Appendix B

Outdoor Residential Water Use and the Potential for Conservation

Appendix B describes methods used to estimate baseline outdoor residential water use in California and the potential for reducing that water use for representative landscapes, lots, and conservation techniques in California. We tried several different methods to estimate a baseline value for outdoor water use. The results ranged from 574,503 to 1,652,806 AF (Table B-1).

Table B-1
Estimates of outdoor water use (2000)

Method	Result (AF)
Summer-winter	574,503
Average month	848,941
Minimum month	907,410
Hydrologic region	1,091,124
Representative city	1,652,806

The following is a more detailed description of these results.

Hydrologic region method

We used CDWR's values[1] population by hydrologic region, percent outdoor water use by region (CDWR 1994b, Bulletin 166-4, table 3-2), and outdoor residential water use as a percentage of total outdoor urban use (CDWR 1994a, Bulletin 160-93, table 6-9) and multiplied them to get total residential outdoor water use (Table B-2). The equation for each region was as follows:

Water use = population * urban water use * percentage of urban that is residential * percentage of use that is outdoor * conversion factor.

For North Coast, for example, the calculation was:

6,000,00 people * 137gpcd * 0.52 * 0.26 * 365 days per year/325,851 gal per AF = 12,449 AFY

[1] 1990 values were used for this analysis since the latest version of Bulletin-160 (CDWR 1994a) does not provide the proportion of urban use that is residential.

Table B-2
Estimating Outdoor Water Use: Hydrologic Region Method

Hydrologic Region	Population (millions)	Percentage of Use that is Outdoor[2]	Percentage of Urban Use that is Residential[3]	Water Use (gpcd)[4]	Total Residential Outdoor use AFY
North Coast	0.6	26	52	137	12,449
San Francisco	5.5	26	54.9	106	93,215
Central Coast	1.3	39	60	112	38,164
South Coast	16.3	34	59	124	454,165
Sacramento River	2.2	56	56	169	130,605
San Joaquin River	1.4	58	70	216	137,525
Tulare Lake	1.5	54	67	202	122,796
North Lahontan	0.1	26	38	160	1,771
South Lahontan	0.6	56	63	175	41,495
Colorado River	0.5	54	58	336	58,939
Total	30				**1,091,124**

The next three methods were based on water use data by month and the assumption that residential use accounts for about 57 percent of urban use, both from Bulletin 166-4. These data are shown in Tables B-3 to B-5.

Table B-3
Bulletin 166-4 Water Use Data

Month	**Days per month**	**Total Urban Water Use**	
		gpcd	**gpcm**
January	31	145	2,562
February	28.25	150	2,415
March	31	170	3,004
April	30	180	3,078
May	31	205	3,622
June	30	225	3,848
July	31	250	4,418
August	31	245	4,329
September	30	225	3,848
October	31	200	3,534
November	30	160	2,736
December	31	150	2,651
Total			

Summer-winter method

Another method for estimating outdoor use is the “summer-winter” approach. Using CDWR’s Bulletin 166-4 estimates of average gallons per capita per day, we calculated monthly use. Our estimate was then based on the assumption that the

[2] B166-4 p.24, table3-2
[3] table 6-9 B160-93
[4] b160-93 table 6-8

difference between winter (October through March) and summer (April through September) use was approximately equal to outdoor use. This assumption is supported by Skeel and Lucas (1998) who found that for single-family homes in Seattle, outdoor water use made up more than 95 percent of the observed increase in peak summer consumption. Eighty-five percent of this increase was due to landscape irrigation and less than 5 percent resulted from a slight increase in indoor use in summer months. For example, for January the calculation was:

Water use = 31days * 145gpcd * 0.57 * 30,000,000 people/325,851 gallons per AF = 235,888 AF

We found the difference between summer and winter use, which we used as the estimate for total outdoor use, to be 574,503 AF. These results indicate that outdoor use accounts for about 16 percent of total use and 27 percent of summer use. Both the outdoor use value and percentage are somewhat lower than what we expected, based on experience and the literature reviewed. Part of the reason for the low result may be that homeowners in some regions do irrigate between October and March. By assuming that all of the October through March water use is for indoor purposes we are likely inflating indoor water use and underestimating outdoor use.

Minimum month method

We used the same Bulletin 166-4 data as the second method, calculated monthly water use and applied a minimum month methodology. In this approach, the lowest-use month (January) was assumed to represent indoor use and all differences between the other months and the January value were considered to be outdoor use. We aggregated these differences to determine a value for total outdoor use. This method is based on the assumption that indoor use remains fairly consistent across seasons and therefore provides a reasonable estimate of annual indoor demand. This assumption was tested by the REUWS (Mayer et al. 1999), which found that, except for the Tampa site, there were no significant differences in indoor use during different seasons.

For the minimum month method we assumed that January, the lowest use month at 145 gpcd, represents indoor use. The difference between January use and water use all other months, calculated on a month-per-month basis (Table B-4), then represents outdoor use. These differences were calculated, summed and multiplied by the current population to yield a result of 907,410 AF. This value indicates that approximately 25 percent of total use or 43 percent of summer use is for outdoor purposes.

Table B-4
Estimating outdoor water use: Summer winter, Minimum month, and Average month methods

Month	Days per month	Total Urban Water Use		Outdoor water use			
				Minimum month method		Average month method	
		gpcd	gpcm	gpcd	AF (statewide)	gpcd	AF (statewide)
January	31	145	2,562	0	0		
February	28.25	150	2,415	5	7,413	2	2,471

March	31	170	3,004	25	40,670	22	35,248
April	30	180	3,078	35	55,102	32	49,854
May	31	205	3,622	60	97,609	57	92,186
June	30	225	3,848	80	125,947	77	120,699
July	31	250	4,418	105	170,816	102	165,393
August	31	245	4,329	100	162,682	97	157,259
September	30	225	3,848	80	125,947	77	120,699
October	31	200	3,534	55	89,475	52	84,052
November	30	160	2,736	15	23,615	12	18,367
December	31	150	2,651	5	8,134	2	2,711
Total					**907,410**		**848,941**

Average month method

For the average month method we used the average of the three lowest water use months, December to February, rather than the minimum month used in the previous method, to represent indoor use (also in Table B-4). The result we obtained was total outdoor use of 848,941 AF. We assume that it is somewhat lower than the minimum month result for the same reason that the summer-winter month result was low. There may be some outdoor use during the winter period that gets lost as indoor use, thereby bringing down the outdoor use value.

Representative city method

For the Representative city method we used data CDWR had collected from 20 cities across the state (Table B-5). The data available from CDWR includes the percentage of urban use that is outdoor (Matyac, personal communications, 2000) and that is residential (CDWR 1994a, Table 6-9), population by hydrologic region and city (CDWR 1994a, Table 4-1), and per capita urban water use (CDWR 1994a, Table 4-8). The population of the representative cities adds up to about one-third of the state's population, we used the water use statistics for these cities as proxies for water use by hydrologic region. There were cases where, within a hydrologic region, water use and the percentage used outdoors for the representative cities were considerably different. For example, in the San Francisco region water use ranges from 132 to 196 gpcd and the proportion used outdoors ranges from 19 to 34 percent, almost double. To account for these differences within hydrologic regions we weighted the populations of the individual cities.

Water use for each hydrologic region was calculated as follows:

Water use for region = [Σ (city population/sum of populations) * hydrologic region population * water use by city * percent outdoor * percent urban] * conversion factor

For the San Francisco Bay region, for example, the calculation was as follows:

Population of San Francisco Bay hydrologic region = 5,500,000

Population of representative cities within the region = 1,200,000+170,000+723,959 = 2,093,959

Water use for the San Francisco Region =
[(1,200,000/2,093,959*5,500,000*196*0.55*0.34) +
(170,000/2,093,959*5,500,000*153*0.55*0.46) +
(723,959/2,093,959*5,500,000*113296*0.55*0.19)]*365/325,851 = 179,005 AFY

Using the representative city method, total outdoor water use for the state in 1990 was estimated to be 1,652,806 AF (Table B-5). This value may be somewhat high — we contacted a number of the representative cities and found that their water use figures were lower than those provided by CDWR by up to 27 percent.[5]

[5] For more information and a comparison of the values that we obtained with CDWR's estimates see: Gleick, P. H. and D. Haasz (1998).

Table B-5
Estimating outdoor water use: By city

City	Hydrologic region	Urban water use in gpcd	Percent of use that is outdoor	Percent of use that is residential	Pop. by hydrologic region	Pop. by city	Weighted population	Water use in AFY
Salinas	Central Coast	153	40	60	1,300,000	108,777	727,613	30,181
Santa Barbara	Central Coast	177	38	60		85,571	572,387	25,913
Blythe	Colorado River	349	63	58	500,000	8,448	105,990	15,031
El Centro	Colorado River	221	47	58		31,405	394,010	26,745
Santa Rosa	North Coast	156	46	52	600,000	113,261	113,261	4,752
South Lake Tahoe	North Lahontan	179	48	38	100,000	21,586	21,586	796
Chico	Sacramento River	296	59	56	2,200,000	39,970	214,822	23,714
Sacramento	Sacramento River	290	53	56		369,365	1,985,178	191,042
EBMUD	San Francisco Bay	196	34	55	5,500,000	1,200,000	3,151,924	130,857
Marin	San Francisco Bay	153	45	55		170,000	446,523	18,860
San Francisco	San Francisco Bay	132	19	55		723,959	1,901,553	29,270
Merced	San Joaquin River	187	65	70	1,400,000	56,155	294,338	28,165
Stockton	San Joaquin River	336	52	70		210,943	1,105,662	152,624
Los Angeles	South Coast	180	35	59	16,300,000	3,485,557	8,946,850	368,986
San Bernadino	South Coast	269	50	59		164,676	422,696	37,516
San Diego County	South Coast	196	35	59		2,700,000	6,930,454	314,204
Ridgedrest	South Lahontan	247	63	63	500,000	28,295	205,128	22,698
Victorville	South Lahontan	340	64	63		40,674	294,872	45,522
Fresno	Tulare Lake	273	60	67	1,500,000	354,091	1,235,920	151,601
Visalia	Tulare Lake	285	61	67		75,659	264,080	34,330
Total						9,990,382	29,334,847	**1,652,806**

Outdoor Residential Water Savings: Method Using Representative Lots and Climates

Landscape water use and savings from irrigating more efficiently are tricky to estimate because of all the unknowns and data limitations, described in the full report in Section 3, which provides statewide estimates of potential savings. To evaluate the economic feasibility of the options, we needed to look at concrete scenarios that could be discretely priced. It was not realistic to try and price each of the different options at a statewide level. Instead, we developed "representative" landscapes from which we could estimate water use, potential savings, and associated costs. The idea was for these landscapes to capture representative lots in terms of landscape (size, turf area, etc.) and climate conditions around California.

Climate conditions vary from cool and moist in the north and coastal areas to hot and arid conditions in the south and Central Valley regions. Precipitation data and landscape requirements by climate type are available through CIMIS and a variety of other sources. The structure of our representative landscapes is based on a set of high-quality landscape data from the East Bay Municipal Utility District's (EBMUD) 1995 Water Conservation Baseline Study and from information on climates and lot sizes around the state. Opitz and Hauer (1995), for example, provide information about landscape and irrigation system characteristics, broken down to reflect differences between the eastern and western parts of the EBMUD service area (Table B-6). The two areas have important socioeconomic (the area east of the hills tends to have higher incomes and larger homes) and physical (the east has a warmer and drier climate than the area west of the hills) differences. In constructing the representative landscapes our goal was to establish a relationship between lot size, area (potentially and actually) landscaped, turf area, and irrigated area. We constructed a typical "small" lot based on a cooler, more humid climate, and a "large" lot based on a warmer, more arid climate to see if, and how, these factors varied. Then we calculated the irrigation requirements and potential savings for these different landscapes and climates.

Table B-6: Sample landscape characteristics for single-family homes served by EBMUD

Lot Characteristics (ft^2)	Complete Survey	East	West
Total lot size	**9,500**	**19,952**	**5,612**
Hardscape Area	3,727	5,419	3,121
Landscape area	5,696	14,533	2,481
Irrigated area	2,513	5,184	1,459
Turf area	**987**	**1,628**	**727**
Percentage of lot that is hardscape	39	27	56
Percentage of lot that is landscape	60	73	44
Percentage of landscape that is irrigated	44	36	59
Percentage of landscape that is turf	17	11	29
Percentage of irrigated area that is turf	39	31	50

Source: Opitz and Hauer 1995

The east-side lots are about 3.5 times larger than those on the west side but the hardscape (including the building footprint) area is only about 60 percent larger. The east-side sites have a larger proportion of their lot landscaped; about 73 percent of the lot compared with about 44 percent on the west side. The east-side homes irrigate only 60 percent as much of their landscape and have about one-third the proportion of turf as do the west side homes, but their average turf and irrigated areas is larger because of the difference in average lot size. On average, the east-side homes irrigate about 5,184 ft^2 and have 1,628 ft^2 of turf while west-side homes irrigate about 1,459 ft^2 and have 727 ft^2 of turf. From this information, we constructed two representative landscapes:

Large landscape:
Lot size: 19,950 ft^2
Landscape area: 14,530 ft^2
Irrigated area: 5,180 ft^2
Turf area: 1,630

Small Landscape:
Lot size: 5,610 ft^2
Landscape area: 2,480 ft^2
Irrigated area: 1,459 ft^2
Turf area: 727 ft^2

The next step was to estimate water use. CIMIS data was used to obtain monthly precipitation and ET information (http://wwwdpla.water.ca.gov/cgi-bin/cimis/cimis/data/get_data). For the east of the hills site we used data from the Walnut Creek CIMIS station, and for the west-side site we used data from the Oakland foothills station. We calculated the water requirements for all four scenarios, varying landscape size and climate permutations (large landscape coastal and arid climates, small landscape coastal and arid climates). The amount of water required by turf was calculated by multiplying turf acreage by one of three ETo coefficients: 1.3 ETo, the amount of water we estimate is currently being used to irrigate turf; 1.0 ETo, the amount typically recommended; and 0.8 ETo, the amount that could be achieved with proper scheduling. The amount of water used for landscape irrigation was calculated using the following equation:

$$\text{Landscape Water Use (gal/yr)} = \frac{\text{Required irrigation (in/yr)} * ETo * \text{acreage (ft}^2\text{)}}{\frac{12\text{ in}}{\text{ft}} * \frac{.1337\text{ ft}^3}{\text{gal}}}$$

ET_o is the variable that represents the efficiency with which the landscape is being maintained. CDWR estimates that statewide ET_o is about 1.3 for turf (which means that 30 percent more water is applied than is typically recommended) and 1.0 for non-turf (CDWR 1998). We applied these ET_o estimates to our representative landscapes to determine baseline use. To determine potential savings we used the same physical landscape and ratio of turf to non-turf but applied lower ET_o values. Studies performed across the state and country and our communications with professionals in the field suggest that ET_o rates of 0.8 for turf and 0.6 for non-turf were a reasonable target for landscape conservation programs. Our calculations indicate that, depending on the size and climate conditions of the landscape, anywhere from about 17,000 to 65,000 gallons of water could be saved every year per site (see Table B-7 and the following scenarios).

Table B-7: Baseline and potential water use for representative landscapes

Water Use (gpy)	Large, Arid	Large, Coastal	Small, Arid	Small, Coastal
Baseline	166,877	147,788	49,341	43,694
Potential	101,084	89,521	30,032	26,595
Savings	65,793	58,267	19,309	17,099

Scenario B-1a: Large Landscape, Arid Climate (gallons per year)

	Irrigation rates---percentage Et_o						
	1.3	1	0.8	1	0.6		
	Turf water use			Non-turf water use			
Jan	1,583	1,218	974	2,660	1,596		
Feb	1,979	1,522	1,218	3,325	1,995		
March	3,825	2,943	2,354	6,428	3,857	**Water Use (gpy)**	
April	5,804	4,465	3,572	9,752	5,851		
May	7,783	5,987	4,789	13,077	7,846	Current	166,877
June	8,706	6,697	5,358	14,628	8,777	Potential	101,084
July	9,762	7,509	6,007	16,401	9,841	Potential savings	65,793
Aug	8,442	6,494	5,195	14,185	8,511		
Sept	6,991	5,378	4,302	11,747	7,048		
October	4,221	3,247	2,598	7,092	4,255		
November	1,979	1,522	1,218	3,325	1,995		
Dec	1,187	913	731	1,995	1,197		
Total	**62,263**	**47,894**	**38,315**	**104,614**	**62,769**		

Scenario B-1b: Large landscape, coastal climate (gallons per year)

	Irrigation rates---percentage Eto						
	1.3	1	0.8	1	0.6		
	Turf water use			Non-turf water use			
Jan	1,979	1,522	1,218	3,325	1,995		
Feb	1,979	1,522	1,218	3,325	1,995		
March	3,694	2,841	2,273	6,206	3,724	**Water Use (gpy)**	
April	5,145	3,957	3,166	8,644	5,186		
May	6,728	5,175	4,140	11,304	6,782	Current	147,787
June	6,991	5,378	4,302	11,747	7,048	Potential	89,521
July	7,915	6,088	4,871	13,298	7,979	Potential savings	58,267
Aug	7,255	5,581	4,465	12,190	7,314		

Sept	6,332	4,871	3,896	10,639	6,383
October	4,089	3,146	2,516	6,871	4,123
November	1,847	1,421	1,136	3,103	1,862
Dec	1,187	913	731	1,995	1,197
Total	**55,141**	**42,416**	**33,933**	**92,647**	**55,588**

Scenario B-2a: Small landscape, Arid climate (gallons per year)

	Irrigation rates---percentage Eto						
	1.3	1	0.8	1	0.6		
	Turf water use			Non-turf water use			
Jan	707	544	435	547	328		
Feb	884	680	544	684	411		
March	1,708	1,314	1,051	1,323	794		
April	2,592	1,994	1,595	2,007	1,204	**Water Use (gpy)**	
May	3,475	2,673	2,139	2,692	1,615	Current use	49,341
June	3,888	2,991	2,393	3,011	1,807	Potential use	30,032
July	4,359	3,353	2,683	3,376	2,026	Savings	19,309
Aug	3,770	2,900	2,320	2,920	1,752		
Sept	3,122	2,402	1,921	2,418	1,451		
October	1,885	1,450	1,160	1,460	876		
November	884	680	544	684	411		
Dec	530	408	326	411	246		
Total	**27,805**	**21,389**	**17,111**	**21,536**	**12,921**		

Scenario B-2b: Small landscape, Coastal climate (gallons per year)

	Irrigation rates---percentage Eto						
	1.3	1	0.8	1	0.6		
	Turf water use			Non-turf water use			
Jan	884	680	544	684	411		
Feb	884	680	544	684	411		
March	1,649	1,269	1,015	1,277	766		
April	2,297	1,767	1,414	1,779	1,068	**Water Use (gpy)**	
May	3,004	2,311	1,849	2,327	1,396	Current use	43,694
June	3,122	2,402	1,921	2,418	1,451	Potential use	26,595
July	3,534	2,719	2,175	2,737	1,642	Savings	17,099
Aug	3,240	2,492	1,994	2,509	1,506		
Sept	2,828	2,175	1,740	2,190	1,314		
October	1,826	1,405	1,124	1,414	849		
November	825	634	508	639	383		
Dec	530	408	326	411	246		
Total	**24,623**	**18,941**	**15,153**	**19,071**	**11,443**		