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INNOVATIONS

A Water Budget Approach for Assessing Urban Residential Irrigation Performance

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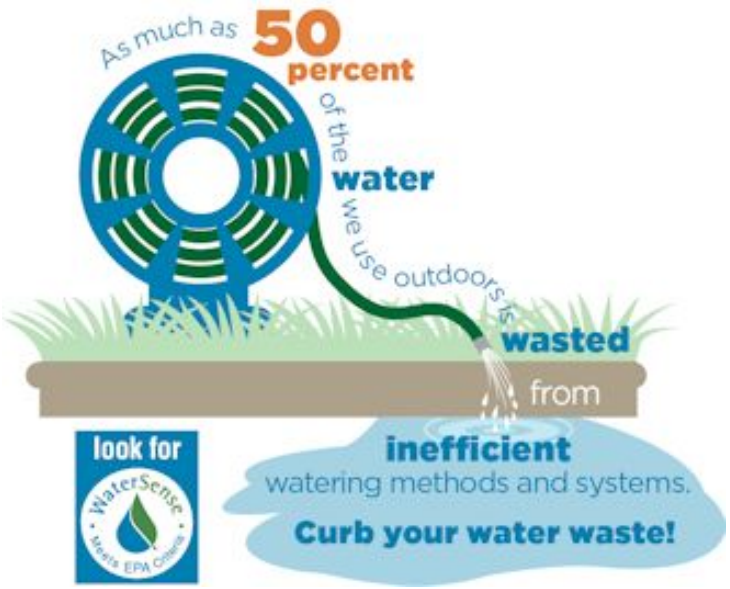
WATER MANAGEMENT & HYDROLOGICAL SCIENCE

Overview

- **Overwatering lawns and landscapes wastes water**
- Causes of overwatering
- Interventions to reduce overwatering
- Developing water budgets
- Assessing irrigation performance
- Next steps

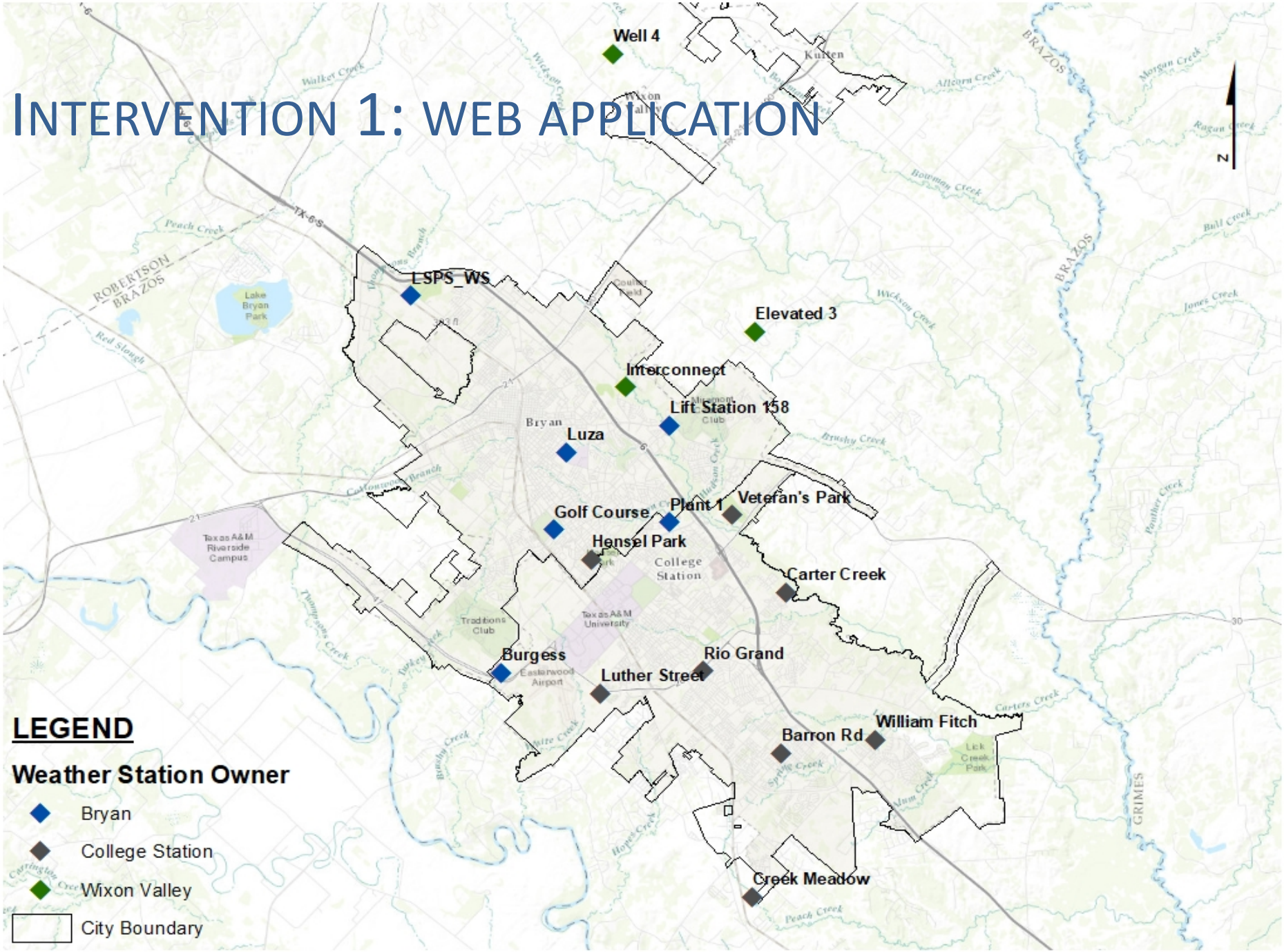
CAUSES OF OVERWATERING

- **Overwatering lawns and landscapes wastes water**
  - **40-60% of single-family residential water use is outdoor**
  - **50% is wasted due to overwatering (EPA)**
- Causes
  - Continuing to run sprinklers after rainfall provides all of turf needs
  - Running irrigation system too long
  - Running irrigation system too often
  - Poor irrigation system design
  - Leaks
- Interventions targeting outdoor water use



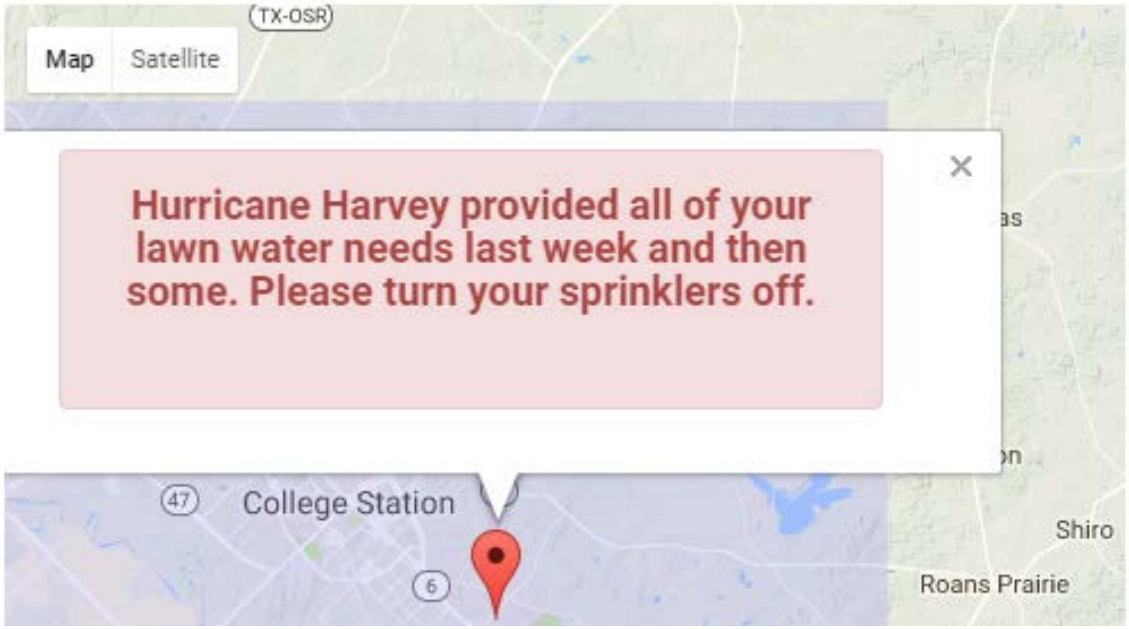
Source: EPA WaterSense

INTERVENTION 1: WEB APPLICATION



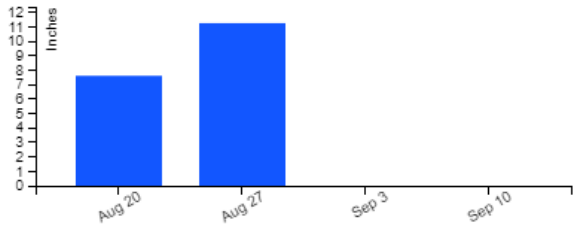
9/10/2017

Address: 4601 Colonial Circle, College Station, TX, United States



Rainfall past 24 hours: 0 inches.
Rainfall past 7 days: 0 inches.
Rainfall last week (Sep 03, 2017 to Sep 10, 2017): 0 inches.

Past Rainfall: Weekly



9/11/2017

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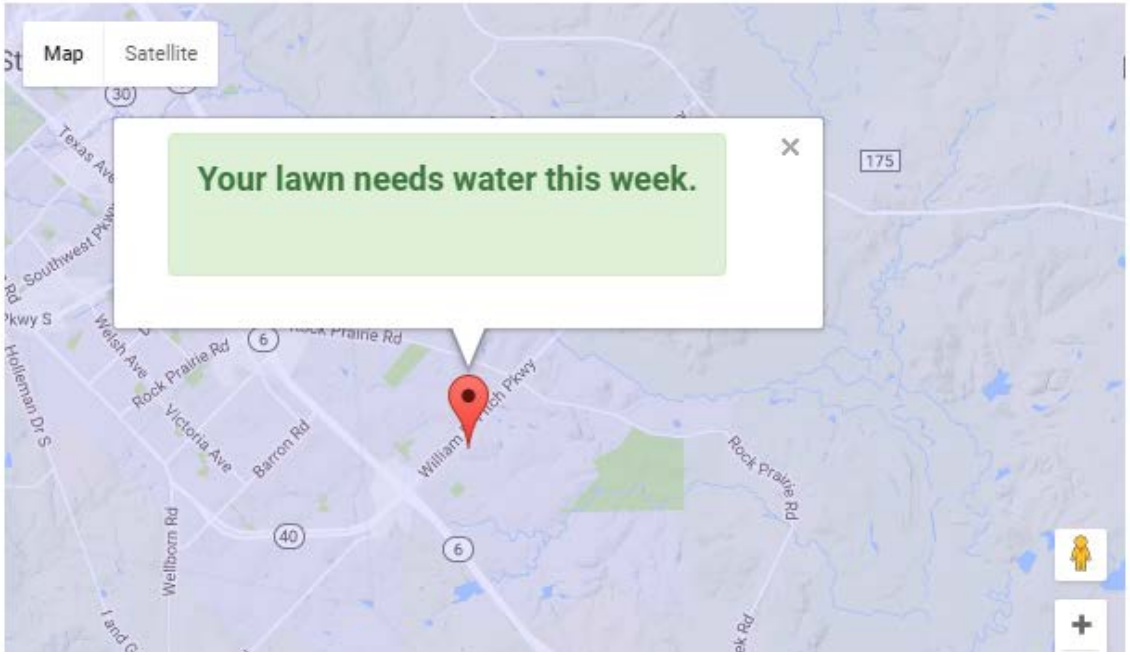


Rainfall past 24 hours: 0 inches.
Rainfall past 7 days: 0 inches.
Rainfall last week (Sep 03, 2017 to Sep 10, 2017): 0 inches.

Click HERE for suggested generic Irrigation Run Times

SUGGESTED SPRINKLER SYSTEM RUN TIMES

Sprinkler Head type

40 minutes per day, twice a week.

30 minutes per day, twice a week.

15 minutes per day, twice a week.

15 minutes per day, twice a week.

Intervention 2: Weekly emails

When watering is required:

A message from Brazos Valley WaterSmart

Dear Ronald Kaiser,

Your lawn needs water this week.

Recommended sprinkler system run times:

•Multi-stream rotors : 40 minutes per day, twice a week.
•Rotors : 30 minutes per day, twice a week.
•Pop-up sprays : 15 minutes per day, twice a week.
•Shrub sprays : 15 minutes per day, twice a week.
If you need more information about sprinkler types see our website

This is based on rainfall of 0.11 inches for the week of Jul 30, 2017 to Aug 06, 2017.
If the forecast for the upcoming week is rainy, please consider turning off your sprinklers.
At any time, for the latest rainfall totals please visit http://bvwatersmart.tamu.edu.
Thank you for helping us conserve water.

Intervention 2: Weekly emails

When watering is not required:

A message from Brazos Valley WaterSmart

Dear Ronald Kaiser,

Rainfall in your neighborhood this past week provided all of your lawn water needs.

This is based on rainfall of 1.66 inches for the week of Aug 06, 2017 to Aug 13, 2017.

If the forecast for the upcoming week is rainy, please consider turning off your sprinklers.
At any time, for the latest rainfall totals please visit http://bvwatersmart.tamu.edu.
Thank you for helping us conserve water.

Impact of weekly emails on total outdoor water use

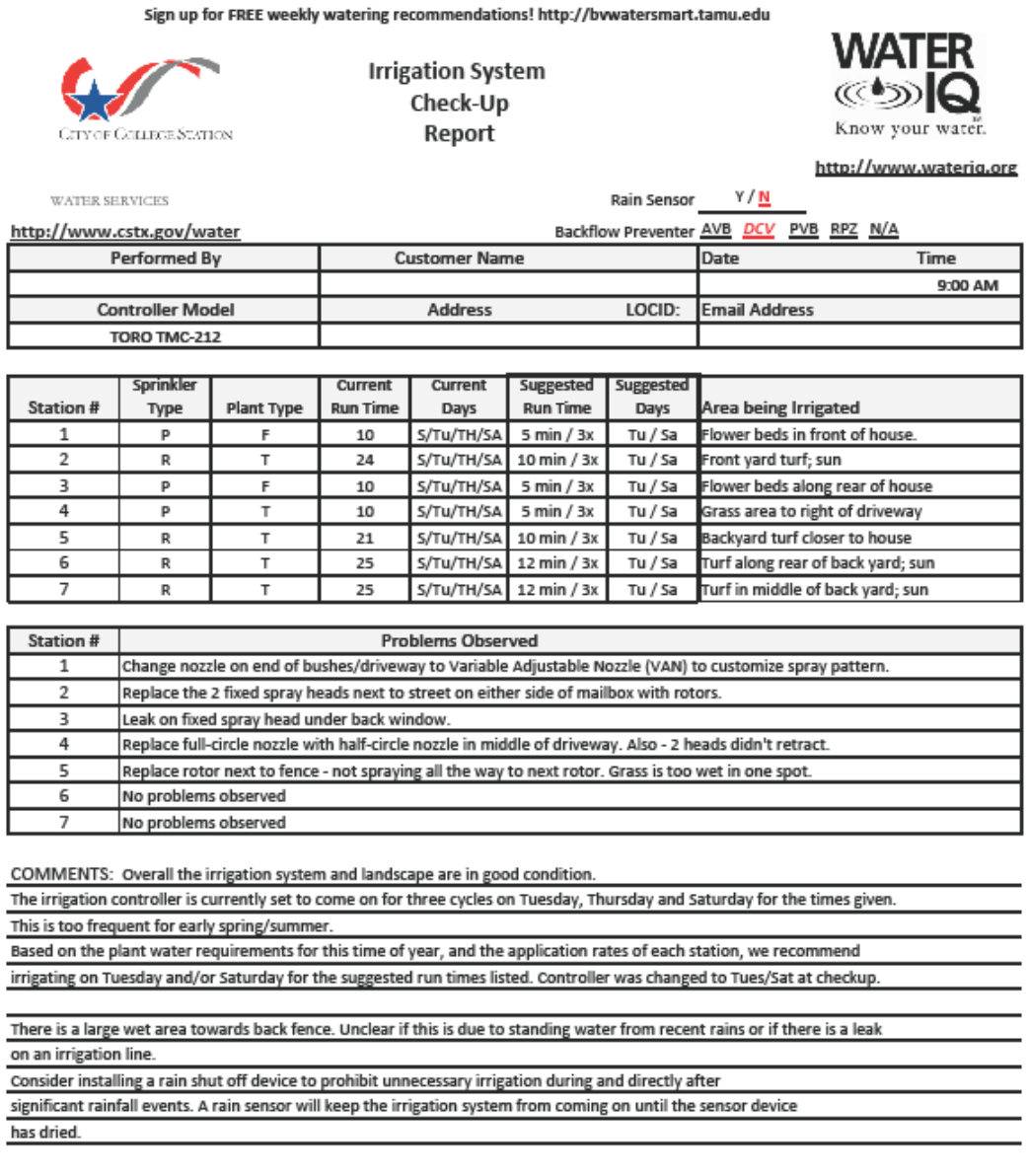
Random sample of 30 customers from 390 subscribers

Year	2013	2014	2015	2016
Volume (gal)	2,455,000	2,553,000	2,544,000	1,572,000

Intervention 3: Irrigation seminars

Intervention 4: Irrigation System Check-Ups

- Voluntary
- Free to homeowner
- Informed through
  - Utility bill insert
  - High water bill
  - Friend/Neighbor referral
  - Irrigation seminar
  - Study letter
- 779 since 2010



Sign up for FREE weekly watering recommendations! http://bvwatersmart.tamu.edu

City of College Station

Irrigation System Check-Up Report

WATER IQ Know your water.

http://www.waterIQ.org

WATER SERVICES

http://www.cstx.gov/water

Rain Sensor Y / N

Backflow Preventer AVB DCV PVB RPZ N/A

Performed By	Customer Name	Date	Time
			9:00 AM
Controller Model	**Address** **LOCID:**	**Email Address**	
TORO TMC-212			

Station #	Sprinkler Type	Plant Type	Current Run Time	Current Days	Suggested Run Time	Suggested Days	Area being Irrigated
1	P	F	10	S/Tu/TH/SA	5 min / 3x	Tu / Sa	Flower beds in front of house.
2	R	T	24	S/Tu/TH/SA	10 min / 3x	Tu / Sa	Front yard turf; sun
3	P	F	10	S/Tu/TH/SA	5 min / 3x	Tu / Sa	Flower beds along rear of house
4	P	T	10	S/Tu/TH/SA	5 min / 3x	Tu / Sa	Grass area to right of driveway
5	R	T	21	S/Tu/TH/SA	10 min / 3x	Tu / Sa	Backyard turf closer to house
6	R	T	25	S/Tu/TH/SA	12 min / 3x	Tu / Sa	Turf along rear of back yard; sun
7	R	T	25	S/Tu/TH/SA	12 min / 3x	Tu / Sa	Turf in middle of back yard; sun

Station #	Problems Observed
1	Change nozzle on end of bushes/driveway to Variable Adjustable Nozzle (VAN) to customize spray pattern.
2	Replace the 2 fixed spray heads next to street on either side of mailbox with rotors.
3	Leak on fixed spray head under back window.
4	Replace full-circle nozzle with half-circle nozzle in middle of driveway. Also - 2 heads didn't retract.
5	Replace rotor next to fence - not spraying all the way to next rotor. Grass is too wet in one spot.
6	No problems observed
7	No problems observed

COMMENTS: Overall the irrigation system and landscape are in good condition.
The irrigation controller is currently set to come on for three cycles on Tuesday, Thursday and Saturday for the times given.
This is too frequent for early spring/summer.
Based on the plant water requirements for this time of year, and the application rates of each station, we recommend
irrigating on Tuesday and/or Saturday for the suggested run times listed. Controller was changed to Tues/Sat at checkup.

There is a large wet area towards back fence. Unclear if this is due to standing water from recent rains or if there is a leak
on an irrigation line.
Consider installing a rain shut off device to prohibit unnecessary irrigation during and directly after
significant rainfall events. A rain sensor will keep the irrigation system from coming on until the sensor device
has dried.

Sign up for FREE weekly watering recommendations! http://bvwatersmart.tamu.edu

INTERVENTION 5: WATER BUDGETS

- Compares
  - How much lawn needs
  - How much is being watered
- Focusing on single-family residential landscape
- Causes of Overwatering
  - Continuing to run sprinklers after rainfall provides all of turf needs
  - Running irrigation system too long
  - Running irrigation system too often
  - Poor irrigation system design
  - Leaks

YOUR LAWN'S WATER BUDGET IN 2016

The table below gives your estimated irrigation budget and estimated outdoor water use for 2016. We determine your budget based on:

the size of your lawn ,
College Station weather conditions , and
your neighborhood rainfall from our many College Station rainfall sensors.

Did you know? Your grass typically needs about half as much water in April, May, and October than it does in June, July, August, and September. Your lawn needs even less if the weather is cool and rainy. Your water budget goes up when the weather is hot and dry, and then goes down when the weather is cool and wet.

	Your Estimated Irrigation Budget (gallons)	How Much Water You Applied (gallons)	Amount You Over-irrigated (gallons)
January February March	Your lawn is sleeping. It does not need to be irrigated.		
April	5,800	17,700	11,800
May	5,300	9,700	4,400
June	12,700	5,900	0
July	17,700	21,200	3,500
August	7,800	16,900	9,100
September	11,300	15,700	4,400
October	7,100	19,600	12,500
November December	Your lawn is sleeping. It does not need to be irrigated.		
Total	67,700	106,700	45,700

If you are over your estimated irrigation budget, please call Water Services at (979) 764-3660 to schedule a FREE LANDSCAPE IRRIGATION CHECKUP

HOW MANY GALLONS IS ONE INCH OF WATER ON MY LAWN?

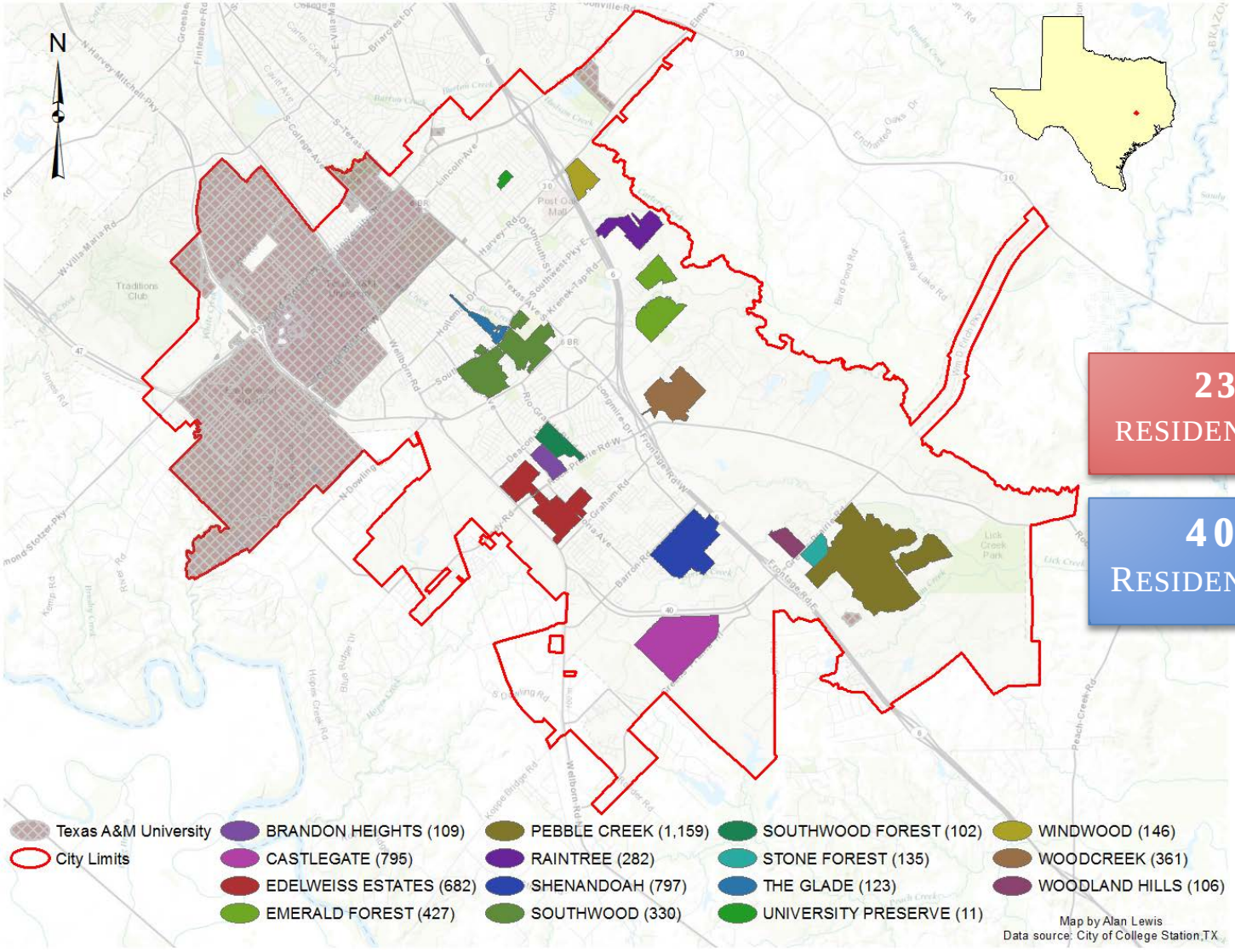
This table is an estimate of the number of gallons of water you use for each 1/2-inch of water applied based on the size of your lawn.

Irrigable Area (sq. feet): 7,000

Amount (in)	Volume (gallons)
0.5	2,100
1	4,300
1.5	6,500

To learn about irrigation runtimes and how to adjust your sprinkler heads, please visit www.BVWaterSmart.tamu.edu

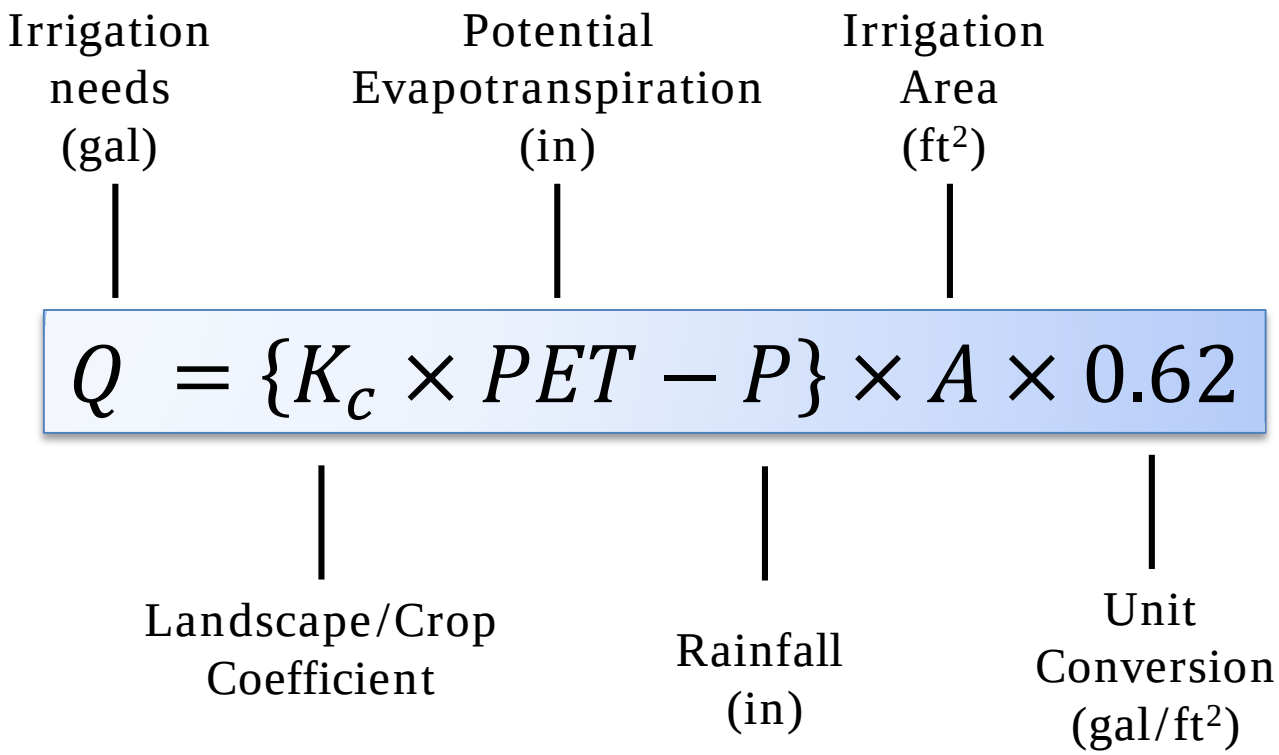
BUDGETS SENT TO 5,565 LOTS IN 2012-2015



23% OF TOTAL RESIDENTIAL CUSTOMERS

40% OF TOTAL RESIDENTIAL WATER USE

ANATOMY OF A WATER BUDGET



A sample Irrigation area

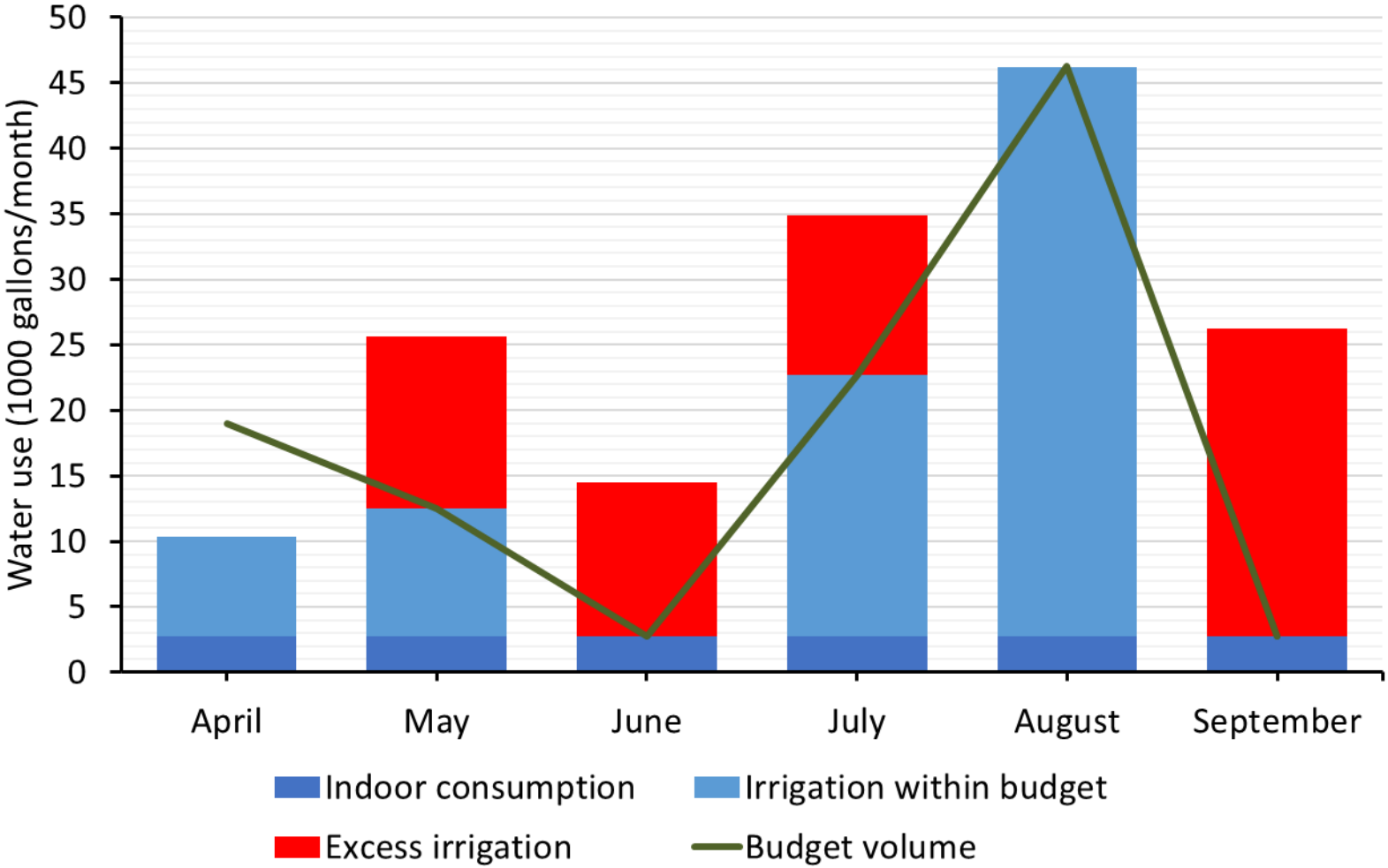
- Sample lot
  - Parcel Area: 21,780 ft^2
  - Living Area: 2,377 ft^2
  - Building Area: 4,083 ft^2
  - Driveway Area: 2,440 ft^2
  - Irrigation Area: 15,257 ft^2

Calculating irrigation Landscape area

		Appraised Lot Area (ft^2)									
		4,000-5,999	6,000-7,999	8,000-9,999	10,000-11,999	12,000-13,999	14,000-17,999	18,000-23,999	24,000-29,999	30,000-59,999	60,000-89,999
Appraised Floor Area (ft^2)	500-999	0.66	0.69	0.76	0.82	0.84	0.87	0.87	0.94	0.94	
	1,000-1,499	0.55	0.60	0.66	0.72	0.75	0.78	0.83	0.86	0.91	0.92
	1,500-1,999	0.50	0.56	0.62	0.67	0.71	0.76	0.80	0.84	0.87	0.90
	2,000-2,499	0.53	0.53	0.57	0.61	0.65	0.70	0.76	0.81	0.86	0.90
	2,500-2,999	0.49	0.56	0.57	0.58	0.60	0.66	0.73	0.77	0.84	0.89
	3,000-3,499		0.52	0.53	0.55	0.58	0.61	0.70	0.75	0.83	0.89
	3,500-3,999			0.54	0.53	0.56	0.60	0.67	0.72	0.80	0.88
	4,000-4,999					0.60	0.61	0.66	0.67	0.75	0.83
	5,000-8,999					0.50	0.60	0.61	0.64	0.74	0.85

Lewis, A., Khedun, C. P., Kaiser, R. (2017). "Coefficients for Estimating Landscape Area on Single Family Residential Lots." *Journal - American Water Works Association* 109(8).

CALCULATING OVERWATERING



Assessing irrigation performance

- Performance can be assessed by comparing actual water use with plant irrigation requirements or water budget volumes
- Criteria
  - Quantity of overwatering per household
  - How frequently per irrigation season overwatering occurred
  - Quantity relative to lot characteristics
- Objective
  - Determine characteristics explaining why overwatering might be higher in some homes relative to others

IRRIGATION PERFORMANCE VERSUS LOT SIZE

- Based on averaged results for 2008-2016 for 5,565 lots

2017 Assessed Lot Size	Number of Accounts	Percentage of Accounts	Average Landscape Area (ft^2)	2008-2016 Total Overwatering – Percentage	Average Annual Overwatering per Account (gallons)	Average Overwatering per Unit Area (inches)	Average Number of Months Overwatered per Summer
4,000 ft^2 - 5,999 ft^2	2910	20%	2,571	0.8%	22,345	13.2	3.4
6,000 ft^2 - 7,999 ft^2	2480	17%	4,040	10.5%	16,694	6.6	2.5
8,000 ft^2 - 9,999 ft^2	1545	11%	5,521	16.4%	19,170	5.2	2.4
10,000 ft^2 - 11,999 ft^2	1377	10%	6,934	19.7%	23,963	5.1	2.5
12,000 ft^2 - 13,999 ft^2	756	5%	8,357	16.0%	28,468	5.0	2.5
14,000 ft^2 - 17,999 ft^2	322	2%	10,627	14.8%	31,068	4.3	2.4
18,000 ft^2 - 23,999 ft^2	374	3%	14,870	10.6%	37,956	3.7	2.3
24,000 ft^2 - 29,999 ft^2	99	1%	19,434	7.3%	48,082	3.6	2.2
30,000 ft^2 - 59,999 ft^2	0	0%	29,658	3.8%	47,002	2.3	1.9
60,000 ft^2 - 89,999 ft^2	0	0%	62,322	0.1%	20,791	0.5	1.2

IRRIGATION PERFORMANCE VERSUS HOME AGE

- Based on averaged results for 2008-2016 for 5,565 lots

Year Built	Number of Accounts	Percentage of Accounts	Average Landscape Area (ft^2)	2008-2016 Total Overwatering – Percentage	Average Annual Overwatering per Account (gallons)	Average Overwatering per Unit Area (inches)	Average Number of Months Overwatered per Summer
1951-1960	1	0.02%	15,706	0.0%	7,958	0.8	1.2
1961-1970	97	1.74%	11,463	1.2%	18,285	2.4	1.7
1971-1980	413	7.42%	11,664	3.9%	13,521	2.0	1.6
1981-1990	728	13.08%	9,308	11.8%	23,063	4.0	2.2
1991-2000	1944	34.93%	8,706	37.1%	27,260	5.0	2.4
2001-2010	2353	42.28%	7,145	45.4%	27,531	6.2	2.7
≥2011	29	0.52%	6,862	0.6%	27,969	7.3	2.2
Total	5,565						

IRRIGATION PERFORMANCE VERSUS HOME VALUE

- Based on averaged results for 2008-2016 for 5,565 lots

2017 Assessed Home Value	Number of Accounts	Percentage of Accounts	Average Landscape Area (ft^2)	2008-2016 Total Overwatering – Percentage	Average Annual Overwatering per Account (gallons)	Average Overwatering per Unit Area (inches)	Average Number of Months Overwatered per Summer
$50,000 to $99,999	7	0%	12,497	0.03%	6,909	1.8	1.7
$100,000 to $149,999	963	7%	6,737	7.24%	10,733	2.7	1.7
$150,000 to $199,999	1617	11%	6,570	18.98%	16,750	4.3	2.2
$200,000 to $299,999	1854	13%	7,968	38.19%	29,399	6.3	2.8
$300,000 to $499,999	693	5%	11,429	19.31%	39,766	6.5	2.8
$500,000 to $999,999	428	3%	15,788	15.88%	52,969	6.2	2.7
$1,000,000 or more	3	0%	21,286	0.38%	178,820	15.6	2.9
Median Value	$210,930						

COMPARING QUANTITY OVERWATERED VERSUS HOW OFTEN OVERWATERING OCCURRED

- Based on average of overwatering and number of months over budget (rounded) for 2008-2016
- Cells show count of lots within category

		Total Amount Overwatered				
		2,500 or less	2,500 to 9,999	10,000 to 24,999	25,000 to 49,999	50,000 or more
Months Over Budget	1	262	427	40	4	0
	2	22	653	762	202	25
	3	0	30	874	637	128
	4	0	0	182	643	258
	5	0	0	9	133	183
	6	0	0	1	16	52

*5,543 lots overwatered

COMPARING QUANTITY OVERWATERED VERSUS HOW OFTEN OVERWATERING OCCURRED

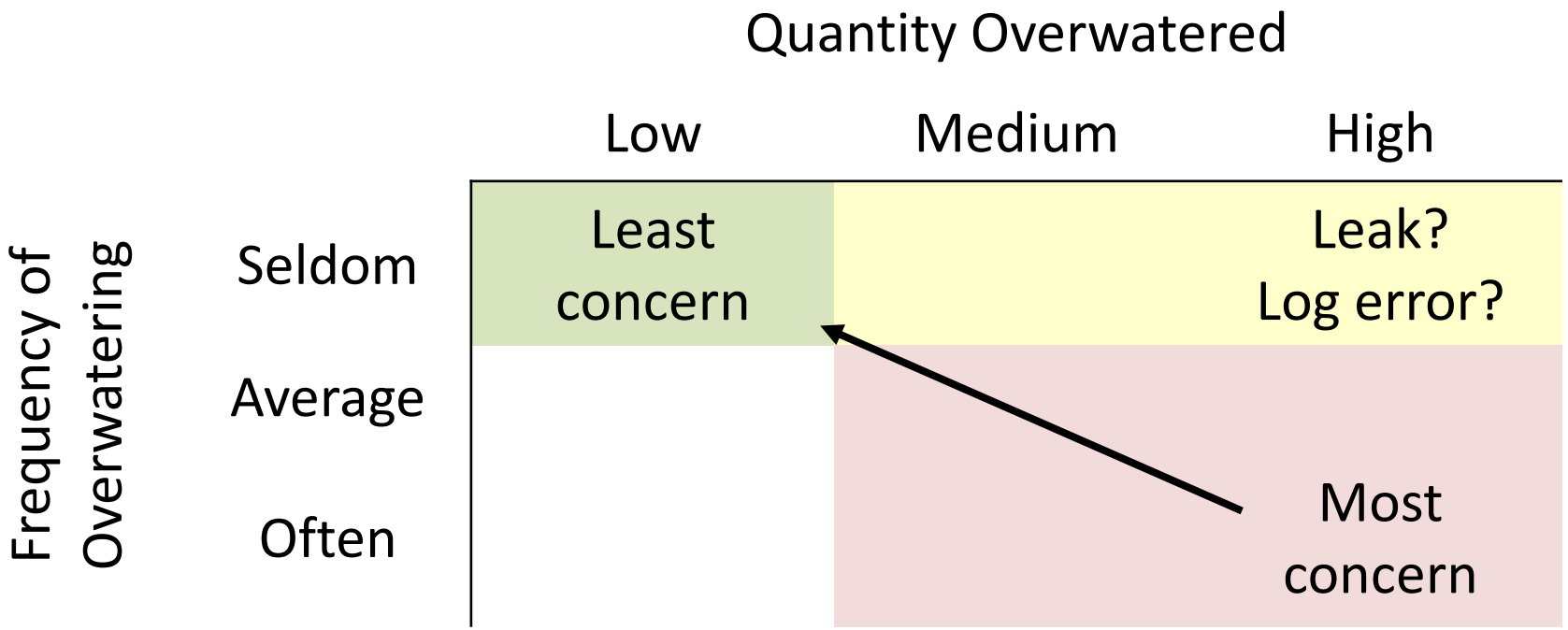
- Based on average of overwatering and number of months over budget (rounded) for 2008-2016
- Cells show percent of total overwatering represented by lots within category

		Total Amount Overwatered				
		2,500 or less	2,500 to 9,999	10,000 to 24,999	25,000 to 49,999	50,000 or more
Months Over Budget	1	0.28%	1.42%	0.35%	0.08%	
	2	0.03%	3.10%	8.34%	4.60%	1.04%
	3		0.18%	11.12%	14.93%	5.83%
	4			2.56%	16.52%	12.59%
	5			0.14%	3.73%	9.53%
	6			0.02%	0.46%	3.12%

Summary of findings

- Overwatering is common, but quantity and frequency varies!
- Overwatering tended to be higher among lots that were larger, newer, and more expensive
- Smaller homes tended to overwater more often and more per unit area
  - However, these tended to be smaller volumes and were much greater quantities relative to the size of the landscape
- Newer homes, irrespective of market value, tended to overwater more often and more per unit area
  - Inclusion of irrigation systems with automatic irrigation controllers

SUMMARY OF FINDINGS



Limitations of analysis

- Monthly budget calculations did not account for when rain falls relative to the start or end of the month
- Weather data was obtained from a single weather station—rainfall varies!
- Weather station switched locations over the analysis period
- Landscape area methodology may overestimate area that is actually being irrigated
- Landscape contains numerous plant species with varying water needs
- Possible errors in water billing data logged by City

What we are currently working on

- Statistical analysis to determine the impact of the interventions on water use
- Better understanding of irrigation performance across single-family residential water customers using a weekly time step
- Using rainfall from nearest weather station
- BV WaterSmart: estimating irrigation budget monthly and comparing to monthly water bill

ACKNOWLEDGEMENTS

- University Council on Water Resources
- City of College Station – Water Services
  - Dave Coleman, Water Services Director
  - Jennifer Nations, Water Conservation Coordinator
- Brazos Central Appraisal District
- David Smith, Brazos Valley WaterSmart

CITY OF COLLEGE STATION
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BRAZOS VALLEY WATERSMART

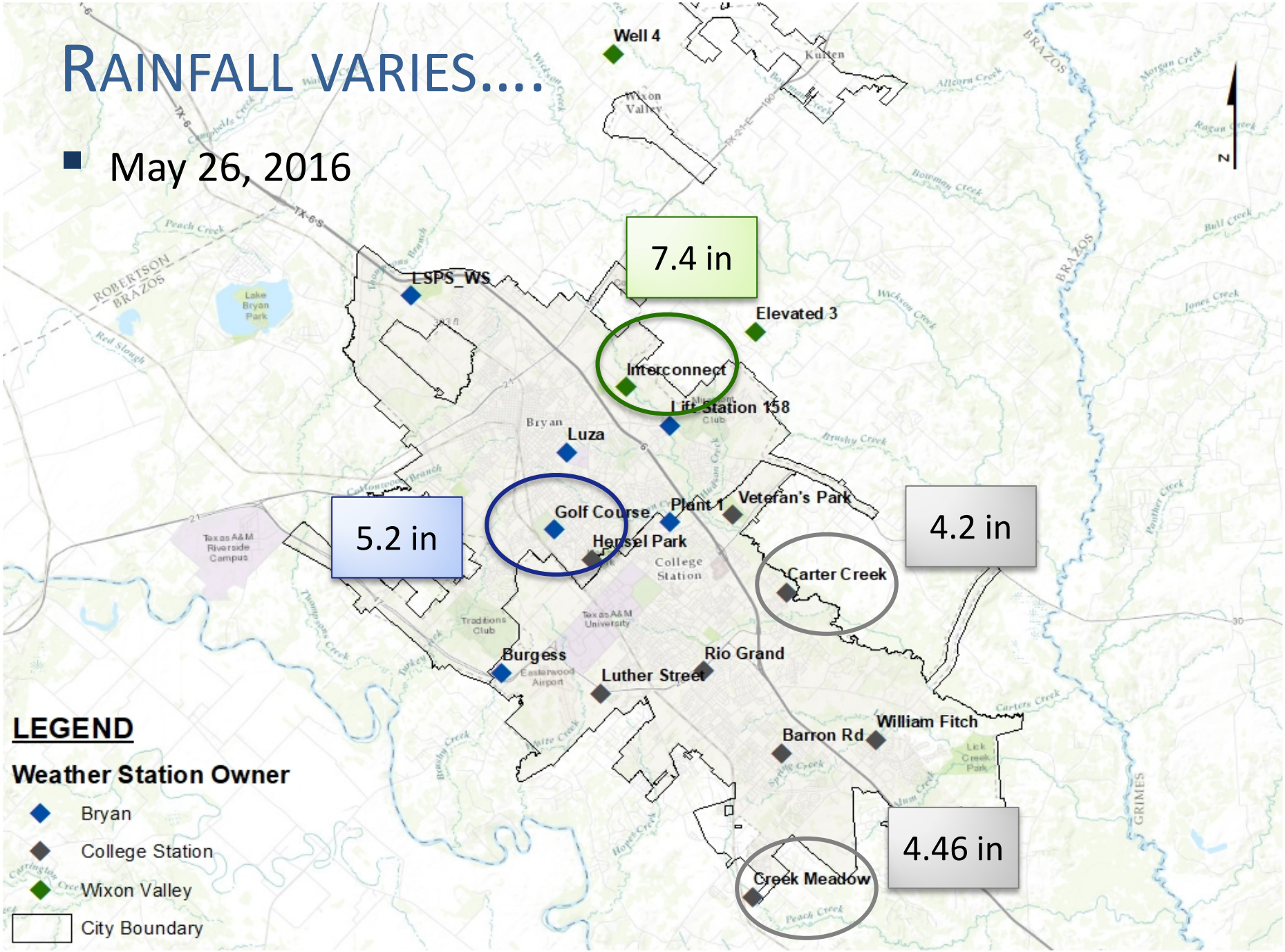
Thank You

REFERENCES

- Burt, C.M., et al, 1997. Irrigation performance measures: efficiency and uniformity. *Journal of Irrigation and Drainage Engineering*, 123:6:423.
- DeOreo, W.B., et al, 2016. *Residential end uses of water, version 2*. Water Research Foundation.
- Gleick, P.H., 2000. A Look at Twenty-first Century Water Resources Development. *Water International*, 25:1:127.
- Glenn, D.T., et al, 2015. Tools for evaluating and monitoring effectiveness of urban landscape water conservation interventions and programs. *Landscape and Urban Planning*, 139:82.
- Lewis, A.C., Khedun, C.P. & Kaiser, R.A., 2017. Coefficients for Estimating Landscape Area on Single Family Residential Lots (In Press). *Journal-American Water Works Association*, 109:8.
- Maupin, M.A., et al, 2014. Estimated use of water in the United States in 2010. 2330-5703.
- Salvador, R., Bautista-Capetillo, C. & Playán, E., 2011. Irrigation performance in private urban landscapes: A study case in Zaragoza (Spain). *Landscape and Urban Planning*, 100:3:302.
- USEPA. WaterSense. <https://www.epa.gov/watersense>, August 20, 2017.

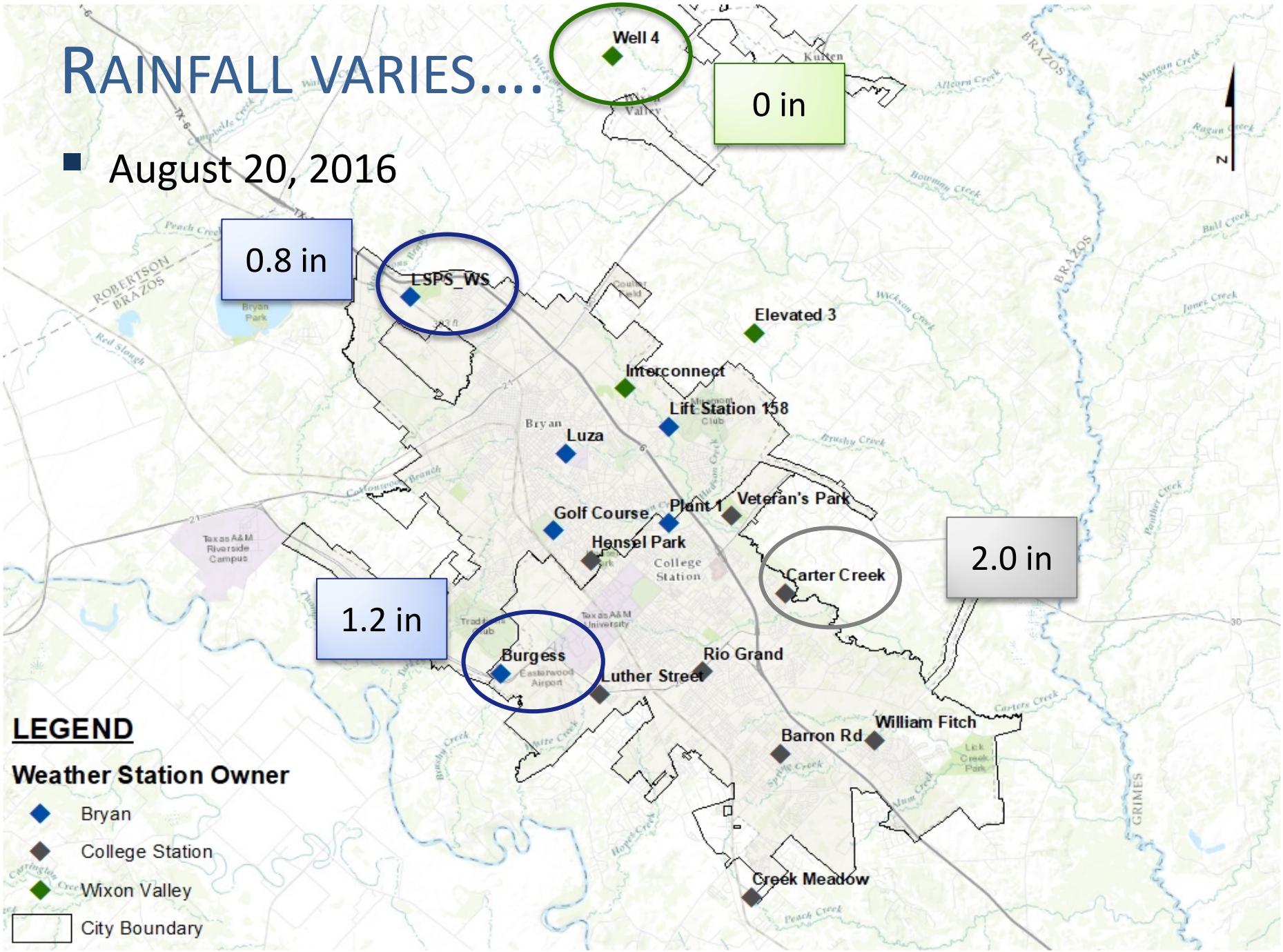
RAINFALL VARIES….

- May 26, 2016



RAINFALL VARIES….

- August 20, 2016



RAINFALL VARIES….

- **Hurricane Harvey**