Water Rating Index (WRI)

Overview

The Water Rating Index (WRI) score can be applied toward Water Efficiency compliance of the 2020 National Green Building Standard™ (NGBS). The process and underlying equations for generating a WRI score are detailed in Appendix D of the 2020 NGBS.

Home Innovation Research Labs has identified an area where Appendix D is incomplete.

Interpretation by Home Innovation Research Labs for Green Certification

To prepare a usable calculator tool for scoring and verification purposes, Home Innovation staff deemed it necessary to make several interpretations related to this issue. These interpretations are detailed in this document (in *italics*) and reflected in the "Amended Appendix D" that is included in the Verifier's Resource Guide (VRG).

D101.8(1) Outdoor Water – Calculations

Appendix D D101.8(1) details the calculations for annual outdoor water.

LandscapeWaterUse is the annual outdoor water required for landscaping. It is a sum of the monthly water use for each landscape zone. LandscapeWaterUse is mainly the result of the difference between the Evapotranspiration (ET) of the plants and the EffectiveRainfall received by that location. Plant type, irrigation controllers, and irrigation efficiency factors can also influence LandscapeWaterUse.

Within the equation for LandscapeWaterUse, the value "$\text{EffectiveRainfall}_{(month)}$" is included. This term is not defined within Appendix D, and no calculations are provided to explain how it is to be derived.

> LandscapeWaterUse = For each month that is a water month and for each landscape zone sum
>
> ([$\text{Evapotranspiration}_{(month)}$ * $\text{PlantFractionEvapotranspiration}_{(zone)}$] – $\text{EffectiveRainfall}_{(month)}$ * $\text{LandscapeArea}_{(zone)}$ * (1 – IrrigationControllerReduction)$_{(zone)}$ / $\text{IrrigatationEfficiency}_{(zone)}$ * 0.623 (gallons/sq ft of 1 in of rain)

Home Innovation utilizes evapotranspiration and rainfall data from the *World Water and Climate Atlas*, a project of the International Management Institute. The U.S. EPA WaterSense team processed the data from 1961 to 1990 to determine monthly values for each zip code in the United States.

Given that Appendix D did not include a definition for EffectiveRainfall, Home Innovation had applied the full monthly rainfall value as EffectiveRainfall. For areas with hot and wet climates, such as Atlanta, Ga., the WRI scoring tool was calculating unrealistic savings (up to 90%, even 100% in some cases), depending on the outdoor area, irrigation method used, and plant type entered, without any data entered for indoor water use. As the contribution of outdoor water use significantly outstripped that of indoor water use, the application of an effective rainfall factor was deemed necessary.

When the full rainfall values were applied, the difference between evapotranspiration and rainfall more often resulted in a negative number or an exact zero (i.e., the rainfall received is more than the evapotranspiration of the plants and there is no need to supply water through irrigation). This translated to very little outdoor water use and subsequently massive savings from few to no water-efficient features being implemented outdoors.

The American Society of Agricultural and Biological Engineers (ASABE) *ANSI/ASABE S623.1 JAN2017 Determining Landscape Plant Water Demands* introduced the concept of "effective" rainfall. A large portion of a rain event cannot be used by plants. Short, extreme burst results in more water being washed away before infiltrating the soil. "Effective rainfall" is an estimate of the amount of water that can be useful to plants. ANSI/ASABE S623.1 applies a 50% rainfall effectiveness factor.

The EPA WaterSense Water Budget Tool applies a 25% rainfall effectiveness factor. The *WaterSense Water Budget Approach* summary document notes that this factor "leads to a more conservative landscape design," and that "this landscape design will be more resilient in drier-than-average years or periods of unexpected drought.

To generate WRI scores that are more representative of actual water use in hot, wet climates, Home Innovation adjusted its WRI Calculator to apply a 25% rainfall effectiveness factor within the WRI Calculator. EffectiveRainfall is now calculated using 25% of monthly rainfall. Our analysis revealed that a 25% factor brought hot, wet climates to a reasonable range of WRI values and more realistic monthly and annual outdoor water use.

LandscapeWaterUse = For each month that is a water month and for each landscape zone sum

([Evapotranspiration$_{(month)}$ * PlantFractionEvapotranspiration$_{(zone)}$] – EffectiveRainfall$_{(month)}$ * LandscapeArea$_{(zone)}$ * (1 – IrrigationControllerReduction)$_{(zone)}$ / IrrigatationEfficiency$_{(zone)}$ * 0.623 (gallons/sq ft of 1 in of rain)

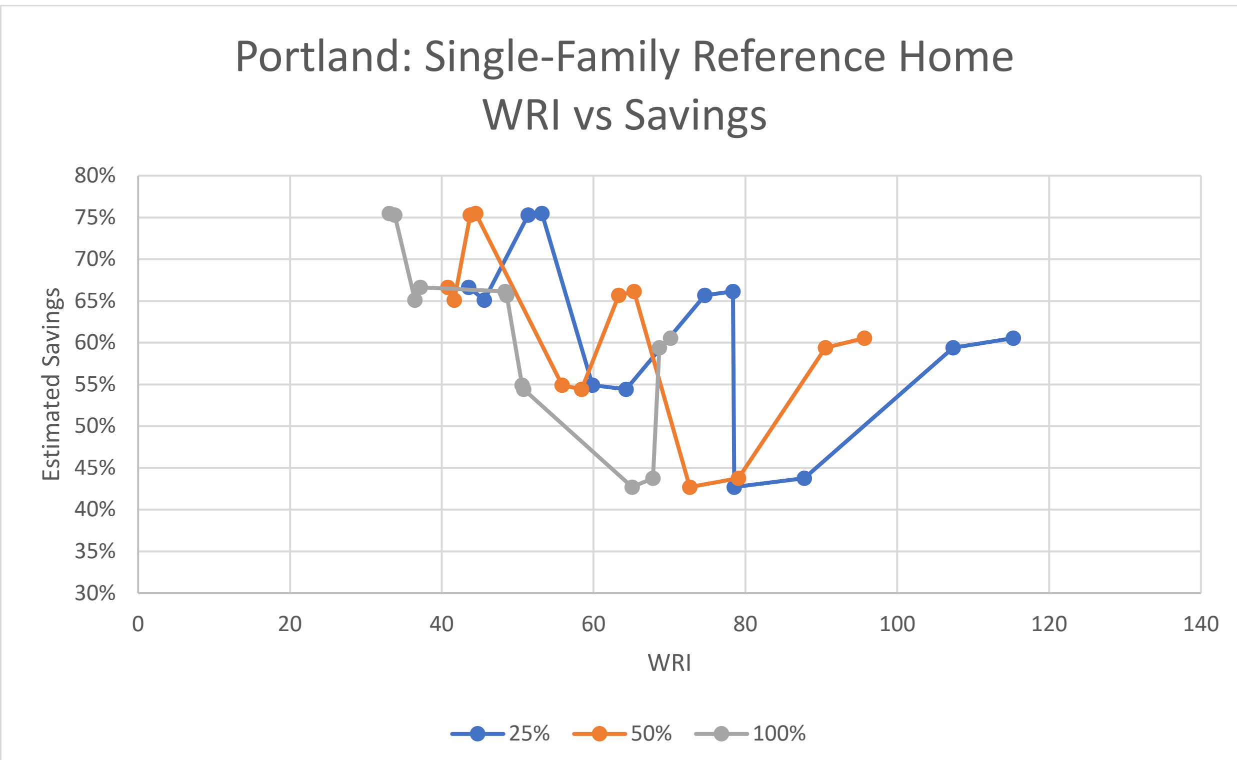
EffectiveRainfall$_{(month)}$ = monthly rainfall * 0.25

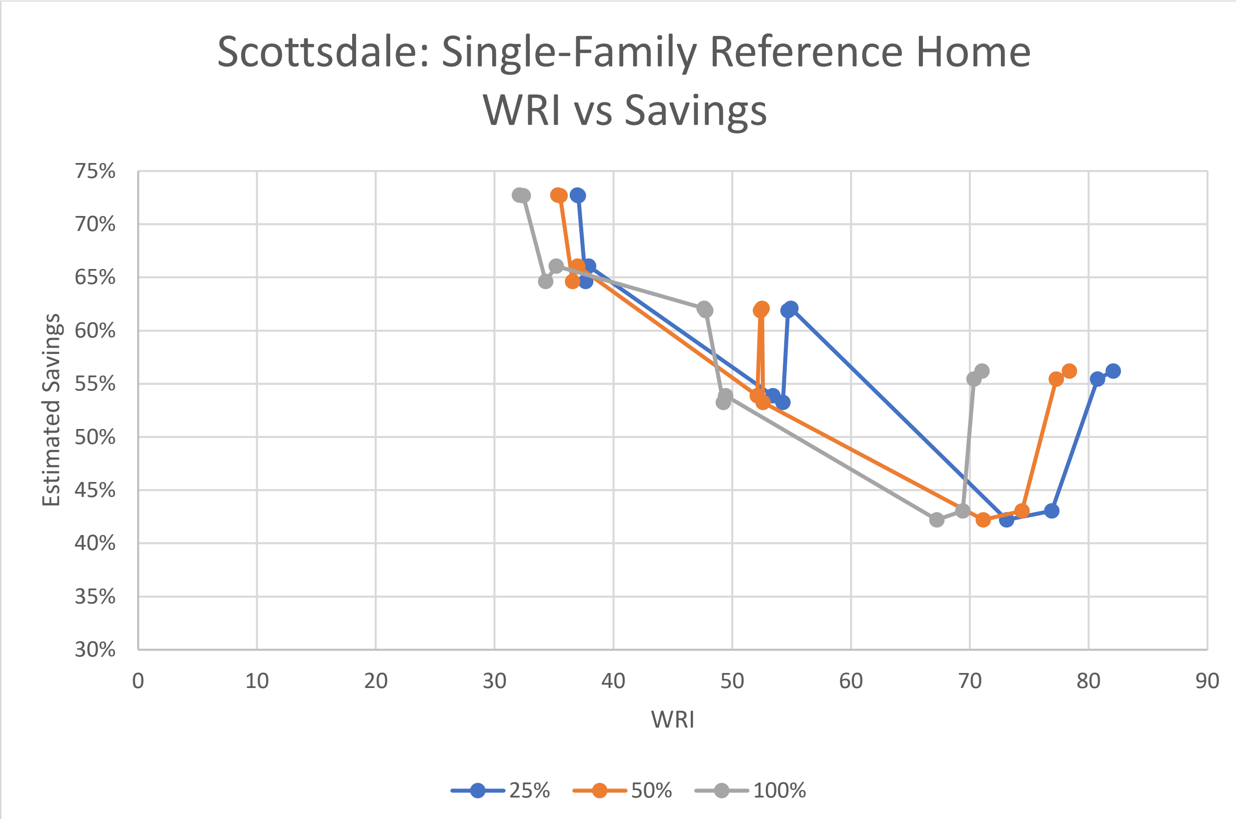
Evaluation

Home Innovation modeled four unique single-family reference home designs with varying levels of indoor and outdoor efficiency using the WRI calculator tool. Models were generated for Atlanta, Ga.; Portland, Ore.; and Scottsdale, Ariz. These three locations represent a range of climate types – Hot/Wet, Cool/Wet, and Hot/Dry, respectively. Plant types appropriate for each region were applied.

When no rainfall factor was applied, the modeling revealed that the WRI tool generated a similar range of WRI values for the same reference homes in Scottsdale and Portland. The most efficient home designs were shown as earning WRI scores between 32 and 36 in Scottsdale and Portland. The least efficient home designs were shown as earning WRI scores between 68 and 71 in Scottsdale and Portland. In contrast, the exact same reference homes in Atlanta showed **significantly** lower WRI values (very high % savings) at all levels of efficiency. The full range of WRI values for the Atlanta references homes was between 9 and 47.

The Home Innovation team then applied an effective rainfall factor to these models to view the impact that a 25% and 50% factor would have for each of the referenced homes. With the lowest annual rainfall of the three models, the Scottsdale reference homes showed an increase of 3 to 7 points on the WRI scale when the 50% effective rainfall factor was applied, and a 5 to 11 point increase when the 25% water factor was applied. The Portland reference homes were impacted a bit more with the application of the rainfall factors, with an increase of 8 to 26 points when the 50% effective rainfall factor was applied and 10 to 45 points when the 25% effective rainfall factor was applied. With the highest rainfall and evapotranspiration of the three locations, Atlanta experienced the greatest shift with the application of the effective rainfall factors – between 20 and 34 when the 50% effective rainfall factor was applied, and between 34 and 66 when the 25% effective rainfall factor was applied. The 25% effective rainfall factor brought the artificially high WRI scores in Atlanta to a more acceptable range of values based on the reference home designs.





Minimum and Maximum WRI Values For Each Location and Each EffectiveRainfall Factor Applied						
Location	25%		50%		100%	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
Atlanta	49	113	34	71	9	47
Portland	48	115	48	96	33	70
Scottsdale	37	82	36	78	32	71

As stated above, LandscapeWaterUse is the annual outdoor water required for landscaping. It is a sum of the monthly water use for each landscape zone. LandscapeWaterUse is mainly the result of the difference between the Evapotranspiration of the plants and the EffectiveRainfall received by that location.

For months where the difference between evapotranspiration and EffectiveRainfall would be a negative number, the WRI tool applies “0” to indicate that no irrigation is required for that month. A positive difference indicates that irrigation is required for that month of the year. A water month is defined in the Water Rating Index as a month where irrigation or hand-watering is expected. For any region, the water months are identified as the months between the first and last frosts.

Atlanta was identified as having seven (7) water months – March, April, May, June, July, August, and September – based on frost data. However, when no factor was applied to EffectiveRainfall, only two (2) months (June and August) actually resulted in positive LandscapeWaterUse values. It seems unrealistic to assume that a homeowner would provide irrigation for only two months in the hot Southeastern climate.

When the 50% EffectiveRainfall factor was applied, six (6) months – April, May, June, July, and August – were shown to require irrigation. When the 25% EffectiveRainfall factor was applied, all seven (7) water months were shown as requiring irrigation. This reaffirmed to the Home Innovation team that a 25% EffectiveRainfall factor offered the most realistic water use estimates.

The calculation of watering months and outdoor water use by region has varying impact with changes in rainfall factor. In Scottsdale, a more arid region, rainfall factor has no effect on the number of months where water is needed for irrigation, and minimal changes to outdoor water use. In more precipitous climates, such as Atlanta and Portland, rainfall factor adjustment can warp the yearly watering months and outdoor water use. Omitting the rainfall factor shows only two (2) months of the year where irrigation is necessary, and outdoor water use volumes an order of magnitude smaller than calculations done with a rainfall factor of 25% and 50%.

For Atlanta, the shift in the number of months requiring irrigation had a **tremendous** impact on annual outdoor water use. The Atlanta model with the most efficient outdoor features was calculated at 8,627 gallons. When the 50% EffectiveRainfall factor was applied, the value increased to 96,961 gallons – a 1,024% increase. When the 25% EffectiveRainfall factor was applied, the value increased to 154,904 – a 1,796% increase. This extreme variation indicates just how artificially low the previous Atlanta outdoor water use values were. In comparison, Portland showed a moderate shift at the 50% and 25% EffectiveRainfall factors (46% and 81%, respectively). As the most arid climate, Scottsdale showed a very minimal shift at the 50% and 25% EffectiveRainfall factors (11% and 17%, respectively).

Number of Months with Outdoor Water Use (ET - EffectiveRainfall) At Each of the Effective Rainfall Values				
Location	**Water Months (Months Between First and Last Frost)**	**Number of Months with Outdoor Water Use**		
		25%	**50%**	**100%**
Atlanta	7	7	6	2
Portland	7	6	5	3
Scottsdale	10	10	10	10

Annual Outdoor Water Use by Location and EffectiveRainfall Factor Applied				
Location	**Efficiency**	**Outdoor Water Use (Gallons)**		
		25%	**50%**	**100%**
Atlanta	*High*	163,531	96,961	8,627
	Mid	240,187	142,413	12,671
	Low	363,920	215,777	19,198
Portland	*High*	127,482	102,629	70,284
	Mid	187,240	150,738	103,231
	Low	283,697	228,391	156,410
Scottsdale	*High*	337,564	321,339	288,888
	Mid	379,759	361,506	324,999
	Low	573,393	547,736	492,423