WaterSense® Notice of Intent (NOI) to Develop a Draft Specification for Spray Sprinkler Nozzles

I. Introduction

A spray sprinkler nozzle is a component of a sprinkler used for landscape irrigation. It is provided in combination with a sprinkler body to distribute water to the landscape. In 2014, the U.S. Environmental Protection Agency's (EPA's) WaterSense program released its *Notice of Intent (NOI) to Develop a Draft Specification for Landscape Irrigation Sprinklers*, which considered specification development for both spray sprinkler bodies and nozzles. However, based on feedback received on the NOI indicating a lack of real-world water savings data and concerns about nozzle performance criteria, EPA only moved forward with specification development for spray sprinkler bodies. The WaterSense spray sprinkler body specification was released in September 2017.[1] WaterSense currently labels three irrigation products (weather-based and soil moisture-based irrigation controllers and spray sprinkler bodies) that are more water-efficient and perform as well as or better than standard models.

With this NOI, WaterSense is reconsidering specification development for spray sprinkler nozzles. More recent water savings studies have indicated that certain types of spray sprinkler nozzles can result in reduced water use, renewing WaterSense's interest in this product category as a potential candidate for the WaterSense label. WaterSense estimates that these more efficient spray sprinkler nozzles could use approximately 10 percent less water than standard spray sprinkler nozzles. This is a conservative weighted average based on data from the savings studies discussed in Appendix A. Assuming 10 percent savings, the average household could save approximately 2,400 gallons of water annually by replacing standard spray nozzles with high-efficiency spray sprinkler nozzles. On a national scale, WaterSense estimates that nearly 26 million irrigation systems could be retrofitted with spray sprinkler nozzles,[2] which corresponds to an estimated 90 percent of irrigation systems.[3] Offering a label for spray sprinkler nozzles could be an effective way for WaterSense to further reduce water use in residential irrigation systems.

Recent research has also identified notable stakeholder interest in a potential WaterSense label for spray sprinkler nozzles, particularly among water utilities. Many water utilities offer rebate programs for this product and are interested in more easily identifying spray sprinkler nozzle models that save water compared to standard nozzles. Therefore, a WaterSense label would

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[1] EPA. 2017. *WaterSense Specification for Spray Sprinkler Bodies, Version 1.0*. www.epa.gov/sites/default/files/2017-09/documents/ws-products-spec-ssb.pdf.

[2] Schein, Letschert, Chan, Chen, Dunham, Fuchs, McNeil, Melody, Stratton, and Williams, 2017. *Methodology for the National Water Savings and Spreadsheet: Indoor Residential and Commercial/Institutional Products, and Outdoor Residential Products.* Lawrence Berkeley National Laboratory. Schein *et al.* describes the detailed technical approach to WaterSense's stock accounting practice for irrigation products using values available as of the publication date. As it is EPA's practice to continuously update its work as data become available, the values referenced here are for the 2018 analysis, the most recent year available.

[3] Dukes, Michael. 2021. Personal communication.

allow more consistency across rebate programs and confidence that models selected for rebates will result in water savings. Manufacturers have also expressed support for a WaterSense label for this product category, since many currently market some models of spray sprinkler nozzle as water-efficient and manufacture other WaterSense labeled irrigation products.

There are no current federal requirements that regulate water use or performance of spray sprinkler nozzles. However, as summarized in Section II Technical Background below, WaterSense is aware of three industry standards that apply to this product category. WaterSense is considering how these standards may inform potential water efficiency and performance criteria.

This NOI to develop a draft specification for spray sprinkler nozzles is intended to share new research on the efficiency and performance of these products, as well as the details of updated water savings studies published since WaterSense's initial NOI from 2014. It also provides consolidated information on the state of spray sprinkler nozzle technology. With this NOI, WaterSense identifies preliminary criteria it is considering related to water efficiency and performance. Finally, this NOI solicits feedback on key data gaps, which are identified throughout the document. WaterSense requests that stakeholders share information that might inform a decision about whether and how to develop a specification for this product category.

II. Technical Background

WaterSense has identified three industry standards that are relevant to this product category and that will help inform the scope and water efficiency and performance criteria.

- The American Society of Agricultural Biological Engineers (ASABE)/International Code Council (ICC) 802-2020 *Landscape Irrigation Sprinkler and Emitter Standard* includes requirements for spray sprinkler nozzles.
- ASAE/ASABE S398.1 *Procedure for Sprinkler Testing and Performance Reporting* includes multiple test methods that could apply to a potential WaterSense specification.
- International Organization for Standardization (ISO) Standard 15886-2:2021 *Agriculture irrigation equipment – Sprinklers* is another standard that could inform the test method for a specification.

WaterSense primarily references definitions and test methods from ASABE/ICC 802-2020 in this NOI. ASABE/ICC 802-2020 is the most widely accepted industry standard for this product category and was the basis of the *WaterSense Specification for Spray Sprinkler Bodies*. ASABE/ICC 802-2020 references ASAE/ASABE S398.1.

According to ASABE/ICC 802-2020, a sprinkler is defined as:[4]

- **Sprinkler:** An emission device consisting of a sprinkler body with one or more orifices to convert irrigation water pressure to high-velocity water discharge through the air, discharging a minimum of 0.5 gallons per minute (gpm) at the largest area of coverage

[4] ICC. 2020. ASABE/ICC 802-2020 *Landscape Irrigation Sprinkler and Emitter Standard*. https://codes.iccsafe.org/content/ICC8022020P1/chapter-2-definitions.

available for the nozzle series when operated at 30 pounds per square inch (psi) or more with a full-circle pattern.

In other words, a "sprinkler" is the combination of a sprinkler body and nozzle, as shown in Figure 1. As discussed below, there are different types of sprinkler bodies.

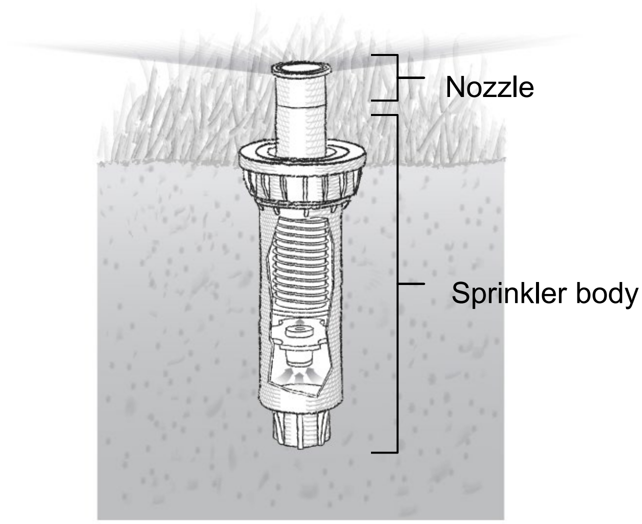

Figure 1. A diagram showing a spray sprinkler, consisting of a sprinkler body and a nozzle. (Image courtesy of Irrigation Association, Smart Water Application Technologies)

ASABE/ICC 802-2020 defines the two components as follows:[5]

- **Sprinkler body:** The exterior case or shell of a sprinkler incorporating a means of connection to the piping system, designed to convey water to a nozzle or orifice.
- **Nozzle:** The discharge opening of a sprinkler used to control the volume of discharge, distribution pattern and droplet size.

ASABE/ICC 802-2020 further defines three types of sprinkler bodies (described here for context):[6]

- **Spray sprinkler body:** A sprinkler body that does not contain components to drive the rotation of the nozzle or orifice during operation and lacks an integral control valve.
- **Rotor sprinkler body:** A sprinkler body that contains components to drive the rotation of the nozzle or orifice during operation and lacks an integral control valve.
- **Valve-in-head sprinkler body:** A sprinkler body that contains an integral control valve.[7]

Of these, spray sprinkler bodies are currently eligible for the WaterSense label in accordance with the *WaterSense Specification for Spray Sprinkler Bodies*.

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[5] *Ibid.*
[6] Another category is impact sprinklers, which are not mentioned in ASABE/ICC 802-2020. They are a small part of the industry but are still commercially available.
[7] ICC. 2020. *Op. cit.*

There is no explicit definition for spray sprinkler nozzles within ASABE/ICC 802-2020, so for the purpose of this NOI, WaterSense developed the following definition based on related definitions included in the standard:

- **Spray sprinkler nozzle:** The discharge opening of a spray sprinkler used to control the volume of discharge, distribution pattern, and droplet size. These nozzles are attached to spray sprinkler bodies that do not contain components to drive the rotation of the nozzle during operation and lack an internal control valve.

Though the general product category of spray sprinkler nozzles is not defined, the ASABE/ICC 802-2020 standard defines one specific type of spray sprinkler nozzle:

- **Multi-stream, multi-trajectory (MSMT) nozzles:** Nozzles designed to distribute discharge water in a number of individual streams, of varying trajectories, which rotate across the distribution area.[8]

MSMT sprinkler nozzles are only available as rotating models. The rotation is driven by the nozzle, not the spray sprinkler body.[9]

Figure 2 and Figure 3 illustrate the difference in spray patterns from standard (i.e., non-MSMT) and MSMT spray sprinkler nozzles, respectively. The distinct spray pattern of MSMT nozzles is the most apparent difference between the two types of nozzles.

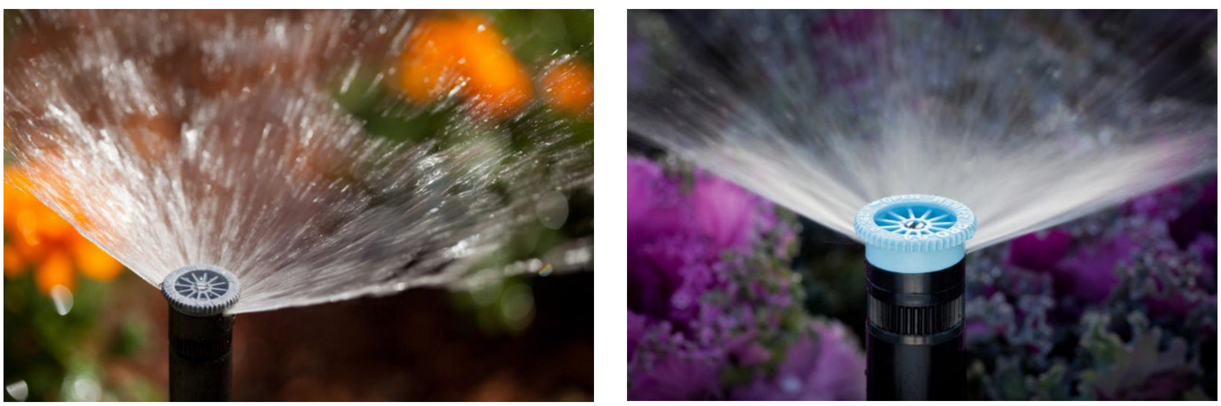

Figure 2. Examples of fan spray pattern from standard sprinkler nozzles (Photos courtesy of Hunter® Industries Incorporated.)[10]

[8] *Ibid.*

[9] Baum-Haley, Melissa. 2014. Evaluation of Potential Best Management Practices–Rotating Nozzles. The California Urban Water Conservation Council. Sacramento, CA.

[10] Hunter Industries, Incorporated. 2021. *Photo Library*. Accessed 05 November 2021. https://www.hunterindustries.com/en-metric/photos.

Figure 3. Example of multi-stream pattern from MSMT sprinkler nozzles (Photos courtesy of Hunter Industries Incorporated.)[11]

Most commonly, spray sprinkler nozzles and bodies are sold separately, though in retail settings, the two products can be sold together. MSMT nozzles are typically compatible with spray sprinkler bodies manufactured by a different brand.

WaterSense would like stakeholder input on its product category definition of "spray sprinkler nozzle."

III. Scope

WaterSense intends to define the scope of a potential specification to include nozzles intended for use in spray sprinklers. Therefore, the product category only applies to sprinkler nozzles that connect to spray sprinkler bodies, which do not have components that drive rotation.[12] Figure 4 shows the relationship among spray sprinkler nozzles, other components of a spray sprinkler, and other types of sprinklers.

[11] *Ibid.*
[12] Based on the definitions included in ASABE/ICC 802-2020.

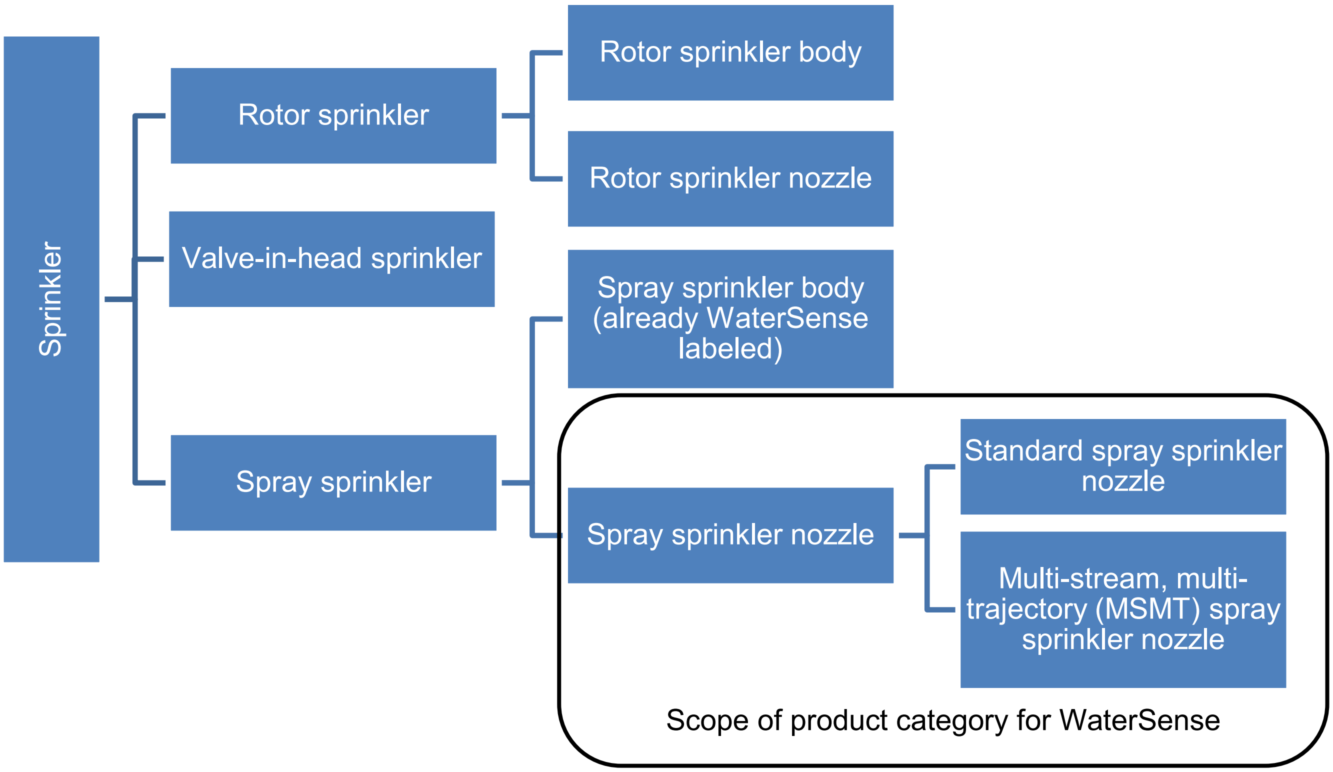

Figure 4. Flow chart illustrating the types of irrigation sprinklers and their components.[13]

Gear-driven rotor sprinkler bodies ("rotor sprinklers" in Figure 4) have components that drive the rotation of the nozzle or orifice during operation; spray sprinkler bodies do not have these components. WaterSense is not aware of any versions of MSMT nozzles for rotor sprinklers. Valve-in-head sprinklers have an integral control valve intended to be operated from a remote location. Rotor and valve-in-head sprinklers are physically different products from spray sprinklers, and the standards and savings studies discussed in this NOI do not apply to them.

WaterSense does not intend for this product category to include sprinkler nozzles that are used exclusively in agricultural irrigation systems, which are fundamentally different products with different testing requirements. WaterSense also intends to exclude other irrigation emission devices, such as bubblers, hose-end water products, and microirrigation emission devices (i.e., those that discharge water in the form of drops or continuous flow rates at less than 30 gallons of water per hour when operated at 30 psi) from a specification.[14] The exclusion of microirrigation devices effectively excludes drip emitters, drip line emitters, and point-source

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[13] Note that a "sprinkler" is defined as the combination of sprinkler body and nozzle. Spray sprinkler nozzles are the intended scope for a specification, as shown above.

[14] ICC. 2020. *Op. cit.*

emitters, as well as micro sprays. These products have a different structure, purpose, and test method compared to spray sprinkler nozzles.

WaterSense would like stakeholder feedback on the intended scope of the specification.

IV. Water Efficiency and Performance

As described in Section VII Estimated Water Savings, WaterSense has estimated that some types of spray sprinkler nozzles use approximately 10 percent less water than standard spray sprinkler nozzles. WaterSense has found that spray sprinkler nozzles marketed as "high-efficiency" are MSMT nozzles that emit multiple streams of water at multiple trajectories. Based on WaterSense's research, water utilities with rebate programs for spray sprinkler nozzles often require MSMT nozzles. Furthermore, although the authors used a variety of terms for the product, MSMT nozzles were considered a more water-efficient option in the water savings studies documented in Appendix A.

It is possible that manufacturers could develop other types of high-efficiency spray sprinkler nozzles in the future. To be inclusive of future developments in the market, WaterSense uses the phrase "high-efficiency spray (HES) sprinkler nozzle" (which includes MSMT nozzles) in this NOI to differentiate the products that WaterSense is considering labeling.

Based on its research, WaterSense identified four attributes that appear to be different between HES and standard spray sprinkler nozzles. These attributes are:

- Application rate,
- Distribution uniformity,
- Distance of throw, and
- Droplet size and spray pattern.

This section describes each attribute and evaluates whether it could be used as either a water efficiency or performance criterion in a WaterSense specification to help differentiate HES models. Some of these attributes have test methods and associated data. If so, WaterSense reviewed the requirements in the available standards and identified material that is relevant to the water efficiency and performance of spray sprinkler nozzles. This section discusses available test methods[15] and associated performance data for each attribute, if available, and considers whether any additional requirements for these products should be included in a specification.

At the end of this section, Table 1 provides details on attributes of MSMT sprinkler nozzles for a variety of product models. Table 2 provides a summary of these attributes based on a review of manufacturer literature for products currently on the market.

[15] Although WaterSense references test methods from ASABE/ICC 802-2020 throughout Section IV Water Efficiency and Performance, WaterSense has not determined whether the test methods have been validated.

Application Rate

The application rate, also known as precipitation rate, is the rate at which a sprinkler applies water to a given area. As explained in ASABE/ICC 802-2020, application rate relates to the flow rate and total irrigated area, as follows:

Equation 1.[16]

$$Application\ rate\ (inches\ per\ hour) = \frac{96.25\ x\ flow\ rate\ (gpm)}{total\ area\ (ft^2)}$$

Where:

- 96.25 is a constant used to convert gallons per minute (gpm) over an area in square feet to inches per hour;
- Flow rate is the cumulative flow rate from all sprinklers in the area, as measured in gpm; and
- Total area is the irrigated area in square feet.

Application rate is typically expressed in inches per hour. It is directly correlated with the flow rate from the sprinkler and indirectly correlated with irrigated area. Sprinkler nozzles with higher application rates apply more water to an area in the landscape in a given amount of time. HES sprinkler nozzles generally have lower application rates than standard sprinkler nozzles. As shown in Table 2, most MSMT sprinkler nozzles have application rates equal to or less than 1.0 inch per hour, whereas standard sprinkler nozzles have application rates greater than 1.0 inch per hour. Nozzles with lower application rates are considered more efficient, as they allow more water to percolate into the soil rather than flow offsite as runoff.[17]

Sprinkler nozzles can be designed to apply water at the same application rate at all arcs (degrees of coverage) and radii (distance of throw), meaning that the application rate will be equivalent across the irrigated area. This feature is known as "matched precipitation." In uniform landscapes such as turfgrass, matched precipitation nozzles help ensure that all areas of the landscape receive approximately the same amount of water during an irrigation event.

Manufacturers advertise application rate (typically listed as "precipitation rate") and the availability of matched precipitation for spray sprinkler nozzles. As shown in Table 2, most MSMT sprinkler nozzles and some standard spray sprinkler nozzles offer matched precipitation.

Pressure regulation can also can directly and independently affect application rate. Pressure regulating spray sprinkler bodies create a constant flow rate to the sprinkler nozzle regardless of supply pressure. Without pressure regulation, spray sprinkler bodies may apply water at higher rates than the sprinkler nozzle's specified application rate.

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[16] Kitsap Public Utility District. 2018. *Determine Your Sprinkler System's Precipitation Rate.* Accessed 14 February 2022. [www.kpud.org/sprinklerRates.php.](www.kpud.org/sprinklerRates.php)

[17] Baum-Haley. 2014. *Op. cit.*

Spray sprinkler nozzles are not necessarily pressure-regulating by design. However, as described in Section V Existing Performance Data, preliminary research results suggest that HES sprinkler nozzles provide a similar effect as pressure regulation, though likely not to the same extent as pressure-regulating sprinkler bodies.

Test Methods and Associated Data

There are two published evaluation methods for application rate. ASABE/ICC 802-2020 provides a method to calculate the theoretical (i.e., gross) application rate as a function of pressure by dividing the average flow rate at a given pressure by the average pattern collection area for a given pressure.[18] The Irrigation Association's Smart Water Application Technologies (SWAT) program published a draft protocol for spray sprinkler nozzles in 2014. The draft protocol calculates gross precipitation rate by dividing flow rate by irrigated area and calculates net precipitation rate based on water measured in catchment devices.[19]

WaterSense is not aware of a test method for evaluating matched precipitation or pressure regulation provided by spray sprinkler nozzles.

As discussed in Section V Existing Performance Data, Dr. Michael Dukes of the University of Florida conducted research to evaluate whether spray sprinkler nozzles could be differentiated based on flow rate. Dr. Dukes developed a test method that aligns with ASABE/ICC 802-2020. His results indicate that flow rate is substantially lower in HES sprinkler nozzles compared to their standard counterparts. Based on these findings, ASABE/ICC 802-2020 could be used to differentiate spray sprinkler nozzles. The application rate can be calculated from flow rate by measuring irrigated area and using Equation 3-1 in ASABE/ICC 802-2020, which aligns with Equation 1 above.

Application Rate as Water Efficiency or Performance Criteria

WaterSense is considering using application rate as a water efficiency criterion to identify HES sprinkler nozzles. For a spray sprinkler nozzle to earn the WaterSense label, WaterSense would propose two thresholds for application rates: one at the manufacturer's recommended operating pressure and one at high pressure. WaterSense would set the thresholds based on Dr. Dukes' data and reference the test method in ASABE/ICC 802-2020.

For the purposes of this NOI, WaterSense is proposing that each radius in a model's product family be tested (for example, 12- and 15-feet radii versions of a model) at the full circle pattern only. If the nozzle has an adjustable radius, WaterSense is considering requiring it to be tested at the maximum radius.

WaterSense is seeking stakeholder feedback on its proposal to use application rate (at recommended operating pressure and high pressure) as a water efficiency criterion for spray sprinkler nozzles. WaterSense is also interested in whether any manufacturers

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[18] ICC. 2020. *Op. cit.*
[19] IA. October 2014. *Spray Head Sprinkler Nozzles Performance Characteristics: Equipment Functionality Testing Protocol, Version 3.1*. www.irrigation.org/SWAT/About/Testing-Protocols/Archives/SWAT/About/Archives.aspx?hkey=a46d9517-4345-4e01-89cb-5e0135da535e#SprayHeadSprinklerNozzles.

currently use the ASABE/ICC 802-2020 test method for application rate and, if so, would be willing to share masked data with WaterSense.

Additionally, WaterSense requests stakeholder opinions on using the following parameters to evaluate spray sprinkler nozzles:

- **Test each radius in a model's product family at the full circle pattern only; and**
- **Test models with an adjustable radius at the maximum radius.**

Although spray sprinkler nozzles are not necessarily pressure-regulating by design, Dr. Dukes' results provide some evidence that MSMT nozzles may provide a similar effect as pressure regulation. (See Section V Existing Performance Data for more details.) As a result, WaterSense would not need to include a separate test method for pressure regulation but would incorporate it into the evaluation of application rate.

To evaluate matched precipitation, WaterSense is proposing that licensed certifying bodies evaluate application rates across an entire family of models. WaterSense is not aware of an industry standard variance in application rates that constitutes matched precipitation for spray sprinkler nozzles. WaterSense would need to identify an acceptable variance for the purposes of the specification.

WaterSense seeks input on whether it should require spray sprinkler nozzles to have matched precipitation to be eligible for the WaterSense label. What would be an acceptable variance in application rates to ensure matched precipitation? If WaterSense requires matched precipitation, how should EPA verify the data?

Distance of Throw

Distance of throw refers to the distance to which the sprinkler nozzle disperses water onto the surrounding landscape. It is typically presented as a radius. Distance of throw can be used to calculate total irrigated area, which is used to calculate application rate (see Equation 1).

The distance of throw is used to determine the appropriate spacing between sprinklers. It primarily relates to water efficiency because of its influence on irrigation system design in a new landscape.

HES sprinkler nozzles tend to have larger distances of throw than standard sprinkler nozzles (as shown in Table 2). It is possible that a longer distance of throw would allow irrigation contractors to increase the size of an irrigation zone and use fewer sprinklers compared to a system with standard spray nozzles, thus reducing the number of sprinklers in a new system. The landscape should use less water overall, because the cumulative application rate from all sprinklers is lower. Using fewer sprinklers could also substantially decrease the cost of a new irrigation system. A study by John Wascher estimated that contractors could save up to 45 percent on their bids for materials alone (e.g., sprinklers, valves, piping) when designing a landscape for

MSMT nozzles as compared to standard sprinkler nozzles.[20] Figure 5, adapted from Wascher's report, illustrates the difference between irrigation system layouts for standard and MSMT sprinkler nozzles. The diagram shows layouts with 55 standard sprinkler nozzles (left) and 34 MSMT nozzles (right).

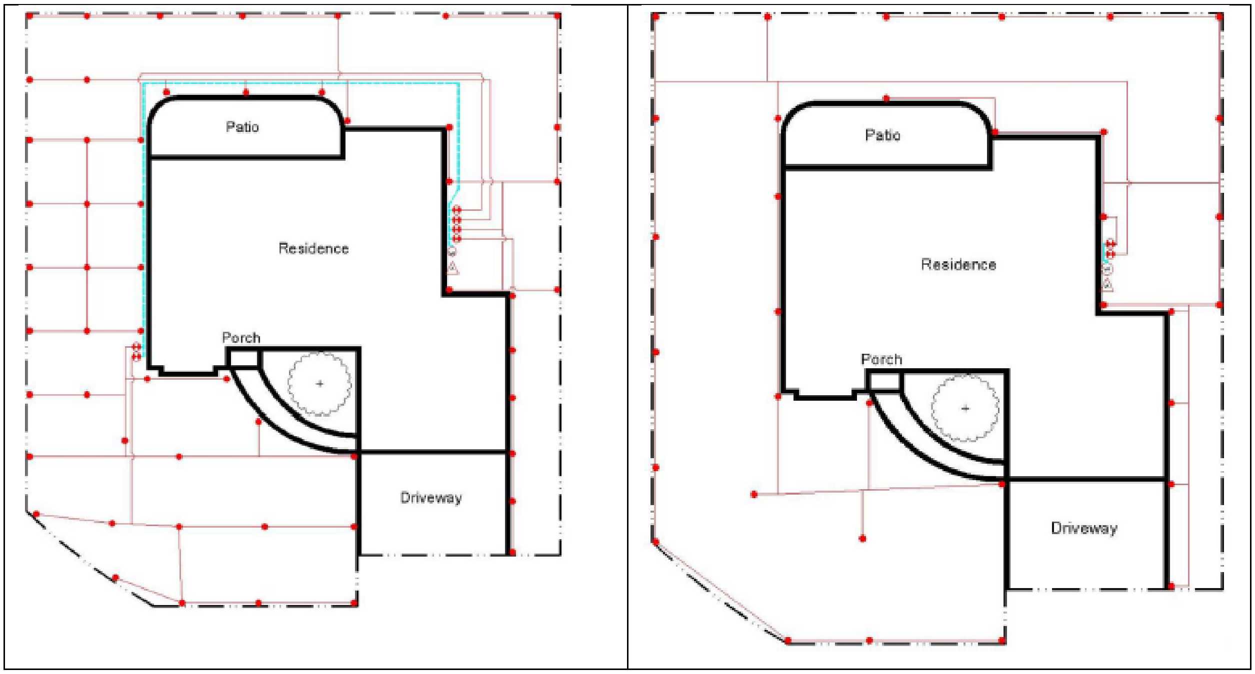

Figure 5. Comparison of irrigation layout with standard sprinkler nozzles (left) and MSMT sprinkler nozzles (right). Figure adapted from a 2011 publication by John Wascher.[21]

When standard sprinkler nozzles are replaced by HES sprinkler nozzles in an existing landscape (i.e., a retrofit), the number of sprinklers typically remains consistent because contractors are unlikely to redesign the irrigation system. As a result, any water savings in the landscape will not be attributable to fewer sprinklers and, indirectly, distance of throw. Instead, contractors will simply replace standard sprinkler nozzles with HES sprinkler nozzles, then adjust them to ensure head-to-head coverage. In some instances, irrigation contractors may cap sprinkler bodies if it is determined they are no longer needed.

WaterSense is interested in feedback from irrigation contractors about whether they are likely to incorporate HES sprinkler nozzles in bids for new irrigation systems, any factors that might influence their decision (i.e., new installation vs. retrofit), and whether HES sprinklers reduce the cost of materials in practice.

[20] Wascher, John. 2011. Multi-Stream, Multi-Trajectory Nozzles; How They Save Water, Labor and Installation Costs. Irrigation Association Technical Papers. www.irrigation.org/IA/FileUploads/IA/Resources/TechnicalPapers/2011/Multi-StreamMulti-TrajectoryNozzles(MSMT)AndHowTheySaveWaterLaborAndInstallationCosts.pdf.

[21] Images from Wascher, John. *Op. cit.*

Test Methods and Associated Data

ASABE/ICC 802-2020 includes a test method to calculate distance of throw. Testing is conducted at the minimum, recommended, and maximum operating pressures, as indicated by the manufacturer. Sprinkler nozzles are tested with a specified type of grid depending on their spray pattern (i.e., regular and symmetrical, or circular).[22] ASABE/ICC 802-2020 references ASAE/ASABE S398.1.[23]

WaterSense is not aware of any distance of throw data generated from the test methods in standards or other research studies. However, manufacturers typically advertise distance of throw for different nozzle models. They may be using ASAE/ASABE S398.1 to measure distance of throw. WaterSense intends to engage with certifying bodies and manufacturers to determine whether the advertised distance of throw is based on data generated as part of testing in accordance with ASAE/ASABE S398.1.

Distance of Throw as Water Efficiency or Performance Criteria

WaterSense is considering requiring distance of throw as part of its water efficiency criterion, since it is used to calculate application rate in ASABE/ICC 802-2020. Measuring distance of throw would also help ensure product performance.

WaterSense is considering requiring that the measured distance of throw be at least equal to, and no more than a specified percent above, the manufacturer's rated distance of throw. These thresholds would ensure that a manufacturer's rated value for distance of throw is accurate (i.e., that the published distance of throw is met without excessive overspray).

WaterSense seeks stakeholder feedback on whether ASAE/ASABE S398.1 is an appropriate test method for distance of throw.

Do stakeholders believe it is reasonable for WaterSense to require the tested distance of throw to align with the value reported by the manufacturer? WaterSense is also interested in stakeholder input on the appropriate percent exceedance (e.g., percentage greater than the rated distance of throw) to prevent water waste due to overspray.

Distribution Uniformity

Distribution uniformity (DU) is a measure of how evenly water is applied to a landscaped area. DU can be considered at the scale of the landscape (i.e., water applied by all sprinkler nozzles) or the sprinkler nozzle (i.e., water applied to the irrigated area of the individual sprinkler). In theory, landscapes with lower DU are expected to use more water, as the irrigation system would be programmed to water to the driest part of the landscape, resulting in overwatering in other areas. Standard sprinkler nozzles are more likely to irrigate unevenly compared to MSMT sprinkler nozzles, based on data from field studies. DU may also be influenced by the uniformity of individual sprinkler nozzles (e.g., if each stream is emitted at a different angle, it will not interfere with adjacent streams[24]); wind conditions; and the design, installation, and

[22] ICC. 2020. *Op. cit.*

[23] ASABE. 1985. *ASAE/ASABE S398.1 Procedure for Sprinkler Testing and Performance Reporting*. https://elibrary.asabe.org/abstract.asp?aid=41295&t=3&dabs=Y&redir=&redirType=.

[24] Wascher, John. *Op. cit.*

maintenance of the irrigation system. As shown in Table 2, researchers have measured DUs in the range of 34 to 78 percent for standard spray sprinkler nozzles and 58 to 81 percent for MSMT sprinkler nozzles.

Despite expectations, field studies have not demonstrated that higher system DU results in increased water savings. See *Application as Water Efficiency or Performance Criteria* below for more information.

Test Methods and Associated Data

ASABE/ICC 802-2020 includes a uniformity test for spray sprinkler nozzles conducted on individual nozzles. Uniformity is modeled using data collected during the distance of throw test. The standard indicates that the modeled uniformity will generate a value equivalent to the lower quarter DU (DU_{LQ}) (Equation 2). DU_{LQ} is a "ratio of the average of the lowest one-fourth of measurements of irrigation water to the average of all measurements captured by collection devices."[25] A certification body models DU_{LQ} using the lowest and highest application rates as bounds.

Equation 2.[26]

$$DU_{LQ} = \frac{V_{LQ}}{V_{avg}}$$

Where:

- V_{LQ} is the volume of the average of lowest quarter of samples from the array of collectors used as part of the test method for determination of application rate, and
- V_{avg} is the average recorded volume as acquired from collectors in consistent units.

WaterSense is not aware of any compiled dataset related to DU that has been generated in accordance with the ASABE/ICC 802-2020 test method. Some manufacturers advertise DU for different nozzle models, but WaterSense is not aware of the test method used to calculate it.

Distribution Uniformity as Water Efficiency or Performance Criteria

Early studies on water savings associated with MSMT sprinkler nozzles focused on DU as the likely mechanism for anticipated water savings. Researchers and utilities suggested that MSMT sprinkler nozzles might use less water and result in healthier landscapes because they distribute water more evenly. Since DU quantifies this metric, stakeholders suggested that DU might be an appropriate way to measure water efficiency, and some researchers attempted to quantify the range of DU that would result in water savings. Many of these studies included

[25] ICC. 2020. *Op. cit*

[26] *Ibid.*

irrigation audits conducted in a controlled environment, such as a field or concrete surface.[27, 28, 29, 30, 31, 32] While many of these studies reported higher DUs for MSMT sprinkler nozzles, the researchers did not observe the expected water savings.

At this point, WaterSense only has DU data from field studies reported in the literature. However, a potential specification would require licensed certifying bodies to use a laboratory-based test method to measure DU. Consequently, WaterSense would need to review DU data generated in accordance with laboratory testing to develop a threshold for DU in a potential specification. It is possible that WaterSense could obtain this data from manufacturers, who can calculate DU based on data generated from the laboratory-based test method for distance of throw.

WaterSense invites manufacturers to submit laboratory data on DU for HES and standard spray sprinkler nozzles. WaterSense also invites manufacturers to indicate whether they collect DU data in accordance with ASABE/ICC 802-2020 or through another method.

Based on laboratory data, WaterSense could take two approaches to establishing a threshold for DU. WaterSense could identify a threshold that indicates a minimum level of performance. Alternatively, WaterSense could identify a DU value that differentiates between HES and standard spray sprinkler nozzles, with the value of the former expected to be higher than the latter. In either case, WaterSense would likely require DU to be calculated based on the ASABE/ICC 802-2020 distance of throw test conducted to measure application rate for WaterSense certification.

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[27] Dukes, Michael D., Haley, Melissa, B., and Stephen A. Hanks. 2006. Sprinkler Irrigation and Soil Moisture Uniformity. Proceedings of the 27th Annual International Irrigation Show, San Antonio, TX., November 5-7, 2006. www.irrigation.org/IA/FileUploads/IA/Resources/TechnicalPapers/2006/SprinklerIrrigationAndSoilMoistureUniformity.pdf.

[28] Kieffer, Douglas L. and Mike Huck. 2008. A Comparison of Fairway Distribution Uniformity Computed with Catch Can Data and with Soil Moisture Data from Three Sampling Depths. Paper presented at the 29th Annual Irrigation Show. Anaheim, CA. November 2-4, 2008. www.specmeters.com/assets/1/7/Kieffer-Huck_Abstract2197.pdf.

[29] Vis, E, Kumar, R., and S. Mitra. 2007. Comparison of Distribution Uniformity of Soil Moisture and Sprinkler Irrigation in Turfgrass. Project funded by the California Landscape Contractors Association Environmental Research Funding Program.

[30] Mecham, Brent Q. 2002. Comparison of Catch Can Distribution Uniformity to Soil Moisture Distribution Uniformity in Turfgrass and the Impacts of Irrigation Scheduling. Northern Colorado Water Conservancy District. Loveland, CO. www.irrigation.org/IA/FileUploads/IA/Resources/TechnicalPapers/2002/ComparisonOfCatchCanDistributionUniformityToSoilMoistureDistributionUniformityInTurfgrassAndTheImpactsOnIrrigationScheduling.pdf.

[31] Kieffer, Douglas L. and T. Sean O'Conner. 2007. Managing Soil Moisture on Golf Greens Using a Portable Wave Reflectometer. Paper presented at the 28th Annual Irrigation Show. San Diego, CA. December 9-11, 2007. www.specmeters.com/assets/1/7/kieffer-OConnor_TDR300.pdf.

[32] Sovocool, K., Morgan, M., and M. Drinkwine. 2009. *Field Study of Uniformity Improvements from Multi-Stream Rotational Spray Heads and Associated Products*. Irrigation Association Technical Library. https://www.irrigation.org/IA/FileUploads/IA/Resources/TechnicalPapers/2009/FieldStudyOfUniformityImprovementsFromMulti-StreamRotationalSprayHeadsAndAssociatedProducts-PreliminaryResults.pdf.

WaterSense would like stakeholder input on whether DU should be used in a specification to establish a minimum level of performance or used to differentiate HES and standard spray sprinkler nozzles.

Finally, as discussed above, WaterSense is not aware of any studies or data connecting DU to water savings.

WaterSense invites stakeholders to submit data pertaining to the relationship between DU and water savings and/or performance (e.g., landscape health).

Droplet Size and Spray Pattern

As noted in Table 2, standard sprinkler nozzles produce fine droplets (resembling mist) that can be blown by the wind and diverted from their intended destination. MSMT sprinkler nozzles have a spray pattern that creates larger droplets and reduces misting.[33] The spray pattern allows MSMT sprinkler nozzles to distribute water more evenly across the landscape despite their lower flow rate. The larger droplet size could also prevent water from being applied to undesirable areas, such as hardscapes, potentially decreasing the total water applied for irrigation.

Test Methods and Associated Data

ISO Standard 15886-2:2021 *Agriculture irrigation equipment - Sprinklers* includes a drop size test in Annex A to Part 2. The stated purpose of the test is to “characterize the distribution of drop sizes discharged by the water jet of a sprinkler.” For this test, measurements are collected in multiple concentric rings within the sprinkler nozzle’s radius of throw at different pressures. These measurements are used to calculate the number of drops collected in groupings of diameter sizes.[34]

WaterSense is not aware of any data on drop size or spray pattern collected in accordance with ISO Standard 15886-2:2021 or published in any research study.

Droplet size or spray pattern as Water Efficiency or Performance Criteria

To date, WaterSense is not aware of any published research measuring droplet size or data demonstrating a correlation between droplet size and water savings. One study suggested that larger droplet size could result in greater resistance to wind.[35] It is possible that droplet size could influence irrigation schedules, especially in windy regions. Landscapes with standard spray sprinkler nozzles may have brown spots if the wind disperses the irrigation water. The irrigation scheduler may respond by increasing irrigation runtimes to address the brown spots. In contrast, MSMT sprinkler nozzles produce larger droplets that may be more resistant to wind, meaning that more of the water emitted is likely to travel to and be used by the plants for which it was intended, reducing the likelihood of brown spots.

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[33] Dukes, Michael. 2021. Personal communication.
[34] International Organization for Standardization (ISO). 2021. ISO 15886-2: 2021 *Agriculture irrigation equipment – Sprinklers.* www.iso.org/standard/77748.html.
[35] Baum-Haley, Melissa. 2014. *Op. cit.*

It may be possible to connect droplet size or spray pattern to performance, but WaterSense is not aware of any related data.

WaterSense invites stakeholders to share data on droplet size and water efficiency, especially collected in accordance with ISO Standard 15886-2:2021. WaterSense welcomes feedback on whether stakeholders think droplet size should be included as a criterion in a WaterSense specification.

Summary and Comparison of Nozzle Features

Table 1 lists the technical features of common MSMT nozzles currently on the market. As described earlier, MSMT nozzles are generally considered to be HES sprinkler nozzles.

Table 1. Product Details for Common MSMT Sprinkler Nozzles Used in Residential Landscapes

Brand	Model Name	Application Rate (inches per hour) for a Range of Radii	Matched Precipitation	Radius (feet)	Rotating?[a]	Multi-stream?	Recommended Operating Pressure (psi)
Hunter®	MP Rotator®	0.37 to 0.45	Yes	8 to 35	Yes	Yes	40
Hunter	MP Rotator MP800	0.79 to 0.84	Yes	6 to 16	Yes	Yes	40
Rain Bird®	R-VAN Rotary Nozzles	0.61 to 0.64	Yes	8 to 24	Yes	Yes	45
Rain Bird	RN High Efficiency Rotary Nozzles	0.61 to 0.65	Yes	13 to 24	Yes	Yes	45
Toro®	Precision™ Series Spray Nozzles[b]	1.0 to 1.1	Yes	5 to 15	No[c]	Yes	30
Toro	Precision™ Series Rotating Nozzles	0.55 to 0.67[d]	Yes	14 to 26	Yes	Yes	45
K-Rain®	Rotary Nozzles	0.42 to 0.49[e]	Yes	13 to 30	Yes	Yes	Not specified. Can operate at 30-50 psi.

Table 1. Product Details for Common MSMT Sprinkler Nozzles Used in Residential Landscapes

Brand	Model Name	Application Rate (inches per hour) for a Range of Radii	Matched Precipitation	Radius (feet)	Rotating?[a]	Multi-stream?	Recommended Operating Pressure (psi)
K-Rain	Fully Adjustable Rotary Nozzles	0.42 to 0.51[e]	Yes	13 to 28	Yes	Yes	Not specified. Can operate at 30-50 psi.

[a] This references a spray sprinkler nozzle that rotates.

[b] Toro Precision Series Spray Nozzles are available in pressure-compensating and non-pressure-compensating models. This table presents data for non-pressure-compensating models.

[c] This sprinkler nozzle creates an oscillating flow, rather than a rotating flow. According to Toro, there is a device inside the nozzle that "creates one or more high-frequency oscillating streams." In person, the Precision Series Spray Nozzles appear to have a more stream-like pattern than a standard sprinkler nozzle.

[d] Toro does not report application rates at the recommended operating pressure of 45 psi for the Precision Series Rotating Nozzles. This table shows application rates at 40 psi.

[e] K-Rain does not specify a recommended operating pressure for this nozzle. The table shows application rates at 40 psi.

Table 2 compares the attributes discussed in Section IV Water Efficiency and Performance. It compares the ranges of the attribute for MSMT and standard spray nozzles and includes potential effects on water use. Again, the term "MSMT sprinkler nozzle" is used to reflect the products currently available on the market.

Table 2. Sprinkler Nozzle Features and Potential Effect on Water Use

Feature of Nozzles	MSMT Sprinkler Nozzles	Standard Sprinkler Nozzles	Factors Affecting Water Use	Expected Effect on Water Use
Application rate	0.39 to 1.1 inches per hour[a]	1.25 to 4.81 inches per hour[a]	Irrigation schedule runs longer for lower precipitation rate	Potential decrease in water use, dependent on length of runtimes.
Matched precipitation	All identified MSMT products have matched precipitation[b]	Available for some standard sprinkler nozzles[b]	N/A	Potential decrease in water use
Distance of throw (radii)	5 to 30 feet[b]	4 to 18 feet[b]	May influence irrigation design in new systems	May decrease, but no known research

Table 2. Sprinkler Nozzle Features and Potential Effect on Water Use

Feature of Nozzles	MSMT Sprinkler Nozzles	Standard Sprinkler Nozzles	Factors Affecting Water Use	Expected Effect on Water Use
DU	58 to 81 percent; weighted average of 69 percent[c]	34 to 78 percent; weighted average of 47 percent[c]	Irrigation system design and sprinkler placement	None demonstrated in field studies
Droplet size	Larger droplets at high pressure	Smaller droplets/mist at high pressure	May result in less wind drift potential, but no known research	May decrease, but no known research

[a] Minimum and maximum application rates were selected for square spacing at full coverage and manufacturer's recommended pressure across all brands, based on a review of sprinkler nozzles manufactured by Hunter, Rain Bird, Toro, and K-Rain. Radii may differ.

[b] Based on review of sprinkler nozzles manufactured by Hunter, Rain Bird, Toro, and K-Rain.

[c] As identified from literature review of Kumar and Vis 2009; Hattendorf & Crookston 2011; Wascher 2011; Solomon *et al.*, 2007; and Sovocool *et al.*, 2009.

Possible Additional Criteria From Existing Standards

The *WaterSense Specification for Spray Sprinkler Bodies* includes additional criteria from ASABE/ICC 802-2020 that help ensure WaterSense labeled products are of high quality, in addition to being high performing.[36] WaterSense could consider including similar requirements in a specification for HES sprinkler nozzles. WaterSense is considering incorporating the following sections in ASABE/ICC 802-2020 by reference. These sections establish requirements for sprinkler design and product marking.

- 302.1. Rated temperature
- 302.2. Inlet connections
- 302.4. Servicing
- 302.5. Adjustments
- 302.6. Burst pressure
- 304.1.1. Units
- 304.1.2. Location
- 304.1.3 Manufacturer name
- 304.1.4. Connectors
- 304.1.5. Nozzle series marking
- 304.1.6. Instructions
- 304.2. Marking of sprays and rotors (as applicable)

[36] ICC. 2020. *Op. cit.*

WaterSense welcomes stakeholder feedback on whether to require these sections of ASABE/ICC 802-2020 in a potential specification.

V. Existing Performance Data

As discussed previously, Dr. Dukes is conducting research on the water efficiency of spray sprinkler nozzles, which will help inform criteria if WaterSense decides to move forward with a specification. Dr. Dukes developed a test method based on ASABE/ICC 802-2020 to measure the flow rate of standard and HES sprinkler nozzles through a non-pressure-regulating sprinkler body, as well as variations in flow rate across a range of water pressures. As explained in Section IV Water Efficiency and Performance, flow rate can be converted to application rate using the methodology in ASABE/ICC 802-2020.

Dr. Dukes is currently analyzing additional data. WaterSense will incorporate his data if the program proceeds with a draft specification.

Figure 6 shows preliminary results from Dr. Dukes' research for a single test comparing flow rate for HES and standard sprinkler nozzles across a range of pressures.[37]

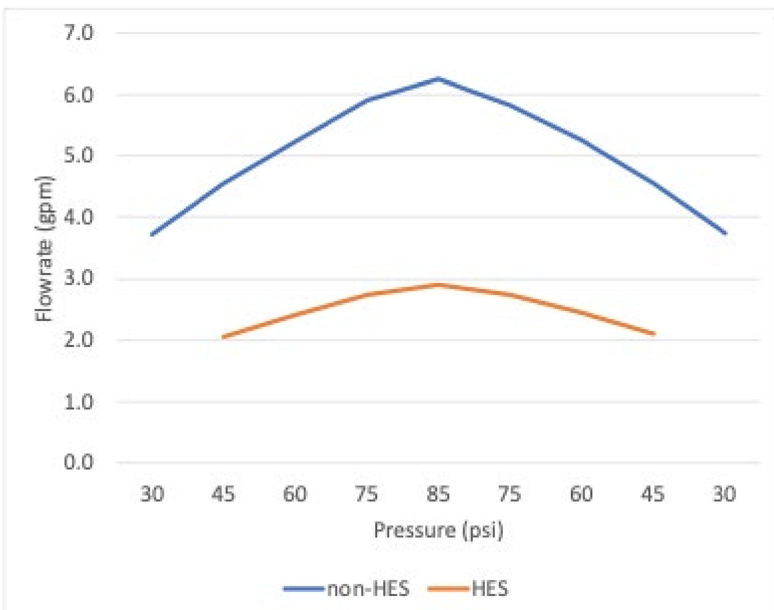

Figure 6. Preliminary results from a 15-foot full-circle single test comparison conducted as part of Dr. Michael Dukes' research on HES sprinkler nozzles and standard sprinkler nozzles (abbreviated as "non-HES").

As shown in Figure 6, the HES sprinkler nozzle had a 44 percent lower flow rate than the standard sprinkler nozzle at the recommended operating pressures (45 and 30 psi, respectively). The flow rate for HES sprinkler nozzles was consistent across the range of pressures, similar to the effect of pressure regulation. For example:

[37] Dukes, Michael. 2021. Personal communication.

- The maximum tested pressure (85 psi) represents conditions without pressure regulation in the sprinkler body (which could result in high pressure). At 85 psi, the HES sprinkler nozzle had a 54 percent lower flow rate than the standard sprinkler nozzle.

- The recommended operating pressure (45 psi) mimics conditions with pressure regulation.[38] The HES sprinkler nozzle had a 66 percent lower flow rate at 45 psi compared to the standard sprinkler nozzle at peak tested pressure (85 psi).

Figure 6 also shows that, for standard sprinkler nozzles, the flow rate was reduced by 40 percent from maximum tested pressure (85 psi) to its recommended operating pressure (30 psi). For HES sprinkler nozzles, the flow rate was reduced by 27 percent between maximum tested pressure (85 psi) and its recommended operating pressure (45 psi).[39] In other words, the percent difference in flow rate between maximum and recommended tested pressure was larger for standard spray sprinkler nozzles than HES sprinkler nozzles.

Overall, Figure 6 shows that HES sprinkler nozzles had a lower flow rate over a wide range of pressures compared to standard spray sprinkler nozzles.

It is important to note that the percentages reported above are not necessarily representative of potential water savings. However, if the irrigated area is the same, the HES sprinkler nozzle will apply less water than the standard sprinkler nozzle over the same length of time due to its lower flow rate. In reality, the area irrigated by a single HES sprinkler nozzle is typically larger than that of a standard sprinkler nozzle, making the potential savings even higher for retrofits.[40]

WaterSense invites stakeholders to share any additional performance data on HES sprinkler nozzles.

VI. Product Marking, Documentation, and Marketing

WaterSense is considering requiring labeled spray sprinkler nozzle marking and documentation to conform to all applicable sections of ASABE/ICC 802-2020, as listed below.

Section 304.1.5 of ASABE/ICC 802-2020, *Sprinkler and Bubbler Product Marking, General* indicates that nozzles shall be individually marked and shall have markings identifiable when the sprinkler is not in operation.

Section 304.1.2 of ASABE/ICC 802-2020, *Marking of Sprays and Rotors* indicates that manufacturers are required to make information in Section 304 of the standard available to the end user in a publicly available means. The following information from Section 304.2 of ASABE/ICC 802-2020, *Marking of Sprays and Rotors* applies to spray sprinkler nozzles and must be made publicly available:

- Flow rate at the minimum, recommended, and maximum operating pressure as measured in Section 303.5.3 of the standard, in units of gpm;

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38 *Ibid.*

39 *Ibid.*

40 *Ibid.*

- Distance of throw at the minimum, recommended, and maximum operating pressure as determined in Section 303.5.4 of the standard, in units of feet;
- Spray pattern and the range of adjustability, as applicable;
- Design trajectory angle in units of degrees;
- Application rate at the minimum, recommended, and maximum operating pressure as calculated in Section 303.6 of the standard, in units of inches per hour; and
- DU of the lower quarter results for each nozzle as defined in Section 303.6.2 of the standard, expressed as a range ± 0.05 of the calculated DU_{LQ}.

For instances where flow rate, distance of throw, and/or application rate vary depending on the nozzle selected, Section 304.2 allows manufacturers to provide a range or table.[41]

WaterSense proposes that certified products and/or their associated packaging or documentation display the recommended and maximum operating pressure.

WaterSense is considering requiring the product packaging of WaterSense labeled spray sprinkler nozzles to indicate whether the nozzle should be installed on a WaterSense labeled spray sprinkler body with integral pressure regulation.

WaterSense invites stakeholder feedback on these proposed product marking and documentation requirements.

VII. Estimated Water Savings

When WaterSense released the NOI for landscape irrigation sprinklers in 2014, it had not identified any studies demonstrating water savings associated with HES sprinkler nozzles. The only studies available (conducted by the Southern Nevada Water Authority [SNWA] and Eugene Water and Electric Board [in Oregon]) did not measure savings. Since 2014, researchers have published several studies demonstrating real-world water savings associated with HES sprinkler nozzles (see Appendix A for details on the studies).

Based on these studies, WaterSense estimates that HES sprinkler nozzles have the potential to use approximately 10 percent less water than standard spray sprinkler nozzles. This estimate is a weighted average based on the number of landscapes in the savings studies in Appendix A. The weighted average was heavily influenced by one study (conducted by the Metropolitan Water District of Southern California) that had the largest number of landscapes. Many other studies reported water savings close to, or exceeding, 20 percent. Although the weighted average savings estimate is lower than WaterSense labeled products' typical water savings percentage, WaterSense has developed specifications for other irrigation products with estimated water savings below 20 percent (e.g., weather-based irrigation controllers) that may still have national applicability and potential for significant water savings.

Assuming 10 percent savings, the average household could save approximately 2,400 gallons of water annually by replacing standard spray nozzles with HES sprinkler nozzles. WaterSense bases this figure on an average household outdoor water use of 50,500 gallons[42] and conservatively assumes that 50 percent of outdoor water use is attributable to spray irrigation.[43]

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[41] ICC. 2020. *Op. cit.*

[42] DeOreo, William B., Peter W. Mayer, B. Dzigielewski and J. Kiefer. 2016. *Residential End Uses of Water, Version 2*. Published by the Water Research Foundation. Table 6.32, Page 154.

[43] Mecham, Brent. 2016. Personal communication.

If the assumption is low, homes would likely experience greater savings from installing HES sprinkler nozzles as a retrofit.

WaterSense is interested in feedback from stakeholders on whether the estimated percentage of outdoor water used for spray irrigation is accurate, or whether spray irrigation typically accounts for more than 50 percent of outdoor water use in residential properties.

Based on WaterSense's current calculations, the average household could save approximately $32 annually per landscape by replacing standard spray nozzles with HES sprinkler nozzles. The payback period is 3 years and 5 months, which is comparable to the average product warranty period for MSMT sprinkler nozzles.[44] WaterSense uses product warranties as an indicator for product lifespan in its calculations of payback period. However, homeowners likely leave their spray sprinkler nozzles installed for much longer—typically until there is a problem—rather than replacing them every three to four years. As a result, sprinkler nozzles may prove to be more cost-effective in reality.

WaterSense is interested in stakeholder feedback on spray sprinkler nozzle replacement behaviors. For example, do stakeholders typically replace nozzles after a designated period of time, or do they wait until they need to fix malfunctioning spray sprinkler nozzles in the event of a problem? Specifically, are there data indicating how long spray sprinkler nozzles are installed in the field before being replaced, and/or how long spray sprinkler nozzles typically last in residential settings?

VIII. Communicating Savings

WaterSense has identified application rates as the primary mechanism leading to water savings with HES sprinkler nozzles. WaterSense suggests that application rate is a more appropriate attribute than flow rate for the purposes of a potential WaterSense label, since the former reflects the irrigated area, as well as the rate at which water is emitted from the sprinkler nozzle.

To understand the influence of application rate on water use by HES sprinkler nozzles, it is useful to compare flow rate between WaterSense labeled showerheads and standard showerhead models. WaterSense labeled showerheads have a lower flow rate than standard models, but still provide adequate performance. Individuals are likely to shower for approximately the same length of time regardless of the showerhead's flow rate, meaning that a lower flow rate results in less water use. Similarly, even though HES sprinkler nozzles provide a lower application rate to a landscape, homeowners are likely to maintain a similar irrigation schedule after retrofitting their sprinkler nozzles, leading to water savings from the lower flow rate. The lower flow rate also allows water to percolate into the soil, limiting runoff and water waste.

It will be important to consider proper consumer messaging for HES sprinkler nozzles. Researchers have speculated that water savings related to HES sprinkler nozzles may be largely influenced by human behavior. Since HES sprinkler nozzles apply water at a lower rate, irrigation systems should operate for longer periods of time (i.e., longer runtimes) to provide sufficient water to the landscape. Typical homeowners likely program their irrigation controllers

[44] EPA's market research found that the most common MSMT sprinkler nozzles on the market offer warranties between 2 and 5 years.

to provide more water than necessary for their landscapes, regardless of the type of spray sprinkler nozzle installed or its precipitation rate. Since HES sprinkler nozzles generally have lower flow rates than standard spray sprinkler nozzles, industry guidance recommends adjusting irrigation schedules to increase the runtime to accommodate the lower precipitation rate following a retrofit.

However, if a system is retrofitted with HES sprinkler nozzles and the schedule is not changed, HES sprinkler nozzles will apply less water to the landscape due to their lower flow rates. This may have occurred in many of the savings studies documented in Appendix A. If HES sprinkler nozzles are installed on a new landscape accompanied by a new schedule, or if a retrofit is implemented along with an alternative schedule that increases runtime, it is not currently known whether HES sprinkler nozzles will apply less water than if the landscape had standard sprinkler nozzles.

Although runtimes *should* be adjusted post-retrofit, some utilities and researchers suspect that homeowners or irrigation contractors may not adjust their irrigation schedules accordingly. Even if homeowners or contractors do adjust irrigation schedules for longer runtimes after installation, it is possible that runtimes are not extended enough to offset the lower application rate from the HES sprinkler nozzles, resulting in net water savings. One water utility WaterSense interviewed noted that customers did not feel comfortable running their sprinklers for more than 30 minutes due to extensive outreach about drought. The utility employee mentioned that these homeowners felt guilty about watering their lawns for extended periods of time and instead wanted to be seen as doing their part to respond to drought. If this is a widespread sentiment, homeowners may see significant water savings from installing HES sprinkler nozzles, because they will not be willing to irrigate for the longer time periods needed to supply the volume of water to their landscapes that was provided by sprinklers with standard sprinkler nozzles. Unfortunately, none of the savings studies discussed in Appendix A examined irrigation schedules before and after retrofits, so WaterSense cannot determine if water savings are due to lower flow rate alone, or if factors such as irrigation scheduling or other system adjustments impacted the results.

WaterSense is interested in stakeholder feedback on suspected reasoning behind potential water savings, including any information on whether stakeholders change irrigation schedules after a retrofit. WaterSense invites stakeholder opinions on irrigation runtimes, including preferences for duration of irrigation.

The influence of application rate on irrigation volume could also cause challenges with local policies. During a discussion with WaterSense, one water utility manager suggested that some regions might have watering windows (i.e., watering restrictions based on time of day). In those locations, there may not be enough time to adequately water larger landscapes with HES sprinkler nozzles. Some water utilities provide residents with a household water budget that can be met over multiple days, avoiding the problem of insufficient time for irrigation. However, it is possible that if municipalities enforce strict time windows for irrigation, residents with HES sprinkler nozzles may not be able to water as long as necessary, even if the resident is comfortable with a longer runtime.

WaterSense is interested in feedback from water utilities on promoting WaterSense labeled HES sprinkler nozzles. In particular, WaterSense is curious whether water utilities have concerns about whether consumers with HES sprinkler nozzles could meet their irrigation needs with watering windows in place.

IX. Summary of Information Requests

WaterSense welcomes stakeholder feedback on all aspects of this notice; summarized below are the specific outstanding issues and questions about which WaterSense is seeking input prior to drafting a specification for spray sprinkler nozzles. All interested parties are encouraged to submit information and comments to watersense-products@erg.com.

Section II Technical Background

- WaterSense would like stakeholder input on its product category definition of "spray sprinkler nozzle."

Section III Scope

- WaterSense would like stakeholder feedback on the intended scope of the specification.

Section IV Water Efficiency and Performance

- WaterSense is seeking stakeholder feedback on its proposal to use application rates (at recommended operating pressure and high pressure) as a water efficiency criterion for spray sprinkler nozzles. WaterSense is also interested in whether any manufacturers currently use the ASABE/ICC 802-2020 test method for application rate and, if so, would be willing to share masked data with WaterSense.
- Additionally, WaterSense requests stakeholder opinions on using the following parameters to evaluate spray sprinkler nozzles:
  - Test each radius in a model's product family at the full circle pattern only; and
  - Test models with an adjustable radius at the maximum radius.
- WaterSense seeks input on whether it should require spray sprinkler nozzles to have matched precipitation to be eligible for the WaterSense label. What would be an acceptable variance in application rates to ensure matched precipitation? If WaterSense requires matched precipitation, how should EPA verify the data?
- WaterSense is interested in feedback from irrigation contractors about whether they are likely to incorporate HES sprinkler nozzles in bids for new irrigation systems, any factors that might influence their decision (i.e., new installation vs. retrofit), and whether HES sprinklers reduce the cost of materials in practice.
- WaterSense seeks stakeholder feedback on whether ASAE/ASABE S398.1 is an appropriate test method for distance of throw.
- Do stakeholders believe it is reasonable for WaterSense to require the tested distance of throw to align with the value reported by the manufacturer? WaterSense is also interested in stakeholder input on the appropriate percent exceedance (e.g., percentage greater than the rated distance of throw) to prevent water waste due to overspray.
- WaterSense invites manufacturers to submit laboratory data on DU for HES and standard spray sprinkler nozzles. WaterSense also invites manufacturers to indicate whether they collect DU data in accordance with ASABE/ICC 802-2020 or through another method.

- WaterSense would like stakeholder input on whether DU should be used in a specification to establish a minimum level of performance or used to differentiate HES and standard spray sprinkler nozzles.
- WaterSense invites stakeholders to submit data pertaining to the relationship between DU and water savings and/or performance (e.g., landscape health).
- WaterSense invites stakeholders to share data on droplet size and water efficiency, especially collected in accordance with ISO Standard 15886-2:2021. WaterSense welcomes feedback on whether stakeholders think droplet size should be included as a criterion in a WaterSense specification.
- WaterSense welcomes stakeholder feedback on whether to require the listed sections of ASABE/ICC 802-2020 in a potential specification.

Section V Existing Performance Data

- WaterSense invites stakeholders to share any performance data on HES sprinkler nozzles.

Section VI Product Marking, Documentation, and Marketing

- WaterSense invites stakeholder feedback on the proposed product marking and documentation requirements.

Section VII Estimated Water Savings

- WaterSense is interested in feedback from stakeholders on whether the estimated percentage of outdoor water used for spray irrigation is accurate, or whether spray irrigation typically accounts for more than 50 percent of outdoor water use in residential properties.
- WaterSense is interested in stakeholder feedback on spray sprinkler nozzle replacement behaviors. For example, do stakeholders typically replace nozzles after a designated period of time, or do they wait until they need to fix malfunctioning spray sprinkler nozzles in the event of a problem? Specifically, are there data indicating how long spray sprinkler nozzles are installed in the field before being replaced, and/or how long spray sprinkler nozzles typically last in residential settings?

Section VIII Communicating Savings

- WaterSense is interested in stakeholder feedback on suspected reasoning behind potential water savings, including any information on whether stakeholders change irrigation schedules after a retrofit. WaterSense invites stakeholder opinions on irrigation runtimes, including preferences for duration of irrigation.
- WaterSense is interested in feedback from water utilities on promoting WaterSense labeled HES sprinkler nozzles. In particular, WaterSense is curious whether water utilities have concerns about whether consumers with HES sprinkler nozzles could meet their irrigation needs with watering windows in place.

X. Schedule and Next Steps

WaterSense is requesting input, supporting information, and data from all interested parties on topics discussed in this NOI and otherwise related to HES sprinkler nozzles. Interested parties can provide input to WaterSense regarding any of the issues presented in this notice by submitting written comments to watersense-products@erg.com. Comments and information on the issues presented in this NOI are welcome and will be taken into consideration as WaterSense considers development of a draft specification. The development and release of a draft specification will be contingent on adequate resolution of questions and issues presented in this NOI.

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Appendix A. Water Savings Studies

Title	Year	Author (or who conducted the study)	Number of Landscapes Included in Study	Savings
High Efficiency Nozzle Evaluation, Measurement and Verification FINAL DRAFT	2015	A & N Technical Services, Inc.	2,175 single-family residences 171 high-use customers	Single-family residences: 7 percent High-use customers: 38 percent
High Efficiency Nozzle Evaluation, Measurement and Verification	2016	Mark Graham	2,175 single-family residences 171 high-use customers	Single-family residences: 7 percent High-use customers: 38 percent
Evaluation of Potential Best Management Practices—Rotating Nozzles	2014	Melissa Baum-Haley	82 single-family residences 148 commercial customers	Single-family residences: 8 percent Commercial customers: 11 percent
Measured Water Savings and Cost Effectiveness of Smart Timers and Rotating Nozzles	2012	Joseph Berg, Melissa Baum-Haley, and Thomas Chestnutt	82 single-family residences 148 commercial customers	Single-family residences: 8 percent Commercial customers: 11 percent

<table>
<tr><th>Title</th><th>Year</th><th>Author (or who conducted the study)</th><th>Number of Landscapes Included in Study</th><th>Savings</th></tr>
<tr><td>Water Savings From Turf Removal and Irrigation Equipment Rebates</td><td>2019</td><td>Neeta Bijoor</td><td rowspan="2">40 single-family residences</td><td rowspan="2">20 percent</td></tr>
<tr><td>Saving Water With a Landscape Water Conservation Rebate Program</td><td>2021</td><td>Neeta Bijoor</td></tr>
<tr><td>Irrigation Conservation Program Evaluation in Orange County, Florida</td><td>2019</td><td>Bernardo Cardenas, Michael Dukes, and Nick Taylor</td><td>34 single-family residences</td><td>17 percent</td></tr>
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