Water Savings for Utilities from Rain Sensor Model

Developed by Heather Rose 2019

This water savings model for utilities who mandate a working rain sensor in single family home irrigation systems is based off the Rain Sensor Water Savings Model for Reduced Irrigation Method (See Appendix Below). It assumes the utility is already enforcing a twice weekly permanent watering schedule at 50% compliance.

The following terms must be defined for the utility:

- Average Single Family Gallons per Capita per day (SF GPCD) with twice weekly watering schedule mandate at 50% compliance
- Number of rain weeks for the region (based on regional weather data)

For methods on determining SF GPCD with a permanent watering schedule see resources below.

<u>Reduced outdoor irrigation demand from working rain sensor:</u>

$$SF\_GPCD_{outdoor-reduction}\left(\frac{gal}{persons \times day}\right) =$$
$$\left[\frac{Rainweeks}{year} \times \frac{1 - RS_{reduced}\ inch\ water}{week} \times \frac{1\ ft}{12\ inches} \times \frac{0.12\ acres}{Home}\right] \times \left(\frac{325{,}851\ gal}{Acre-feet} \times \frac{1\ Home}{2.84\ persons} \times \frac{1\ year}{365\ days}\right) \qquad \text{(Eq. 1)}$$

Where,

$$Rainweeks$$
$$= Number\ of\ weeks\ out\ of\ the\ year\ where\ the\ region\ receives\ at\ least\ a\ net\ 0.125\ inches\ of\ rainfall$$
$$Can\ be\ obtained\ from\ regional\ weather\ data$$

$$RS_{reduced} = Rain\ Sensor\ reduced\ watering\ factor = 0.86\ inches\ per\ week$$

See Appendix for derivation

Assume irrigation acreage is 70% of landscape area of average size single family lot in Texas (Home Advisor 2019), or 0.12 acres. Assume 2.63 persons per household (US Census Bureau 2019).

Water Savings per Utility:

First we find the reduced SF GPCD with the application of rain sensors:

$$SF\_GPCD_{reduced} = SF\_GPCD_{perm\_watering\_schedule} - \left(SF_{GPCD_{outdoor-reduction}} \times C_f\right) \qquad \text{(Eq.2)}$$

We then determine a base case demand for a single utility if there is only a twice weekly permanent watering schedule:

$SF_{WU\_basecase\_i}\ (\frac{af}{yr}) = SF\_GPCD_{perm\_watering\_schedule} \times P_i \times \frac{365\ days}{year} \times \frac{1\ af}{325{,}851\ gallons}$, for ith year (Eq.3)

We then determine what the reduced demand for the utility would be if rain sensors were mandated:

$SF_{WU\_reduced\_i}\ (\frac{af}{yr}) = SF_{GPCD_{reduced}} \times P_i \times \frac{365\ days}{year} \times \frac{1\ af}{325{,}851\ gallons}$, for ith year (Eq. 4)

The water savings for the utility is then considered to be the difference between the base case demand and the reduced demand for that year:

$Water\ Savings_i\ \left(\frac{af}{yr}\right) = SF_{WU\_basecase\_i} - SF_{WU\_reduced\_i}$, for ith year (Eq. 5)

Terms

$SF_{GPCD_{perm\_watering\_schedule}} = Avereage\ Single\ Family\ GPCD\ for\ the\ utility\ with\ permanent\ twice\ weekly\ watering\ schedule\ mandate, at\ 50\%\ compliance$.

$C_f =$
$Compliance\ Factor, Percent\ of\ Connections\ in\ compliance\ with\ working\ rain\ sensor\ ordinance$ set to 50%

$P_i = Population\ of\ utility\ for\ ith\ year, available\ on\ Texas\ Water\ Development\ Board\ website$

The total forecasted demand are considered to be the sum of the forecasted base case demands, reduced demands, and water savings for all utilities. Equations 6, 7, and 8 below show this calculation.

$Total\ Base\ Case\ Demand_i\left(\frac{af}{yr}\right) = \sum_1^{n\ WUGs}\left[SF_{WU\_basecase\_i}\right]$, for ith year (Eq. 6)

$Total\ Reduced\ Demand_i\left(\frac{af}{yr}\right) = \sum_1^{n\ WUGs}\left[SF_{WU\_reduced\_i}\right]$, for ith year (Eq. 7)

$Total\ Water\ Savings_i\left(\frac{af}{yr}\right) = \sum_1^{n\ WUGs}\left[SF_{WU\_basecase\_i} - SF_{WU\_reduced\_i}\right]$, for ith year (Eq. 8)

References:

Home Advisor. *The United States Ranked by Yard Size*
https://www.homeadvisor.com/r/average-yard-size-by-state/

Rose, Heather (2019). *Water Savings Models for Utilities with Permanent Twice Weekly Watering Schedules.*
https://heatherscarlettrose.com/papers-and-publications/

Texas Water Development Board (2019). *Population and Water Demand Projections.*
http://www.twdb.texas.gov/waterplanning/data/projections/index.asp

US Census Bureau (2019)
https://www.census.gov/quickfacts/fact/table/US/HCN010212

Appendix: Water Savings from Rain Sensors Model Reduced Irrigation Method

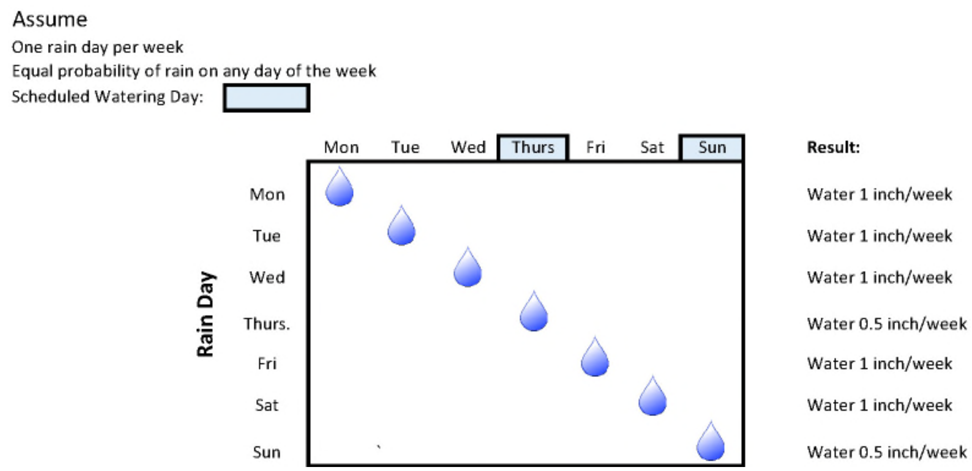
Developed by Heather Rose 2019

This method for water savings from rain sensors is based on the reduced irrigation demand by incorporating rain sensors into irrigation systems. Inputs required for this model are:

- Regional weather data
- Average number of weeks per year with irrigation events
- Number of irrigation days per week with spacing of watering days
- Acreage of irrigated turf

Irrigation Event Skip Patterns

Incorporating rain sensors will allow for skipped irrigation days for weeks when a rain event occurs. These skip patterns were developed to account for rain events that do not fall on scheduled irrigation days. Below is the skip pattern for weeks in the year with rain events. This example is for districts with 2 day per week permanent watering schedules, spaced out at every 3-4 days (or Thursday and Sunday for example). It also assumes one rain event per week and equal probability of rain on any day of the week.



Weighted Average for Required Watering on Rain Weeks:

$$Watering\ Requirement\ on\ Rain\ Weeks$$
$$= (5/7)(1\ inches\ per\ week) + (2/7)(0.5\ inches\ per\ week)$$
$$= 0.86\ inches\ per\ week\ on\ rain\ weeks$$

Base Case Irrigation Demand

Base case irrigation demand (or watering demand without rain sensors but *with* a twice weekly permanent watering schedule) can be calculated by:

$$Irrigation_{basecase}\left(\frac{acre-feet}{year}\right) = \frac{Irrigation\ weeks}{year} \times \frac{1\ inch\ water}{week} \times \frac{1\ ft}{12\ inches} \times \frac{Irrigation\ acres}{lot} \times (No.of\ Lots)$$

(Eq.1)

This assumes irrigated lots receive a total of 1 inch of water per irrigated acre per irrigation week (or ½ inch per watering at two waterings per week). For lots described as single family homes in Texas, an average of 0.12 irrigated acres per home can be assumed based on average lot size data and an assumption of 70% of landscape area is irrigated turf (Home Advisor 2019).

Reduced Irrigation Demand on Rainweeks

We will define a rainweek as a week in the year where at least 0.125 inches of rain fall after. This is the recommended threshold for setting off a rain sensor (Dukes, Haman U Florida). To simplify this model, we assume there is an equal probability of rain to fall during any week of the year. Reduced irrigation demand is then calculated by:

$$Irrigation_{reduced}\left(\frac{acre-feet}{year}\right) = \frac{Non-Rain\ weeks}{year} \times \frac{1\ inch\ water}{week} \times \frac{1\ ft}{12\ inches} \times \frac{Irrigation\ acres}{Lot} \times (No.of\ Lots) + \frac{Rainweeks}{year} \times \frac{RS_{reduced}\ inch\ water}{week} \times \frac{1\ ft}{12\ inches} \times \frac{Irrigation\ acres}{Lot} \times (No.of\ Lots)$$

(Eq. 2)

Where
$RS_{reduced} = Rain\ Sensor\ reduced\ watering\ factor = 0.86\ inches\ per\ week$

$Rainweeks$
$= Number\ of\ weeks\ out\ of\ the\ year\ where\ the\ region\ receives\ at\ least\ 0.125\ inches\ of\ rainfall$
Can be obtained from regional weather data

$Non - Rainweeks = 52 - Rainweeks$

Water Savings

The water savings was then considered to be the difference between the base case irrigation demand and the reduced irrigation demand, or

$$Water\ Savings\ \left(\frac{acre-feet}{year}\right) = Irrigation_{basecase} - Irrigation_{reduced} \qquad \text{(Eq. 3)}$$

Limitations

This model does not account for:

- If rain events are not isolated to one event per week
- The seasonality of rain patterns
- Users overriding the rain sensor shut off

Despite these limitations, this model can provide an order of magnitude estimate for water savings from incorporating rain sensors in an irrigation system.

References:

Dukes, Haman. *Residential Irrigation System Rainfall Shutoff Devices, or Rain Sensors.* University of Florida, IFAS Extension