Water Conservation by the Yard:

Estimating Savings From Outdoor Watering Restrictions

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The goals of the project include:

1) Ensure adequate water for both people and the environment,
2) Reduce future demand for water and foster efficient and sustainable use of current water supplies,
3) Educate the public and decision makers about the impact of wasteful water use and the opportunities for water conservation, and
4) Involve citizens in the decision-making process for water management.

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You can learn more about the Texas Living Water Project at www.texaslivingwaters.org.

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Executive Summary

Outdoor water use, particularly lawn watering, accounts for almost one third of annual residential water use in Texas, and can represent a much higher percentage during our hot, dry summers. Studies show that homeowners have a tendency to overwater landscapes by as much as two to three times the amount needed.

Although conversion to alternative outdoor landscapes that emphasize native vegetation is the preferable long-term approach to reducing outdoor watering, placing limits on the frequency of irrigation of existing landscapes is a more immediate way to reduce excessive outdoor water use and stretch existing supplies. Such limits are among the most cost-effective means of achieving the greatest near-term reductions in municipal per capita water usage. Cities such as Dallas, Frisco, Fort Worth, and The Woodlands recognize that this is a straight-forward approach to achieve substantial water conservation at a minimal cost, and have already implemented ordinances limiting residential irrigation to no more than twice per week.

Based on a review across multiple states (including Texas) of the savings associated with outdoor watering restrictions, we have identified potential water savings of about 8 percent in Texas water planning Region C (Dallas-Fort Worth and surrounding areas) and about 4 percent in Region H (the Houston-Galveston area and neighboring counties) from limiting landscape irrigation to no more than twice per week. These two regions collectively represent about 50 percent of Texas' population and contain some of the fastest growing areas in the state. If outdoor water use were reduced by these estimated percentages across the single-family, multi-family, commercial, institutional, and public sectors, then annual water savings of more than 120,000 acre-feet could be expected in Region C and more than 38,000 acre-feet in Region H based on recent water use levels.Based on projected 2060 water use levels in the 2012 State Water Plan, annual savings in Region C could exceed 230,500 acre-feet and exceed 62,300 acre-feet in Region H.

An "acre foot" is approximately 326,000 gallons of water by volume, this is equivalent to the amount of water that it would take to cover one acre of land to a depth of one foot.

Additional outdoor water savings are attainable through practices that are being embraced by cities in Texas and elsewhere. These practices include encouraging the installation of drip irrigation and evapotranspiration-based (ET-based) irrigation controllers, and promoting water smart landscaping or even limiting irrigated landscape area.

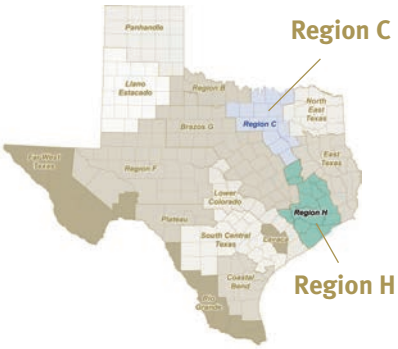
Faced with a Texas state water plan that projects (rightly or wrongly) future water demands that may require over $50 billion of investment—with Regions C and H representing the largest piece of that—water conservation is a less expensive alternative to developing new groundwater or surface water supplies. Water conservation is critical to meeting Texas' water needs. It enables cities to stretch existing water supplies to meet the needs of more people and businesses. Moreover, since that supply and the infrastructure to deliver it has already been developed, that water is less expensive than any future water supplies are likely to be.

Introduction

Multiple studies have shown that outdoor water use can rival the amount of water used indoors (e.g., Utah DNR, 2010; Aquacraft, 2011a). In the early years of water conservation efforts, high-use, low-efficiency appliances such as toilets and washing machines were targets of municipal water conservation campaigns and subsidies. With more efficient plumbing standards for items such as faucets, showers, and toilets in place, and indoor water usage falling, the next critical water conservation opportunity is the yard.

Since outdoor water use is largely discretionary, outdoor watering restrictions have been a first line of defense for municipalities when drought occurs. Drought contingency or other emergency plans commonly call for reduced outdoor irrigation when water supplies are limited. These can range from requests for voluntary action to mandatory restrictions such as no more than twice per week watering, no more than once per week, or only manual watering. Increasingly, restrictions on outdoor watering that were once seen as drought response measures are being included as an ongoing water conservation measure in water conservation plans. Landscape watering restrictions are becoming more widely accepted as a standard practice throughout Texas and elsewhere in the United States as water supplies are tightening.

Why is that? Faced with a Texas state water plan that projects (rightly or wrongly) future water demands that may require over $50 billion of investment—with Regions C and H representing the largest pieces of that—water conservation is a less expensive alternative to developing new groundwater or surface water supplies. Regions C and H account for about one half of Texas' population and are growing at a rapid pace. Between 2010 and 2012, Houston was ranked third in the U.S. in absolute growth, adding more than 61,000 residents ("The fastest growing US cities", 2014). Fort Bend County (southwest of Houston) was the fifth-fastest growing county in the U.S. between 2010 and 2012 (Ryan, 2013). The second (Frisco) and 13th (McKinney) fastest growing U.S. cities between July 2012 and July 2013 were in Region C , while the 15th (Pearland) was in Region H ("Everything is bigger", 2014).



Regions C and H account for about one half of Texas' population and are growing at a rapid pace.

Water conservation is critical to meeting Texas' water needs. It enables cities to stretch existing water supplies to meet the needs of more people and businesses. Moreover, since that supply and the infrastructure to deliver it has already been developed, that water is significantly less expensive than any future water supplies are likely to be.

Conserving water also has environmental benefits. Energy is saved by not having to pump, treat, and distribute water. In addition, there are benefits that stem from allowing more water to remain in aquifers and rivers. Conservation reduces water extraction and avoids additional pumping or diversions that would further reduce the amount of water available to support fish and wildlife habitat in our rivers, bays, and estuaries. Texas' bays and estuaries rely on water flowing downstream from rivers. Conservation will allow more of the precious resource, on which they depend, to reach them. Healthy rivers, bays, and estuaries provide both direct and indirect economic and recreational benefits to fishing and seafood industries, boaters, hunters, wildlife enthusiasts such as bird watchers, and the communities that support these groups.

Why Single Out the Yard?

Typical residential (and commercial) landscapes often require a disproportionately large amount of water to keep them aesthetically pleasing because they contain non-native plants that are not well adapted to Texas' geographically diverse climate.

Under ideal conditions, landscapes should contain plants well adapted to the local region, that is, plants should be selected on the basis of tolerance to local temperature ranges and natural water availability. For many reasons—aesthetic, cultural, lack of selection, personal preference—our planted landscapes are often ill suited to their climates. This is particularly true in the drier parts of Texas. The advent of in-ground irrigation systems has helped perpetuate this unsustainable pattern and resulted in increased landscape water use. During times of ample rainfall, additional water may not be required to support even an ill-suited outdoor landscape. However, during times of average or below-average rainfall, drought, or just the heat of the summer, we often supplement rainfall by using hoses or irrigation systems to keep our yards uniformly green. Non-native plants, especially poorly adapted turf grasses, tend to require more water to keep them looking aesthetically pleasing during the growing season than native plants.

However, a growing body of evidence suggests that even our poorly adapted landscapes could get by with a lot less water than is typically applied, especially if plants are well-established in adequate soil. A Florida study showed that homeowners over-watered as much as 2-3 times the amount needed by plants when compared to climate-based estimates of recommended water replenishment (Hayley et al., 2007). This study also reported that although homeowners used significantly less water in the winter months, when plant water requirements are at a minimum, they are still prone to over-irrigate.

If there is at least six inches of soil, once a week watering is sufficient to maintain a lawn's appearance in Texas (Finch, 2014). Twice per week watering will replenish moisture if soil is shallower than six inches. During severe droughts, watering a lawn with St. Augustine grass on six inches of soil once every two weeks will provide enough water for it to survive (Finch, 2014). More drought-tolerant turf varieties such as Bermuda, buffalo, and zoysia can go even longer without water because they are capable of entering a dormant-like state. Native flowering plants, shrubs, and trees are adapted to long stretches without water.

A growing body of evidence suggests that even our poorly adapted landscapes could get by with a lot less water than is typically applied, especially if they are well-established in adequate soil.

Multiple studies show that at least some segment of the population overwaters and some of those over-irrigators overwater by a very large margin.

Plant water requirements

Recommendations to apply at least an inch of water per week to landscapes during the growing season to compensate for evapotranspiration (ET) are commonly found on the Internet (e.g., Robson, no date) and in homeowner guides (e.g., TCEQ, 2012), but that recommendation is not scientifically based. In fact, determining how much water to apply to a landscape is complicated by plant selection, soil depth, day-to-day weather variability, and the range of efficiency represented by different types of irrigation practices. Multiple studies show that at least some segment of the population overwaters and some of those over-irrigators overwater by a very large margin (e.g., De Oreo, 2011). It is possible to estimate irrigation needs based on knowledge of how much water different plants lose to the atmosphere (i.e., transpiration) and how much water is lost from the soil surface via evaporation under different climatic conditions. In a study conducted by Texas A&M University in College Station, replacing 70 percent of the water lost from a landscape of turf, trees, and shrubs during the summer months through a combination of rainfall and reduced irrigation was sufficient to maintain landscape quality (White et al., 2004). Similar conclusions have been reached in other studies (e.g. Aquacraft, 2006).

The City of Frisco, Texas, uses a weather station and rain gauges to provide residents with weekly watering recommendations based on climate conditions. In 2010, for example, the city advised residents that their lawns did not need any supplemental irrigation 25 out of 52 weeks (TRWD, 2014). In addition, the city only recommended watering more than once per week during three of those weeks. Even during the record drought of 2011, the city recommended no more than twice per week watering during only 11 weeks and no more than once per week watering during eight weeks, with Mother Nature providing what landscapes needed the remaining 33 weeks.

Landscape plant growth in Texas is minimal between November and April (White et al., 2004). During winter, plants need very little supplemental water due to the combination of cool temperatures, periodic rainfall (most years), and plants being dormant or otherwise growing very slowly. During a drought, turf might benefit from a little supplemental watering, but a monthly application of one-half inch would be sufficient (“Winter lawn watering,” 2009).

Effective Measures for Reducing Outdoor Water Use

There is a lot of water to be saved from implementing more efficient landscape irrigation practices. Landscape irrigation is estimated to be the single, largest component of municipal water use, and municipal water use is the second largest use of water in Texas (Cabrera et al., 2013).

Actions that can conserve outdoor water range from selecting drought-tolerant plant species to cities adopting ordinances that reduce inefficient watering practices. Some of these topics were explored by the Texas Living Waters Project in its 2010 report *Sprayed Away*, which highlighted opportunities to reduce outdoor water usage through landscape rebate programs, rainwater harvesting, revamped pricing structures, and watering ordinances (McCormick and Walker, 2010). While the focus of this report is on quantifying the savings that could accrue from watering ordinances, several of those other topics are revisited below as well.

Savings from Watering Restrictions

Cities and towns across the United States started adopting irrigation restrictions more than a decade ago Unfortunately, there is no database one can search to find these examples, and data on the water savings associated with various practices are often hard to find. What follows are data we were able to locate on the water savings from **no more than twice per week watering** restrictions implemented for longer than an emergency period. Watering day limitations are typically paired with time-of-day restrictions (e.g., no watering between 10 am and 6 pm) and prohibitions against wasting water (e.g., no runoff or no watering impervious cover).

EXAMPLES OF SAVINGS FROM OUTDOOR WATERING RESTRICTIONS

- **Fort Worth** has twice adopted no more than twice per week watering restrictions, first in 2011 as a drought measure and more recently in 2013 on a permanent basis; municipal savings were 8 and 9 percent, respectively (Freese and Nichols, 2014).
- **Tarrant Regional Water District** observed an average decline in demand among customers of about 8 percent after Stage 1 drought restrictions that limited watering to no more than twice per week were implemented in 2011 (TRWD, 2014).
- **The Woodlands** saw water usage drop 13 percent from 2012 to 2013 after implementing its no more than twice per week watering ordinance (R. Dailey, personal communication, September 10, 2014).
- **Dallas** has reported savings of more than 7 percent since implementing no more than twice per week watering restrictions in 2012 (C. Davis, personal communication, September 10, 2014).
- **Austin** adopted no more than twice per week watering restrictions in 2009 and realized savings of slightly more than 7 percent over 2006 based on May to October data (D. Gross, personal communication, August 13, 2014; Figure 1).

- **Waukesha, Wisconsin** adopted its no more than twice per week watering ordinance in 2006 and saw a 16.8 percent decline in peak season pumping between 2005 and 2009 (M. Adelmeyer, personal communication, September 8, 2014).
- A **Florida** study of single-family residences reported savings of 12 to 18 percent in two service areas when no more than twice per week watering restrictions were enacted in the early 2000s (Whitcomb, 2006).
- The **St. Johns River Water Management District in Florida** separately documented an 11 percent reduction in water usage across their member cities from 2006 through 2012 from no more than twice per week watering limits (D. Brandes, personal communication, September 8, 2014).

Additional savings associated with no more than *once* per week watering policies have also been documented. Six Florida municipalities saw more than 13 percent savings from that change (Whitcomb, 2005). During the summers of 2012 and 2013, Austin limited watering to once per week due to drought conditions and saw another drop in water usage compared to 2009 when watering was limited to twice per week (**Figure 1**). May to October savings were 6.6 percent in 2012 and 8.8 percent in 2013.

FIG. 1: AUSTIN MAY-OCTOBER WATER USAGE

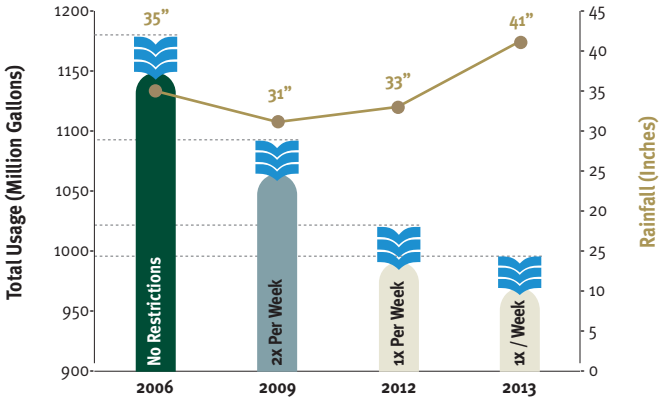


Figure 1: Reduction in Austin's summer municipal water usage over a time period coinciding with implementation of permanent watering restrictions. Its new and permanent year-round conservation program generated savings of just over 7 percent in 2009 when no more than twice per week restrictions were implemented compared with the baseline year of 2006, which represented normal rainfall in addition to unrestricted watering. Temporary Stage 2 drought restrictions implemented in 2012 and 2013 stemming from low reservoir levels limited watering to once per week and generated an additional 6.6 to 8.8 percent savings, respectively, in municipal water usage compared to 2009. Precipitation in 2012 and 2013 was normal to slightly above normal. (Data supplied by D. Gross, personal communication, August 13, 2014.)

As we discovered, water utilities report a wide range of savings from watering restrictions, which appears to reflect their underlying service base (**Figure 2**). Savings rates in the double digits (11 to 18 percent) come from utilities serving primarily single-family homes (data from Florida, Wisconsin, and The Woodlands). The lower savings (averaging 8 percent) are reported by utilities serving a mixture of single-family, multi-family, commercial, and industrial sectors (Dallas, Fort Worth, Austin, and Tarrant Regional Water District). The difference makes sense considering that single-family residences generally use water outdoors to a greater degree than these other sectors. When outdoor usage is curtailed, the largest portion of the savings should come from single-family homes. Since the goal of this report is to project overall municipal water savings, we incorporate the 8 percent savings rate into our calculations starting on page 14.

FIG. 2: PERCENT SAVING FROM WATERING ORDINANCES

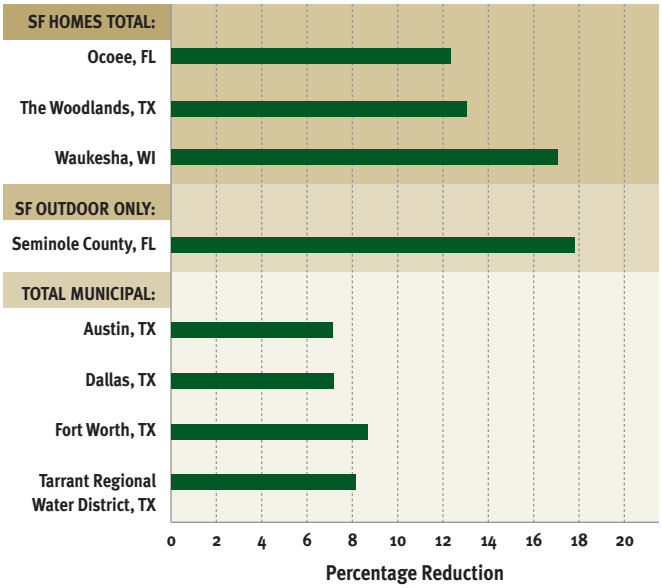


Figure 2: Water conservation savings as reported by water suppliers throughout the U.S. The top 3 bars represent annual savings by single-family homes. The fourth bar represents annual savings from the portion of single-family homes water usage that was applied outdoors. The bottom 4 bars represent annual savings across a range of municipal use categories.

During severe droughts, comprehensive programs to reduce water use that include restricting outdoor watering to no more that twice per week have yielded reductions of 30 percent or more (Kenney et al., 2004; Mini et al., 2014). However, in these studies it is unknown what portion of those savings was a direct result of reducing outdoor irrigation. Moreover, in a crisis situation residents may be

more willing to "tighten their belts" and push down water demand on a temporary basis than they would be if these were ongoing conservation measures. Hence, assigning 30 percent savings to permanent watering restrictions is probably overly optimistic based on available data.

We acknowledge that embedded in the savings reported in Figure 2 may be the effects of other activities aimed at lowering water consumption such as incentive or rebate programs, conservation education initiatives, and even shifts in pricing. There are not sufficient data to tease out other factors. However, water suppliers often point to watering restrictions as yielding the greatest proportion of savings by far. Furthermore, with aggressive public education and enforcement efforts, greater savings than those reported here from no more than twice per week watering restrictions are achievable.

Based on the data available to us, we conclude that municipal water savings of 8 percent from a no more than twice per week watering ordinance is a reasonable projection.

With aggressive public education and enforcement efforts, greater savings than those reported here from no more than twice per week watering restrictions are achievable.

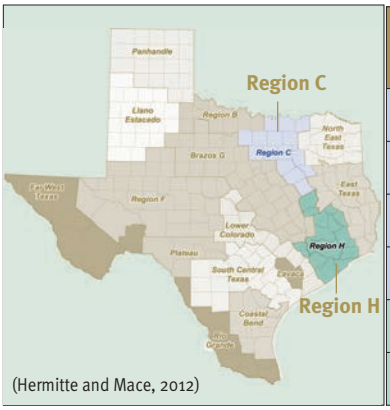
Outdoor Watering in Texas

In 2012, the Texas Water Development Board (TWDB) released a report on outdoor water usage associated with single-family homes in Texas in which they evaluated outdoor consumption patterns for 259 Texas cities from 2004 through 2008 and for 17 Texas cities from 2004 through 2011 (Hermitte and Mace, 2012).

The analysis showed that about 31 percent of single-family residential water consumption on an annual basis goes toward outdoor use, and 80-90 percent of that is applied to lawns, plants, and food gardens. The study also found a gradient in water usage that roughly mirrored the east-west precipitation gradient with drier areas using a larger proportion of water outdoors than wetter areas, though variability within areas was noted.

Using a common methodology of assigning the lowest utility usage record of the year to strictly indoor consumption, the TWDB study computed outdoor water usage as a percentage of total annual usage ranging from a low of 13 percent in Galena Park, Texas, to a high of 64 percent in Gail, Texas, for the period of 2004 through 2008. Average outdoor water usage over the five years ranged from 26 percent to 38 percent. A smaller subset of cities whose data were evaluated for the period from 2004 to 2011 showed a narrower range in outdoor water usage from a low of 20 percent in Houston, Texas, to a high of 53 percent in Tyler, Texas. The overall average still remained at 31 percent.

TABLE 1: ANNUAL AVERAGE WATER USE BY SINGLE-FAMILY HOUSEHOLDS—2004-2011



(Hermitte and Mace, 2012)

City	Water Planning Region	Outdoor Use (gal)	Outdoor Use % of Total	Daily Outdoor Household Use (gal)
Arlington	C	3,806,411,375	36	114
Dallas	C	11,668,235,723	41	125
Fort Worth	C	6,819,864,226	37	97
Garland	C	2,234,119,198	33	100
Houston	H	5,629,024,250	20	37
Katy	H	202,737,375	40	135

Table 2: Annual Outdoor Water Usage by Region C Municipalities		
Region C Cities	Outdoor Use (gal)	Outdoor %
Dallas	11,533,979,620	40
Fort Worth	6,382,544,622	35
Arlington	3,736,446,400	36
Garland	2,249,155,076	33
Frisco	1,912,898,980	46
Irving	1,814,771,400	45
Flower Mound	1,774,098,459	50
Grapevine	1,333,912,362	43
Allen	1,242,558,800	42
Denton	1,070,996,403	40
Mesquite	1,050,005,276	31
Rockwall	645,870,888	43
Hurst	614,847,772	44
Murphy	495,088,230	57
Highland Park	438,324,600	45
Highland Village	430,377,240	51
Corinth	392,687,943	47
Duncanville	380,134,200	33
Wylie	379,867,591	40
Farmers Branch	347,475,200	39
Waxahachie	273,595,305	39
Weatherford	249,872,021	36
Corsicana	246,905,540	43
Athens	180,059,320	43
Ennis	134,189,800	31
Terrell	106,577,000	33
Richland Hills	85,557,492	33
River Oaks	64,853,659	33
Melissa	62,609,937	53
Bonham	49,871,124	29
Lake Worth	46,770,400	32
Bridgeport	45,813,000	27
Fairfield	29,309,175	37
Honey Grove	26,355,802	36
Whitesboro	26,189,288	23
Howe	20,682,180	35
Alvarado	18,814,000	26
Aubrey	18,249,060	32
Ferris	16,746,900	29
Josephine	14,534,830	34
Callisburg	13,086,560	37
Gunter	9,927,204	33
Tioga	9,307,325	31
Bells	8,125,244	23
Emhorse	5,338,468	30
Ladonia	5,045,500	25
Richland	3,040,750	30

Table 2. Data on outdoor water use by single-family residences based on utility records from 2004 to 2008 (Hermitte and Mace, 2012). Data show total gallons used outdoors by single-family residences in an average year and percentage of total water usage that is outdoor use.

If outdoor usage in the Region C municipalities represented in Table 2 is weighted according to the number of single-family connections, the result is that approximately 38 percent of total water use by single-family residences from 2004 to 2008 was outdoor use.

Outdoor water usage by single-family residences in Region C was 38% of total single-family use during 2004 - 2008.

Table 3: Annual Outdoor Water Usage by Region H Municipalities		
Region H Cities	**Outdoor Use (gal)**	**Outdoor %**
Houston	4,909,456,400	18
Sugar Land	879,076,854	33
Friendswood	551,364,400	48
Pasadena	474,770,600	19
Conroe	423,540,620	42
Baytown	297,589,200	24
Katy	157,997,400	35
La Porte	145,508,450	18
Tomball	115,586,200	46
Rosenberg	82,243,820	18
Richmond	76,135,600	26
Humble	66,880,600	26
Sealy	66,818,360	39
Bellville	64,494,812	37
Alvin	57,020,917	15
Hempstead	47,271,651	30
Meadows Place	44,423,500	28
Jacinto City	24,422,686	16
Shenandoah	23,829,800	37
Galena Park	23,547,400	13
Needville	15,185,541	22
Buffalo	14,804,480	25
Brazoria	12,811,560	20
Wallis	8,862,488	26
Daisetta	8,362,784	29
Webster	6,885,000	23
Anahuac	5,745,375	14
Orchard	4,338,790	31
New Waverly	3,894,174	20
Liverpool	3,628,240	38
Midway	3,130,257	20

Table 3. Data on outdoor water use by single-family residences based on utility records from 2004 to 2008 (Hermitte and Mace, 2012). Data show total gallons used outdoors by single-family residences in an average year and percentage of total water usage that is outdoor use.

If outdoor usage in the Region H municipalities represented in Table 3 is weighted according to the number of single-family connections, the result is that approximately 20 percent of total water use by single-family residences from 2004 to 2008 was outdoor use.

Outdoor water usage by single-family residences in Region H was 20% of total single-family use during 2004 - 2008.

A comparison of the two regions shows a marked difference in outdoor water usage (38 percent in Region C versus 20 percent in Region H). Why might that be? Climate likely plays a role in explaining those differences (Vickers, 2001). Not only does Region H receive more rainfall than Region C, it also experiences higher humidity that results in lower rates of evapotranspiration than occur in Region C (Sanford and Selnick, 2013). However, outdoor water usage by single-family homes is highly correlated with a variety of other factors such as age of housing stock, lot size, and assessed value. Newer homes have a greater tendency to have in-ground irrigation systems than older homes, and irrigation systems are associated with high water usage (Aquacraft, 2011b). The 2nd and 13th fastest growing U.S. cities between July 2012 and July 2013 were in Region C ("Everything is bigger", 2014).

Projected Water Savings in Regions C and H from Watering Ordinances

We previously identified an 8 percent savings rate in municipal water use from Texas cities that have implemented no more than twice per week watering restrictions (Figure 2). The majority of those data come from Region C where the average single-family home uses outdoor water above the state average of 31 percent according to the TWDB (Hermitte and Mace, 2012).

Using data assembled by the TWDB in support of their outdoor water use report, we calculated weighted averages of single-family outdoor water usage at 38 percent for Region C and 20 percent for Region H. Because outdoor water usage by single-family homes in Region H is about half of that of Region C, and because single-family homes use more water outdoors than other municipal categories, for purposes of projecting water savings from no more than twice per week watering restrictions in the two regions, we have chosen to reduce the projected savings to 4 percent in Region H while maintaining the 8 percent savings rate for Region C.

From available data, we anticipate that limiting outdoor watering to no more than twice per week would yield savings of about 8 percent across municipal water providers in Region C and of about 4 percent in Region H.

We can use the 2010 municipal demand values included in the 2012 State Water Plan for Regions C and H as the starting point for savings calculations from recent use levels. If we multiply municipal demand by the estimated savings from watering ordinances, we generate annual savings of more than 120,000 acre-feet per year in Region C and more than 38,000 acre-feet per year in Region H (**Table 4**).

TABLE 4 : 2010 ESTIMATED SAVINGS

	2010 Municipal Demand (af-yr)	2x Per-Week Savings (%)	Water Savings (af-yr)
Region C	1,512,231	8	120,978
Region H	968,949	4	38,758

Table 4. Estimate of municipal conservation savings from implementing practices that would limit outdoor irrigation across the municipal sector to no more than twice per week. Municipal demand for the year 2010 comes from the 2012 State Water Plan (TWDB, 2012). The projected percentage savings were identified in the prior section of this study. Water savings (right column) were generated by multiplying the columns to the left.

TABLE 5 : 2060 ESTIMATED SAVINGS

	2060 Projected Municipal Demand (af-yr)	2x Per-Week Savings (%)	Water Savings (af-yr)
Region C	2,882,356	8	230,588
Region H	1,558,706	4	62,348

Table 5. Estimate of municipal conservation savings from implementing practices that would limit outdoor irrigation across the municipal sector to no more than twice per week. Projected municipal demand for the year 2060 comes from the 2012 State Water Plan (TWDB, 2012). The projected percentage savings were identified in the prior section of this study. Water savings (right column) were generated by multiplying the columns to the left.

Limiting outdoor watering to no more than twice per week across all municipal use sectors could achieve savings from recent use levels of more than 120,000 acre-feet in Region C and 38,000 acre-feet in Region H annually. Based on projected 2060 water use levels, annual savings in Region C would exceed 230,500 acre-feet and exceed 62,300 acre-feet in Region H.

Because we based our calculations on data collected before the implementation of no more than twice per week restrictions, the savings we calculate here represent new savings. Some of those savings are already being realized as municipalities such as Dallas, Fort Worth, Frisco, and The Woodlands have adopted ordinances limiting residential watering to a maximum of two days per week.

Limiting outdoor watering not only has the direct effect of reducing water use, it may also have the indirect payoff of eliminating the need to build costly new infrastructure that is intended to meet transitory summer demands. Because outdoor watering is often the primary factor in summer "peak" water use that drives the size of water treatment and delivery infrastructure, targeting outdoor usage through water conservation programs can translate into significant infrastructure cost savings. Because of the peak capacity issue, total cost savings from reduced landscape water use can be much larger than the savings represented by outdoor water conservation alone.

Recognizing the value of reducing wasted landscape water, the largest regional water providers and cities in Region C (North Texas Municipal Water District, Tarrant Regional Water District, Upper Trinity Regional Water District, the Trinity River Authority, and the cities of Fort Worth and Dallas) have collaborated and agreed to start encouraging their customers to implement a year-round, no more than twice per week watering schedule. In fact, Tarrant Regional Water District identified implementation of a maximum twice weekly watering schedule among member cities as the single conservation measure that would achieve the greatest five-year reduction in per capita water use (TRWD, 2014). Unfortunately, only a few municipalities and water utilities have implemented no more than twice per week watering schedules on a permanent basis.

Of course, water conservation savings will only accrue to the degree that ordinances are adopted and followed. Enforcement and enforceability are key to achieving desired water savings. Studies have shown that lack of enforceability often hinders the effectiveness of water conservation measures (Whitcomb, 2006). Successful irrigation ordinances specify watering days by address or associate watering days with garbage collection. The City of Conroe, while moving in the right direction by adopting a year-round, no more than twice per week watering program in 2013, has left the door open to non-compliance by allowing individual residents to choose any two days per week they wish to water.

We all know that old habits die hard and altering watering behavior requires campaigns to re-educate the public. Ordinances, by themselves, only set the foundation for irrigation water savings. The greatest outdoor water conservation savings are achieved when homeowners are educated not only about proper irrigation practices, but also on irrigation system maintenance, and good landscape management practices. With the ongoing drought in Texas, many cities have beefed up online resources to educate residents about water conservation. Dallas Water Utilities and Tarrant Regional Water District have been promoting their Lawn Whisperer campaign for the past three years. The multi-media campaign educates homeowners that their lawns need no more than two waterings per week, even in drought-stricken North Texas. And by tracking the weather, the Lawn Whisperer tells followers when enough rain has fallen so that they can cancel waterings or consider delaying watering if rain is expected. The program is highly effective, with more than three quarters of residents surveyed saying that the Lawn Whisperer campaign was the major reason they changed their water use habits (Litterski, 2013).

Elements of Successful Watering Ordinances

The best watering rules or ordinances governing outdoor water use limit sprinkler irrigation to no more than twice per week while also restricting watering during the hottest and windiest part of the day. They may also restrict watering during precipitation or freeze events. These rules tend to prohibit water waste—such as leaks and excessive runoff or watering of sidewalks or other impervious surfaces—and may limit the length of time a sprinkler station can run and cycles per day. Some cities have decided to differentiate the spring/summer growing season from a fall/winter dormant season by specifying that no more than twice per week watering may occur during Daylight Savings Time (from March through October) and no more than once per week watering may occur the rest of the year. Florida, for example, enforces watering ordinances irrespective of the source of water (i.e., private well versus municipal water supply), a practice different from what is occurring in some Texas cities where homeowners are tapping private wells to circumvent watering restrictions. An outdoor watering ordinance could include some or all of these concepts.

Below is a sample watering ordinance that includes time-of-year, day-of-week, and time-of-day provisions, as well as language to address water runoff, maximum irrigation application rates, and freezing conditions.

In addition, municipalities should adopt requirements that irrigation systems be inspected at the same time as initial backflow preventer inspection and periodically thereafter, and that prohibit the operation of poorly maintained sprinkler systems that waste water.

A MODEL ORDINANCE[1]

1. When Daylight Savings Time is in effect (approximately March – October), landscape irrigation shall occur only in accordance with the following irrigation schedule:

a. Residential landscape irrigation at odd numbered addresses or no address may occur only on Wednesday and Saturday and shall not occur between 10:00 a.m. and 6:00 p.m.; and

b. Residential landscape irrigation at even numbered addresses may occur only on Thursday and Sunday and shall not occur between 10:00 a.m. and 6:00 p.m.; and

c. Non-residential landscape irrigation may occur only on Tuesday and Friday and shall not occur between 10:00 a.m. and 6:00 p.m.; and

d. No more than 1 inch of water may be applied per irrigation zone on each day that irrigation occurs, and in no event shall irrigation occur for more than 1 hour per irrigation zone on each day that irrigation occurs.

2. When Central Standard Time is in effect, landscape irrigation shall occur only in accordance with the following irrigation schedule:

a. Residential landscape irrigation at odd numbered addresses or no address may occur only on Saturday; and

b. Residential landscape irrigation at even numbered addresses may occur only on Sunday; and

c. Non-residential landscape irrigation may occur only on Tuesday; and

d. No more than ¾ inch of water may be applied per irrigation zone on each day that irrigation occurs, and in no event shall irrigation occur for more than 1 hour per irrigation zone on each day that irrigation occurs.

3. In addition to the limitations listed above, all landscape irrigation shall be limited in amount to only that necessary to meet landscape needs.

4. No outdoor watering of landscapes is allowed during precipitation events or when temperatures are below 40°F.

5. Waste of water from landscape irrigation, including watering of impervious surfaces and significant water runoff flowing away from irrigated areas, is prohibited at all times.

1 https://georgetown.org/planning/files/2012/12/Bulletin-111-Water-Conservation-Ordinance1.pdf

Other Water-Saving Landscape Measures

Watering ordinances that target the water waste associated with overwatering landscapes by limiting landscape watering are an important step in reining in our wasteful discretionary water use. In fact, there may not be another single, municipal water conservation strategy that can generate savings as quickly, inexpensively, and as painlessly. However, this strategy should be considered an interim step in achieving significant reductions in outdoor water use. There are other practices being adopted in Texas and elsewhere that will further reduce outdoor water use. These practices are directed at saving water by encouraging water-efficient landscape design, minimizing irrigated landscape area, and installing state-of-the art irrigation systems.

Water Smart Landscaping

The greatest savings in outdoor water conservation will likely come from conversions to what is called water smart landscaping (i.e., landscaping and gardening that reduce or eliminate the need for supplemental water). Such landscaping emphasizes native plants that are well adapted to the prevailing climate. With its arid and hot climate and ever-declining water supply, Nevada has been very aggressive in banning turf in new developments and subsidizing the conversion of existing high water-demanding plantings to desert-adapted landscapes. A study conducted by Aquacraft (2000) documented a reduction of nearly 40 percent in outdoor water use associated with landscape conversions to types that were suited to the Nevada climate. Follow-up research by the Southern Nevada Water Authority has shown that for every 10 customers that convert turf to a Water Smart Landscape, one will have no water savings, one will have increased water usage, and eight will save water. Overall, they have documented annual savings of 55 gallons per square foot converted (Bickmore and Francis, 2014). In Southern California, a turf conversion program of the Metropolitan District yielded an 18 percent reduction in water use by participating single-family homes (Ramos, 2014).

Limiting Irrigated Landscapes

Georgetown, Texas, adopted a comprehensive array of irrigation measures in 2014 to reduce outdoor usage. As of June 1, new construction must meet the following requirements:

- Irrigated turf area of the lawn is limited to 2.5 times the foundation footprint area of the house or 10,000 square feet, whichever is less. The limit does not apply to non-irrigated space such as natural areas or landscaped areas such as flower beds that are irrigated with drip irrigation or bubblers. The limitation does not affect the overall size of a residential yard.
- When a lot is developed, the irrigated turf area is required to have at least six inches of soil. Areas of a residential lot left in its natural state are exempt from the soil depth requirement.
- Turf grass should be a variety that is dormant in the hot summer months and has less need for water. Turf grasses, such as St. Augustine, that require more water can only be used in shady areas of a lawn.

Other elements of the ordinance include requirements for rain sensors and soil moisture sensors on irrigations systems and the placement of irrigation spray heads at least four inches from paved surfaces to reduce overspray. This type of proactive approach is helpful in making new development more water efficient. Many cities in Texas are growing and adding new housing at a rapid rate. Putting an ordinance in place that provides for efficient landscape watering from the beginning is a step in the right direction.

Landscape regulations for efficient irrigation that apply to new development can be found in other parts of the country. For example, Tampa Bay, Florida, limits turf with a permanent irrigation system to 50 percent of landscaped area (Hazen and Sawyer, 2005). Desert cities in Nevada, New Mexico, Arizona, and California have adopted similar measures restricting the extent of irrigated landscaping and/or plant materials. In Texas, the City of Boerne has taken the step of limiting turf grasses planted at all new residential and commercial development within the city limits to zoysia, buffalo, or Bermuda grasses or other grasses approved by the city.[2]

The greatest savings in outdoor water conservation will likely come from conversions to what is called water smart landscaping.

2 http://www.isatexas.com/members/ordinances/boerne.htm, accessed 11/17/14

Water-Saving Irrigation Measures

Not all irrigation practices are equal; some are more efficient than others. Nonetheless, water can be over-applied to a landscape no matter the application system. It is the human operator who ultimately controls the application rate.

Drip irrigation is considered the most efficient irrigation system since it applies water directly above the root zone of plants rather than spraying it in the air, as sprinkler heads do, where it can evaporate. But even drip irrigation is subject to misuse and some municipalities (e.g., San Antonio) restrict the hours that drip irrigation can be used in drought situations. Special care should be taken when specifying irrigation equipment or types in ordinances. There can be unintended consequences.

Evapotranspiration-Based Irrigation

Our understanding of how to optimally irrigate landscapes continues to advance. New technologies such as "smart" irrigation controllers and wireless soil-moisture sensors offer potential efficiency improvements. Determining the least amount of water that can be applied to maintain acceptable landscape appearance and health is the goal of a lot of current evapotranspiration (ET) research by agronomists, horticulturalists, and landscape experts. Derivation of ET factors is purposefully location-specific, and the sponsor decides what replenishment factor, typically 40 to 70 percent of replacement moisture, to use in developing irrigation guidance. Texas universities have teamed up with cities like Fort Worth and Waco to develop these factors and make this information available to the public. Texas A&M AgriLife Extension has an online calculator at http://texaset.tamu.edu as part of its Irrigation Technology Program that irrigators—from homeowners to farmers—can use to determine watering requirements for their landscape in select parts of the state.

A 2009 study in Utah found that the majority of overwatering occurred at the end of the growing season (August through October) when automatic timers on sprinkler systems had not been adjusted to lower ET requirements (Utah DNR, 2010). In Texas, it is likely the months of September and October when overwatering is likely to occur based on this premise. Of course, watering during the months of November through March is still a common practice and generally equates to overwatering. ET-based irrigation systems can be advantageous in matching the quantity of water applied to a landscape to a scientifically-derived value.

However, ET-based irrigation has its drawbacks. The information being shared with the public will never be able to account for all the nuances of individual yards such as soil depth, exposure, exact plant mix, and so on. In addition, because in each community some fraction of households under-irrigate, ET-based irrigation could actually increase outdoor water usage among a segment of the population (Aquacraft, 2009). Unless a homeowner owns a smart controller, they would have to adjust an irrigation system by themselves on a weekly basis, something a lot of people find difficult to do. Moreover, most people do not know how much water their sprinkler system or even a hand-held hose emits so that directing residents to apply one half inch or three quarters of an inch may be largely meaningless in many cases. A concise summary of the opportunities and challenges, as well as current references, can be found in Cabrera et al. (2013).

Drip Irrigation

Drip irrigation exceeds 90 percent efficiency compared to conventional sprinkler systems that typically range from 50 to 70 percent efficiency (Wilson and Bauer, 2014). Drip irrigation achieves higher efficiency because water is delivered under low pressure directly to plants and much more slowly than with sprinkler irrigation. Water dripped to plants is not subject to loss from runoff, wind, and evaporation. It is ideal for sloping terrain where water is more likely to runoff before it can penetrate the soil if applied via a spray system. Drip irrigation has the additional benefit of helping to maintain a desirable balance of air and water in the soil through its low-volume application of water, which facilitates even soil moisture and healthy plant growth (Wilson and Bauer, 2014). But drip systems do not work well for lawn irrigation because of the difficulty of spreading the water evenly. As with any irrigation system, proper installation and maintenance are key to achieving high quality results, and it is possible to waste water through over-irrigation with any system.

As with any irrigation system, proper installation and maintenance are key to achieving high quality results, and it is possible to waste water through over-irrigation with any system.

Conclusion

The bottom line: significant water savings could be achieved if Texas cities adopt ordinances restricting outdoor watering to no more than twice per week.

Using data culled from Texas and other states, we calculated an 8 percent savings rate for Region C and 4 percent for Region H, annual savings that could easily exceed 120,000 acre-feet and 38,000 acre-feet from recent use levels, respectively, by reducing the frequency of landscape irrigation. Based on projected 2060 water use levels, annual savings in Region C could exceed 230,500 acre-feet and exceed 62,300 acre-feet in Region H.

We are confident that with public education efforts, enforcement, and adoption of year-round restrictions (i.e., of no more than twice per week watering during the spring and summer, and no more than once per week watering during the fall and winter) that at least 8 percent savings is achievable in Region C and at least 4 percent savings is achievable in Region H. These practices would meet the needs of managed landscapes while also providing economic and environmental benefits. Long-term measures to further reduce discretionary, outdoor water usage include encouraging installation of or conversion to water smart landscapes, limiting irrigated areas in new development, and promoting technology such as ET-based smart controllers and wireless moisture sensors. All of these measures, and more, are already being implemented by cities throughout Texas. The entire state should follow their lead.

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