping a wet wick around the bulb of a thermometer and the measured temperature corresponds to the wet-bulb temperature.

# 6.0 References

DWR and State Water Board (California Department of Water Resources and State Water Resources Control Board). 2018. Making Water Conservation a California Way of Life. Primer of 2018 Legislation on Water Conservation and Drought Planning Senate Bill 606 (Hertzberg) and Assembly Bill 1668 (Friedman). Accessed at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Water-Use-And-Efficiency/Make-Water-Conservation-A-California-Way-of-Life/Files/PDFs/Final-WCL-Primer.pdf?la=en&hash=B442FD7A34349FA91DA5CDEFC47134EA38ABF209

MWA (Mojave Water Agency). 2022. Evaporative Cooler Study 2020. January.

Pacific Energy Center. 2006. The Pacific Energy Center's Guide to: California Climate Zones and Bioclimatic Design. October.

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# Appendix A – Urban Water Use Efficiency Recommendation Package Reports Incorporated by Reference

DWR (California Department of Water Resources). September 2022. Recommendations for Urban Water Use Efficiency Standards, Variances, Performance Measures, and Annual Water Use Reporting. DWR Report Number: WUES-DWR-2021-01A.

DWR (California Department of Water Resources). September 2022. Recommendations for Guidelines and Methodologies for Calculating Urban Water Use Objective. DWR Report Number: WUES-DWR-2021-01B.

DWR (California Department of Water Resources). September 2022. Summary of Recommendations for Variances. DWR Report Number: WUES-DWR-2021-04.

DWR (California Department of Water Resources). September 2022. Methods for Estimating Residential Evaporative Cooler Water Consumption and Prevalence Using Account-Level Water and Energy Consumption Data. DWR Report Number: WUES-DWR-2021-05.T1.

DWR (California Department of Water Resources). September 2022. Recommendations for Deferring Variance for Significant Water Use of Home Use Medical Devices. DWR Report Number: WUES-DWR-2021-06.

DWR (California Department of Water Resources). September 2022. Recommendations for Performance Measures for Commercial, Industrial, and Institutional Water Use. DWR Report Number: WUES-DWR-2021-15.

DWR (California Department of Water Resources). September 2022. Stakeholder Outreach Summary for Developing Urban Water Use Efficiency Standards, Variances, and Performance Measures. DWR Report Number: WUES-DWR-2021-20.

DWR (California Department of Water Resources). September 2022. Urban Water Use Efficiency Recommendation Package: Glossary and Abbreviations and Acronyms. DWR Report Number: WUES-DWR-2021-21.

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# Appendix B – Template for Calculating the Efficient Water Use for Variance for Significant Water Use of Evaporative Coolers

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**Urban retail water suppliers should follow these steps to calculate the water use of evaporative coolers in their service areas:**

1. This spreadsheet tool comes with an add-in folder called "psych". Make sure you follow the instruction available in "PsychManual.pdf" in the psych folder and install this add-on extension on your local computer.

2. Reboot all of your open Microsoft Excel workbooks after installation of the add-in to make sure Excel tool package is updated.

3. Open this calculation spreadsheet, and click on "update", "continue" and ignore the errors.

4. Go to tab "Total Water Use Calculation" and fill in the grey cells.

5. Go to tab "WeatherData" and fill in the information to all grey cells and columns.

6. Go to "WeatherData" sheet of this workbook and enter the following equation into cell H5, manually. Remember to remove the " " marks from the start and end of the equation when you copy into cell H5.

"=IF(F5 < 72, 0, 60*CFM* (1/3.79) * (Hum_rat((F5 - 32) * 5/9 - Eff*((F5 - 32) * 5/9 -Wet_bulb((F5 - 32) * 5/9, G5/100,P)), Wet_bulb((F5 - 32) * 5/9, G5/100,P), P) - Hum_rat((F5 - 32) * 5/9, Wet_bulb((F5 - 32) * 5/9,G5/100,P), P)) * (1/35.3147) * Dry_Air_Density(P,(F5 - 32) * 5/9, Hum_rat((F5 - 32) * 5/9 -Eff*((F5 - 32) * 5/9 - Wet_bulb((F5 - 32) * 5/9,G5/100,P)), Wet_bulb((F5 - 32) * 5/9,G5/100,P), P )))"

7. Drag the equation to cover the entire column H. Now, the values must be updated without any error.

8. Go back to tab "Total Water Use Calculation" to check total water use by evaporative coolers in your service area and learn whether your agency is qualified to recived the variance.

## Variance: Significant Water Use of Evaporative Coolers

*Fill in the grey rows to determine: 1. efficient water use under this variance, and 2. whether your agency is qualified to apply for this variance.

| Name of Variable | Value (if constant) | Notes |
|---|---|---|
| ***P*** [a] | 102.07 | Do not change. |
| ***Eff*** [b] | 0.8 | Do not change. |
| ***CFM*** [c] (cubic feet per minute) | 1000 | This number is an example. Should be updated by urban retail water suppliers. |
| **Total number of customers/homes with evaporative coolers** | | |
| **Total Water Use** (gallons) | #NAME? | |
| **What is your Annual Urban Water Use Objective?** | | |
| **Are you qualified to apply for this variance?** | | |

a. *P* is a constant in the water use equation that is applied to calculate the evaporative cooler water use. The equation is used in tab "WeatherData", column H. This number should not be changed.

b. *Eff* refers to the evaporative cooler efficiency rate. DWR recommended value for this efficiency rate is 0.8 (or 80 percent). This number should not be changed.

c. *CFM* is the cubic feet per minute of air exchange, which is the EC-unit-specific information provided by the manufacturer. *CFM* is usually marked on the front of the cooler and would need to be reported to the urban retail water supplier by customers. An urban retail water supplier should calculate the average *CFM* of all the evaporative cooler units in their service area and enter the average number to cell B8. If the urban retail water supplier decides to calculate the evaporative coolers' water use per customer, *CFM* reported by each customer should be entered in cell B5. Then, cell B13 will only show the water use per customer. Therefore, "Total Water Use" in the service area will be the summation of all water use per customer which needs to be calculated seperately.

**Variance: Significant Water Use of Evaporative Coolers (Sample)**

*Fill in the first 7 columns to determine water use in gallons per hour for an EC unit with "CFM" that is entered in "Total Water Use Calculation" sheet.

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/6/2021 | 1600 | 74.4 | 31 | 1.734125905 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 1700 | 73.7 | 33 | 1.658573739 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 1800 | 71.3 | 43 | 0 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 1900 | 65.4 | 57 | 0 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 2000 | 60.9 | 57 | 0 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 2100 | 57.4 | 55 | 0 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 2200 | 53.6 | 64 | 0 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 2300 | 50.5 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/6/2021 | 2400 | 49.1 | 79 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 100 | 48.4 | 81 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 200 | 47.7 | 82 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 300 | 46.9 | 85 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 400 | 46.5 | 87 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 500 | 46 | 89 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 600 | 45.8 | 90 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 700 | 47.2 | 85 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 800 | 49.5 | 79 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 900 | 54.2 | 68 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1000 | 59.3 | 55 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1100 | 62.9 | 48 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1200 | 66 | 43 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1300 | 68.9 | 35 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1400 | 71.5 | 33 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1500 | 72.5 | 32 | 1.658850796 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1600 | 71.5 | 31 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1700 | 68.8 | 32 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1800 | 63.4 | 43 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 1900 | 57.8 | 54 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 2000 | 54 | 60 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 2100 | 52.7 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 2200 | 50.2 | 71 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 2300 | 48.6 | 77 | 0 |
| 6 | Davis | Sacramento Valley | 4/7/2021 | 2400 | 48.4 | 78 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 100 | 46.9 | 81 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 200 | 44.9 | 85 | 0 |

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/8/2021 | 300 | 42.1 | 87 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 400 | 40.8 | 90 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 500 | 40.6 | 91 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 600 | 39.4 | 92 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 700 | 40.9 | 93 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 800 | 46.2 | 86 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 900 | 51.5 | 74 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1000 | 55.8 | 66 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1100 | 60.7 | 56 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1200 | 65.1 | 43 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1300 | 68.6 | 35 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1400 | 71.6 | 31 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1500 | 74.1 | 26 | 1.876569185 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1600 | 75.3 | 22 | 2.034870427 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1700 | 74.7 | 29 | 1.801547364 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1800 | 73.4 | 32 | 1.680486264 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 1900 | 69.7 | 40 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 2000 | 63.5 | 47 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 2100 | 59.8 | 48 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 2200 | 57.6 | 51 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 2300 | 55.4 | 55 | 0 |
| 6 | Davis | Sacramento Valley | 4/8/2021 | 2400 | 53.1 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 100 | 51.9 | 69 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 200 | 49.9 | 74 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 300 | 49.3 | 74 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 400 | 48.1 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 500 | 45.3 | 89 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 600 | 44.4 | 94 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 700 | 45.9 | 91 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 800 | 49.6 | 80 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 900 | 54.6 | 68 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1000 | 58.9 | 60 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1100 | 63.6 | 53 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1200 | 67.9 | 45 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1300 | 71.5 | 37 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1400 | 73 | 36 | 1.556760208 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1500 | 73.5 | 33 | 1.653872986 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1600 | 73.9 | 32 | 1.692494286 |

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1700 | 72.6 | 35 | 1.576055789 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1800 | 69.5 | 42 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 1900 | 63 | 49 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 2000 | 57.9 | 56 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 2100 | 55.4 | 61 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 2200 | 53.1 | 67 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 2300 | 51 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/9/2021 | 2400 | 49.6 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 100 | 48.6 | 79 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 200 | 47.4 | 81 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 300 | 46.5 | 83 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 400 | 45.4 | 86 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 500 | 43.3 | 89 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 600 | 42 | 92 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 700 | 43.9 | 91 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 800 | 49.1 | 81 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 900 | 53.7 | 72 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1000 | 58.3 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1100 | 63.5 | 52 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1200 | 67.9 | 44 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1300 | 71.9 | 38 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1400 | 74.6 | 34 | 1.650303845 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1500 | 76.8 | 33 | 1.731292456 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1600 | 76.3 | 35 | 1.65919086 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1700 | 76 | 34 | 1.682435142 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1800 | 76.2 | 33 | 1.717245657 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 1900 | 72.5 | 38 | 1.490053027 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 2000 | 66.1 | 44 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 2100 | 60 | 49 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 2200 | 57.2 | 52 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 2300 | 54.8 | 58 | 0 |
| 6 | Davis | Sacramento Valley | 4/10/2021 | 2400 | 52.8 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 100 | 52.1 | 66 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 200 | 50.1 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 300 | 47.9 | 82 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 400 | 47 | 83 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 500 | 46.3 | 90 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 600 | 45.9 | 91 | 0 |

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/11/2021 | 700 | 47.1 | 89 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 800 | 56.4 | 55 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 900 | 63.5 | 33 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1000 | 66.3 | 31 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1100 | 70.1 | 26 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1200 | 73.3 | 24 | 1.914962009 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1300 | 76.7 | 18 | 2.208271742 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1400 | 78.9 | 16 | 2.348925028 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1500 | 80 | 16 | 2.385680741 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1600 | 80.8 | 17 | 2.375967235 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1700 | 81.1 | 17 | 2.385793405 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1800 | 78.1 | 29 | 1.888370116 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 1900 | 74.1 | 37 | 1.552275715 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 2000 | 69.2 | 42 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 2100 | 62.6 | 53 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 2200 | 58.7 | 59 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 2300 | 55.5 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/11/2021 | 2400 | 52.4 | 68 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 100 | 51.9 | 66 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 200 | 56 | 44 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 300 | 55.4 | 41 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 400 | 51.2 | 61 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 500 | 49.7 | 71 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 600 | 47.5 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 700 | 49.6 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 800 | 60 | 36 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 900 | 65.8 | 24 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1000 | 69.6 | 21 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1100 | 74.1 | 18 | 2.125062725 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1200 | 76.2 | 16 | 2.258838021 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1300 | 78.4 | 15 | 2.367292265 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1400 | 79.8 | 15 | 2.415015399 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1500 | 81.2 | 13 | 2.537536267 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1600 | 82.1 | 13 | 2.56955184 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1700 | 81 | 19 | 2.310078536 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1800 | 78.9 | 29 | 1.908746271 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 1900 | 75.3 | 31 | 1.756182993 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 2000 | 69.8 | 32 | 0 |

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/12/2021 | 2100 | 63.2 | 44 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 2200 | 59.1 | 46 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 2300 | 56.9 | 52 | 0 |
| 6 | Davis | Sacramento Valley | 4/12/2021 | 2400 | 55.1 | 64 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 100 | 52.9 | 71 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 200 | 51.5 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 300 | 51 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 400 | 50.2 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 500 | 49.5 | 78 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 600 | 48.8 | 79 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 700 | 50.2 | 74 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 800 | 53.8 | 67 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 900 | 58 | 60 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1000 | 61.8 | 52 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1100 | 65.4 | 37 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1200 | 68.3 | 30 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1300 | 69.9 | 29 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1400 | 71.8 | 29 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1500 | 72.5 | 33 | 1.630355163 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1600 | 72.3 | 33 | 1.625649078 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1700 | 70 | 34 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1800 | 65.5 | 39 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 1900 | 61.7 | 44 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 2000 | 59 | 48 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 2100 | 56.3 | 52 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 2200 | 53.8 | 61 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 2300 | 52.2 | 69 | 0 |
| 6 | Davis | Sacramento Valley | 4/13/2021 | 2400 | 50.1 | 75 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 100 | 49.4 | 75 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 200 | 48.2 | 78 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 300 | 46.9 | 81 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 400 | 45.8 | 82 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 500 | 47.8 | 66 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 600 | 44.2 | 72 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 700 | 48.5 | 65 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 800 | 55.7 | 46 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 900 | 59 | 42 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1000 | 60.7 | 43 | 0 |

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1100 | 63.5 | 38 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1200 | 66.2 | 34 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1300 | 68.6 | 29 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1400 | 70.1 | 25 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1500 | 71.3 | 21 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1600 | 71.5 | 26 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1700 | 70.3 | 33 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1800 | 68.6 | 33 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 1900 | 65.6 | 33 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 2000 | 61.6 | 40 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 2100 | 58.8 | 43 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 2200 | 56.4 | 50 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 2300 | 53.5 | 58 | 0 |
| 6 | Davis | Sacramento Valley | 4/14/2021 | 2400 | 51.9 | 59 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 100 | 49.9 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 200 | 49.8 | 66 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 300 | 48.3 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 400 | 47.2 | 78 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 500 | 45.6 | 90 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 600 | 45 | 95 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 700 | 45.5 | 95 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 800 | 49 | 84 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 900 | 53.5 | 67 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1000 | 59.1 | 54 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1100 | 63.4 | 43 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1200 | 66.2 | 38 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1300 | 69.2 | 33 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1400 | 71.6 | 30 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1500 | 72.9 | 25 | 1.873673552 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1600 | 73.5 | 21 | 2.012494494 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1700 | 73.3 | 20 | 2.037312759 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1800 | 71.8 | 20 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 1900 | 68.5 | 23 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 2000 | 64.1 | 31 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 2100 | 59.3 | 48 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 2200 | 55.9 | 57 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 2300 | 52.9 | 62 | 0 |
| 6 | Davis | Sacramento Valley | 4/15/2021 | 2400 | 50.9 | 63 | 0 |

| Station ID | Station Name | CIMIS Region | Date | Hour (PST) | Air Temperature (°F) | Relative Humidity (%) | Water Use (gallon/hour) |
|---|---|---|---|---|---|---|---|
| 6 | Davis | Sacramento Valley | 4/16/2021 | 100 | 49.2 | 64 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 200 | 47.5 | 71 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 300 | 46.1 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 400 | 45.3 | 79 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 500 | 44.2 | 80 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 600 | 44 | 79 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 700 | 46 | 76 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 800 | 51.9 | 66 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 900 | 57.5 | 57 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1000 | 63.1 | 45 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1100 | 68.2 | 38 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1200 | 72.7 | 31 | 1.692414161 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1300 | 75.4 | 27 | 1.880951541 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1400 | 77.8 | 23 | 2.075573999 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1500 | 80.3 | 19 | 2.288081751 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1600 | 81.2 | 16 | 2.425799306 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1700 | 81.4 | 15 | 2.469612448 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1800 | 80.3 | 17 | 2.359591255 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 1900 | 74.4 | 26 | 1.884738903 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 2000 | 68.5 | 35 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 2100 | 60.3 | 53 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 2200 | 55.9 | 63 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 2300 | 53.7 | 70 | 0 |
| 6 | Davis | Sacramento Valley | 4/16/2021 | 2400 | 52.3 | 73 | 0 |
| 6 | Davis | Sacramento Valley | 4/17/2021 | 100 | 50.7 | 77 | 0 |
| 6 | Davis | Sacramento Valley | 4/17/2021 | 200 | 49.2 | 78 | 0 |

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