LANDSCAPE SIZING IN SANTA ANA HEIGHTS – A MODEL TO EFFICIENTLY SIZE LANDSCAPE AREA FOR ANY COMMUNITY

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Irvine Ranch Water District is a recognized leader in water use efficiency. One of the key elements is its unique rate structure, adopted in 1991. A tiered rate billing system based on a water budget allocation was established to encourage conservation and discourage substandard irrigation systems. The rate structure is based upon providing customers with the water they need at the lowest rates in Orange County ($0.75 per CCF). Inefficient use is penalized with higher rates, ranging from $1.50 to $6.00 per CCF. Since the introduction of this rate structure, water consumption has dropped significantly, while the health of the landscape has improved.

By 1997, inclining rates and outreach education programs had accounted for a reduction of 29.8 inches of water per year.[1] From 1994 to 1997 a visual assessment study of the turf at 16 different sites was conducted comparing turf appearance prior to 1991. The study showed that despite the reduction in allocation due to the introduction of the new rate structure, turf quality either improved or remained unchanged. Sites that were initially poor prior to the introduction of the new rate structure improved the most.[2] Since 1991, water use has dropped from an average of 4.4 acre foot per acre to 2.2 acre foot per acre. In the year 2000, the number of acres that were developed in IRWD's service area doubled, yet water use only increased by 3% over water use in 1992.

IRWD'S SINGLE-FAMILY RESIDENTIAL RATE STRUCTURE

Tier	Rate Per CCF	Use (As a Percent of Allocation)
Low Volume Discount	$0.59	0-40%
Conservation Base Rate	$0.75	41-100%
Inefficient	$1.50	101-150%
Excessive	$3.00	151-200%
Wasteful	$6.00	201% +

Effective July 1, 2003
1 CCF = 748 gallons

RESIDENTIAL USE

IRWD's residential use has dropped from 0.32 AF/yr/customer in 1989-90 to 0.28 AF/yr/customer in 2002-03. This is a 12.5% decrease in residential use per customer. The residential water use per customer for Los Alisos (an area annexed to IRWD, but not yet on IRWD's water-budget rate structure) was 0.35 AF/yr/customer in 2002-3. This is 25% higher than the IRWD use per customer.

WATER BUDGET ALLOCATION

Upon introducing this new billing system to its customers, Irvine Ranch Water District was keenly aware of its responsibility in making sure their customers would be confident in and accept the new system. It was important that their customers understood that the new rate system was structured to encourage conservation and efficient irrigation, and not simply to limit allocation for the sole purpose of collecting revenue by penalizing customers. The key to doing this was by developing valid, scientifically based numbers for calculating customer allocations.

Looking at the following equation, all of the figures are readily available, even landscape size. The majority of IRWD's service area is made up of planned communities. This unique situation makes it relatively simple to come up with landscape area. IRWD uses a standard default of 1350 sq. ft of irrigated landscape for calculating single-family residential allocations.

$$\textbf{Single Family Allocation} = \frac{Kc \times ET \times LA(acres)}{Eff.} + \text{Indoor Use (4 people per home/ 3 CCF/person per month (billing period))}$$

CCF = 100 cubic feet = 748 gallons

Kc

The relative amount of water needed to irrigate the landscape. When determining the crop coefficient for Irvine Ranch Water District customers it is assumed that all of the irrigatable area is covered with cool-season turf.

Et (reference ET)

The amount of water that evaporates into the air and the amount of water that is transpired through the vegetation. Evapotranspiration numbers are computed daily from all three of Irvine Ranch Water District's weather stations. Adjusted daily. Multiply by 36.3 to convert to CCF.

Indoor Use

Each customer (single family residence) is automatically allocated 3 CCF, per person per month for 4 people or, a total of 12 CCF (12 x 748 gallons = 8976 gallons) per month.

LA

Landscape area in acres. IRWD has established 1,350 sq.ft. as the universal landscape area default for single family residences. The allocation assumes that 100% of the landscape is cool-season turf grass. Irvine Ranch Water District will provide a variance to any property owner that shows that their situation requires a larger allocation of water for their property. Divide sq.ft. by 43,560 to convert to acres.

Eff.

Efficiency. This is the efficiency of the irrigation system. Irvine Ranch Water District assumes 80%.

APPLICABILITY TO OTHER AREAS

Since the water-budget based rate structure is working so well, other districts have become interested in the same type of system in order to encourage water use efficiency. However, most of the communities within IRWD's service area have been built in the last twenty-five years. Since almost every single-family residence is located within a planned community, IRWD's method for establishing landscape allocation is not necessarily transferable to other cities or water districts.

In 1997, Irvine Ranch Water District acquired the community of Santa Ana Heights. Santa Ana Heights is very different than the rest of IRWD's service area and is mostly made up of single-family residences built in the 1950's. It is not a "cookie cutter" community like Irvine. Parcel sizes range from 4,000 square feet to 140,000

square feet, with most falling in a range between 7,000 to 10,000 square feet. Santa Ana Heights is not a community where Irvine Ranch Water District can simply base its water allocation on a default of 1,350 square feet of irrigated area per household. IRWD needed to develop an alternative methodology for calculating irrigated area that would give Santa Ana Heights customers an equitable allocation based upon site.

INSURING CUSTOMER CONFIDENCE IN ALLOCATION DETERMINATION

Landscape area is the only variable in the allocation formula that cannot be universally determined based on Irvine Ranch Water District's original method. The Kc, ET, and Indoor Use numbers that are used are selected to allocate the most amount of water in the most extreme conditions, (100% cool season turf grass), while always providing enough water for four people whether four people reside in the home or not. In addition, any customer can apply for a variance to address specific circumstances. So if a universal methodology to establish allocation levels for different communities is to be established, landscape area measuring must be studied.

MEASURING LANDSCAPE AREA

There are a number of ways to determine landscape area.

- Actual physical measurement using a measuring wheel.
- Using ArcView or a similar program to measure aerial photographs of parcels.
- Using aerial photographs and infrared imagery to measure parcels.

These are just a few methods for measuring landscape areas within lots. Each one has its advantages and disadvantages. When choosing a method of measurement, the level of pinpoint accuracy has to be weighed against the cost of obtaining the data to develop allocation levels. If the cost to obtain area measurements equals or exceeds the cost in water that is saved, the method is impractical.

MEASURING METHOD

For this study, we chose to use ArcView along with the aerial photographs of the Santa Ana Heights community. Lot size data was obtained from the county assessor and confirmed using ArcView. The cost for the photography and setup in ArcView was around $24,000. Resolution was approximately 6" per pixel. ArcView allowed us to trace polygons around the hardscape of each property and subtract the hardscape area from the total lot size to calculate the irrigatable area, or landscape area. It takes about one minute to measure the total lot size and the hardscape. Using this method of measurement, the only question in accuracy is in identifying landscape or hardscape that is hidden underneath any sort of canopy.

Sample aerial image of Santa Ana Heights

THE IMPORTANCE OF ACCURACY AND MEASURING

The accuracy of measuring using ArcView was found to be within 10% of manual measurements and about 10% compared with infrared measurements. The following example shows the difference in allocation with roughly a 10% (500 sq.ft.) difference in landscape area:

$$\text{Alloc.} = \frac{\text{Kc x ET x LA(acres)}}{\text{Eff.}} + \text{Indoor Use}$$

Assume:

Kc - .907 average for month

Et - 4.2 total for month (multiply by 36.3 to convert to CCF)

LA - Convert 4,500 sqr.ft to acres = 4500/43560 = **.1033 acres**

5,000 sqr.ft to acres = 5000/43560 = **.1148 acres**

Eff. – 80%

Indoor Use – 4 people x 3 CCF per person

For 4,500 sq.ft. of landscape

$$\text{Alloc.} = \frac{.907 \times (4.2 \times 36.3) \times .1033}{.8} + (4 \times 3) = \textbf{29.86 CCF}$$

For 5,000 sq.ft. of landscape

$$\text{Alloc.} = \frac{.907 \times (4.2 \times 36.3) \times .1148}{.8} + (4 \times 3) = \textbf{31.84 CCF}$$

The difference is **1.98 CCF**. Again, when determining allocations the level of conservation must be weighed against the cost of pinpoint accuracy and the confidence of the customers. Manually measuring each property and then measuring the hardscape within that property may be more accurate, however manual measurements are extremely impractical for a whole district and are still subject to error.

The following is a summary of our measurements. We categorized the lots by sizes, taking samples in 1,000 square foot increments, starting at the smallest lots of 4,000 sqr.ft. up to 12,000 sqr.ft., at which point we increased the square footage of the categories. Out of a total population of 1,380 for all categories, our sample size was 437.

Lot Sizes (Sq. Ft)	Total Pop.	Sample Size	Median Lot Size	Median Landscape Size	Median Landscape %	Max. Landscape Size with 1 Std.Dev.	Max. Landscape Size with 2 Std.Dev.
4,000 - 5,000	59	40	4332	1358	31%	1,866	2,301
5,000 - 6,000	59	50	5750	2225	39%	2,793	3,314
6,000 - 7,000	160	50	6267	3015	48%	3,614	4,161
7,000 - 8,000	414	50	7368	3735	51%	4,276	4,850
8,000 - 9,000	346	50	8686	4433	51%	5,315	6,149
9,000 - 10,000	103	50	9506	5080	53%	5,862	6,674
10,000 - 11,000	56	50	10473	5532	53%	6,566	7,582
11,000 - 12,000	37	30	11597	6384	55%	7,888	9,413
12,000 - 16,000	44	30	13819	7607	55%	9,082	10,637
16,000 - 80,000	95	30	19800	12531	60%	25,448	36,039
80,000 - 140,000	7	7	114715	85229	74%	99,012	113,280

SIZING LANDSCAPE

The ultimate goal is to develop a cost-effective methodology for sizing landscape areas for any district that is accurate in determining water allocations for single-family residences. The key factors are as follows:

- Insure customer confidence in allocation determination
  - Include landscape areas that fall within 1 standard deviation of mean, not median lot size.
- Develop allocation that truly promotes efficient irrigation practices
  - Include landscape areas that fall within 1 standard deviation of mean, not 2 standard deviations from mean.
- Develop a method that can be used universally in any community for a nominal cost
  - Method cannot require individual measurements, only lot sizes required. Any district can obtain lot sizes using Track Map data.

Landscape area is a percentage of the total parcel or lot area. If a ratio can be established showing landscape area to total lot size, allocation can be based upon this ratio.

The objective of this study was to develop a ratio that can be used in any community that is broken down by lot size, for instance every 1000 square feet. Using the ratio, the district would only need total lot size to calculate landscape percentages. If this method does not work for a certain district, the district could take samples of lots in each total square footage category, 4,000, 5,000 etc., and measure the samples to get their own ratio. However, the following will demonstrate that the ratios in this study should apply everywhere, when landscape areas that fall within 1 standard deviation are included.

ALLOCATION AND 1 STANDARD DEVIATION

The following table shows the calculated water allocations for Santa Ana Heights for the months of August ’02 and September ’02. These examples represent a good sample of the total population for all categories. Columns A and F show actual water use, whereas Columns B and G show allocation based on the median landscape area for the total lot category; 6,000 – 7,000 square feet and 7,000 – 8,000 square feet. Columns D and I show the allocation based on the median landscape area for the same lot category with landscape size increasing to include landscape areas 1 standard deviation from the mean. In this case, 95.5% of the properties will be provided with enough water without a need to request a variance. When looking at Columns E and J, it is clear that some customers have used less water than they would be allocated, but at the same time some customers have used more than what they would be allocated. These over-allocation customers would either need a variance, or be penalized and encouraged to investigate the efficiency of their irrigation system. The difference in allocation from Columns B and G versus Columns D and I is quite small, roughly 2 to 3 CCF, however, the number of variances, and the number of customer complaints drops significantly, since the number of landscape areas that are included at the standard rate level increases from 68.8% to 95.5%.

If the allocation is based on the landscape area to include lots within 2 standard deviations, 99.7% would be included and the emphasis on conservation would be less significant. If the allocation is based on the average landscape area, 68.8% of the customers would not need a variance. That leaves 31.2% of customers that will possibly be requesting variances. This would not build confidence in the rate structure.

Basing the allocation on the size of lots where the landscape area falls within 1 standard deviation of the average landscape area size encourages conservation, and provides the customer with a level of confidence in the water-budget based rate structure.

ALLOCATION (CCF) BASED ON MEDIAN LANDSCAPE AREAS AND LANDSCAPE AREAS THAT FALL WITHIN 1 STANDARD DEVIATION OF MEAN

6,000 - 7,000 SQUARE FOOT LOTS		A	B	C	D	E	F	G	H	I	J
Account Street Name	Total Area	AUG02 Used	Alloc.based on Median Size 6-7,000 sqr.ft.	Over Allocation (Difference) CCF	Alloc.based on 1 Std.Dev.	Over Allocation (Difference) CCF	SEP02 Used	Alloc.based on Median Size 6-7,000 sqr.ft.	Over Allocation (Difference) CCF	Alloc.based on 1 Std.Dev.	Over Allocation (Difference) CCF
E. Wilson	6600	54	24.61	29.39	27.12	26.88	31	22.41	8.59	24.48	6.52
Norse	6900	16	24.61	-8.61	27.12	-11.12	18	22.41	-4.41	24.48	-6.48
Brentwood	6125	29	24.61	4.39	27.12	1.88	32	22.41	9.59	24.48	7.52
24th Place	6873	20	24.61	-4.61	27.12	-7.12	21	22.41	-1.41	24.48	-3.48
Brentwood	6284	18	24.61	-6.61	27.12	-9.12	38	22.41	15.59	24.48	13.52
Orange	6558	21	24.61	-3.61	27.12	-6.12	25	22.41	2.59	24.48	0.52
E. Wilson	6268	26	24.61	1.39	27.12	-1.12	33	22.41	10.59	24.48	8.52
E. Wilson	6930	23	24.61	-1.61	27.12	-4.12	35	22.41	12.59	24.48	10.52

Median landscape area for lots that are 6,000 - 7,000 sqr.ft is - 3,015 sqr.ft.
Landscape area within 1 standard deviation for lots that are 6,000 - 7,000 sqr.ft is - 3,614sqr.ft.

7,000 - 8,000 SQUARE FOOT LOTS		A	B	C	D	E	F	G	H	I	J
Account Street Name	Total Area	AUG02 Used	Alloc.based on Median Size 7-8,000 sqr.ft.	Over Allocation (Difference) CCF	Alloc.based on 1 Std.Dev.	Over Allocation (Difference) CCF	SEP02 Used	Alloc.based on Median Size 7-8,000 sqr.ft.	Over Allocation (Difference) CCF	Alloc.based on 1 Std.Dev.	Over Allocation (Difference) CCF
Bay Farm	7200	38	27.62	10.38	29.89	8.11	44	24.90	19.10	26.77	17.23
Orchid Hill	7291	36	27.62	8.38	29.89	6.11	28	24.90	3.10	26.77	1.23
Orchid Hill	7199	24	27.62	-3.62	29.89	-5.89	57	24.90	32.10	26.77	30.23
Norse	7300	30	27.62	2.38	29.89	0.11	38	24.90	13.10	26.77	11.23
Santa Isabel	7487	15	27.62	-12.62	29.89	-14.89	18	24.90	-6.90	26.77	-8.77
24th Place	7557	41	27.62	13.38	29.89	11.11	35	24.90	10.10	26.77	8.23
E.Wilson	7835	42	27.62	14.38	29.89	12.11	46	24.90	21.10	26.77	19.23
Westminster	7794	12	27.62	-15.62	29.89	-17.89	13	24.90	-11.90	26.77	-13.77

Median landscape area for lots that are 7,000 - 8,000 sqr.ft is - 3,735 sqr.ft.
Landscape area within 1 standard deviation for lots that are 7,000 - 8,000 sqr.ft is - 4,276sqr.ft.

CONCLUSION

The reason for setting allocation limits is to encourage conservation and efficient irrigation practices. It is important to have an accurate and fair method for developing allocation levels in order to implement a billing rate system that the public will be confident in. Irvine Ranch Water District has been able to accomplish this and the methodologies being developed in this study will make it easier for other communities to adopt a similar rate structure model. The other half of the equation is how each single-family residence can meet these allocations. As water management becomes increasingly more important to communities, these communities will be looking for better ways to set allocation levels. As more communities adopt these methods, proper irrigation system design, effective irrigation products and effective maintenance and water management will become more important to the water user.

REFERENCES

1.,2. "EFFICIENT TURFGRASS Management: Findings From the Irvine Spectrum Water Conservation Study"
Authors: d.d. Pagano, Inc., Irrigation Consultants
James Barry M.S., Enviromental Consulting
A report submitted to Metropolitan Water District of Southern California
350 South Grand Ave., Los Angeles, CA 90054-0153

"Landscape Water Conservation Programs: Evaluation of Water Budget Based Rate Structures"
Authors: David M. Pekelney
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