Appendix D

Details of Commercial and Industrial Assumptions, by End Use

Restrooms

Water Use

Restroom water use consists of toilet, urinal, faucet, and shower use. Our first step in calculating conservation potential for restrooms involved estimating the percentage of water flowing to each of these sub-end uses. Calculating restroom water use in this way also provided data for the restrooms portion of our models that we used to crosscheck water use in several commercial industries.

Toilets

In California, toilets use 1.6, 3.5, or 5.0 gallons per flush (gpf).[1] Using data collected in detailed regional audits performed by the East Bay Municipal Utilities District (EBMUD) and MWD, we calculated the amount of water an average flush in the CII sector uses based on the mix of toilets in each water district's service area. These data and our assumptions about the amount of water used for the average toilet flush in the state's CII sectors are shown below in Table D-1.

Table D-1
Toilet Water Use per Flush (2001)

Use Per Flush (gpf)	**Penetration (percent)**							
	EBMUD Ware-houses[1]	EBMUD Retail[1]	EBMUD Food Sales[1]	EBMUD Fast Food[1]	EBMUD Restau-rants[1]	EBMUD Offices[1]	**EBMUD Overall**[2]	**MWD Overall**[3]
1.6	32%	45%	47%	68%	44%	50%	**55%**	**26%**
3.5	32%	42%	30%	28%	38%	29%	**27%**	**43%**
5.0	36%	13%	23%	4%	18%	21%	**18%**	**30%**
Average	3.43	2.85	2.96	2.27	2.93	2.86	**2.73**	**3.45**
Average Water Use per Flush								**3.0**

Sources: Hazinski 2002 and Hagler Bailly Services 1997
[1] Hazinski's estimates of penetration rates included some toilets with an unknown flush rate. Hazinski calculated the number of these toilets belonging in the 1.6 gpf category and we estimated how many of the remaining toilets used 3.5 gpf and 5.0 gpf based on the ratio of toilets with known flush rates in each category.
[2] This is a weighted average of the various industries.
[3] MWD data were from audits performed between 1992 and 1996. We converted these numbers into a 2001 estimate based on the assumption that four percent of toilets between 1995 and 2001 were replaced annually through natural replacement (Hagler Bailly Services 1997). Because programs encouraging toilet

[1] Some older toilets use more than 5.0 gpf, but these models are becoming increasingly obsolete and most studies do not include them in their analysis.

replacement were not taken into account, we suspect that our 2001 MWD estimate may overestimate water use.

From the data reported by EBMUD and MWD, we determined that the average toilet flush in California's CII sectors uses approximately 3.0 gallons of water. We decided to use an average across all industries because MWD's data were reported as a whole rather than by industry and some of EBMUD's industry samples were very small, making the individual estimates less reliable.

To determine how much water toilets use in a specific industry annually, we used the existing literature to first calculate the number of times the average employee and customers in the industry use the toilet daily. In addition to having employees and customers, schools, hotels, and hospitals also have students, guests, and patients, collectively referred to as "others" herein, who use toilets.

To estimate total toilet water use in each industry, we multiplied the number of times employees, customers, and others flush toilets daily by the average gallons used per flush. Then, we multiplied the daily toilet use by the number of workdays in that industry to determine annual toilet water use.[2]

Table D-2
Toilet Water Use in the CII Industries (2000)

		Flushes Per Day			Number (1,000)			Total Flushes/Day	Annual Use
Industry	**gpf**	**Employee[1]**	**Visitor**	**Other**	**Employee**	**Visitor**	**Others**	**(1,000)**	**(TAF)**
Office	3.00	2.60	0.33[2]	-	3,788	3,788[3]	-	11,099	22.99
Schools	3.00	1.95[4]	0.86[5]	1.95[4]	1,289	2,199	5,952	16,011	26.33
Restaurants	3.00	2.60	0.34[6]	-	891	11,150[7]	-	6,029	20.26
Retail	3.00	2.60	0.13[8]	-	1,421	10,512[9]	-	5,096	17.12
Hospitals	3.00	2.60	1.00[10]	4.00[10]	428	95[10]	47	1,399	4.70
Hotels	3.00	2.60	-	4.00[11]	182	-	255[12]	1,493	4.95
Laundries	3.00	2.60	-	-	44	-	-	114	0.24
Textiles	3.00	2.60	-	-	27	-	-	71	0.15
Metal Finishing	3.00	2.60	-	-	133	-	-	346	0.72
Preserved Fruit and Veg.	3.00	2.60	-	-	41	-	-	105	0.22
Dairy	3.00	2.60	-	-	16	-	-	42	0.09
Meat	3.00	2.60	-	-	19	-	-	49	0.10
Beverages	3.00	2.60	-	-	38	-	-	98	0.20
Paper and Pulp	3.00	2.60	-	-	30	-	-	77	0.16
Petroleum	3.00	2.60	-	-	13	-	-	34	0.07
High Tech	3.00	2.60	-	-	535	-	-	1,391	2.88
Total									**101**

[1] Based on three studies of office buildings in which the numbers varied from 2.0 to 3.45 toilet flushes per employee per day (Darell Rogers cited in Schultz Communications (1999); Konen cited in A and N Technical Services, Inc. (1994); and Eva Opitz cited in PMCL (1996)).
[2] Without published data, we assumed that 50 percent of all visitors use the restroom. Of these visitors, 66 percent used toilets and 33 percent used urinals (Vickers 2001).

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[2] We assumed 225 workdays except for those industries that are generally open every day (restaurants, retail, hospitals, hotels, and coin laundries) and for schools, which are open 180 days per year.

[3] Without published data, we assumed that each employee has one visitor per day.
[4] The number of flushes per K-12 student and school employee was assumed to be 25 percent less than office workers because an average school day is approximately six hours whereas an average office workday is approximately eight hours.
[5] In schools, visitors are considered all non K-12 students in colleges, trade schools etc. We assume that in these schools, students tend to use the restroom 75 percent less often than office workers because they are on campus for short periods of time.
[6] An MWD case study of a Los Angeles restaurant reported 50 percent of visitors use the restroom (MWD 1992). We assumed that 66 percent of these visitors used toilets and 33 percent used urinals (Vickers 2001).
[7] Derived from the number of restaurant meals eaten out per week (Restaurant USA 2000).
[8] A case study of Walmart indicates that 20 percent of visitors use the restroom (Eastern Municipal Water District 1995). We assumed that 66 percent of these visitors used toilets and 33 percent used urinals (Vickers 2001).
[9] The number of customers is based on a customer to employee ratio (Dziegielewski et al. 2000).
[10] MWD (1996).
[11] The number of flushes/occupied hotel room (Brown and Caldwell 1990).
[12] The number of occupied hotel rooms (California Hotel and Motel Association 2001).

Urinals

In addition to using toilets, male employees, customers, and, in schools, students also use urinals. Urinal use was calculated in much the same way as toilet use, but using only EBMUD data because MWD data were not available. Table D-3 shows our assumptions about average urinal flushes in the CII sector.

Table D-3
Urinal Water Use per Flush (2001)

Use Per Flush (gpf)	Penetration (percent)[1]						
	EBMUD Ware-houses	EBMUD Retail	EBMUD Food Sales	EBMUD Fast Food	EBMUD Restau-rants	EBMUD Offices	**EBMUD Overall[2]**
1 or less	22%	6%	24%	22%	23%	24%	**45%**
1.5[3]	5%	53%	12%	0%	34%	21%	**41%**
2.5[3]	14%	0%	8%	6%	0%	3%	**8%**
5.0[4]	8%	0%	0%	6%	0%	3%	**6%**
Average Water use per Flush							**1.6**

Source: Hazinski 2002
[1] Penetration rates do not add up to 100 percent because urinals with unknown flush volumes were reported by Hazinski, but were not included in this analysis.
[2] The overall penetration percentages of each urinal type were derived by summing the total number of each urinal type observed across all industries and then dividing these numbers by the total number of urinal observations.
[3] Gpf were reported in the following ranges: 1.1 to 2.0 and 2.1 to 3.0. We averaged these two ranges to produce two average gpfs (1.5 and 2.5).
[4] Hazinski reported the most water intensive urinals as those using over 3.0 gpf. Because older urinals can use well over 5.0 gpf and many use 5.0 gpf, we reported this range as 5.0 gpf, which is a typical flush amount in the literature.

From the data reported in Table D-3, we determined that the average urinal flush uses approximately 1.6 gpf. We averaged all of the data reported by industry into one number because, with the exception of offices, the sample sizes for each industry were very small.

We estimated water use by urinals in the same way we estimated total toilet water use. The results are shown in Table D-4.

Table D-4
Urinal Water Use in the CII Industries (2000)

		Flushes Per Day			Number (1,000)[1]			Total Flushes/Day	Annual Use
Industry	**gpf**	**Employee[2]**	**Visitor[3]**	**Other[3]**	**Employee**	**Visitor**	**Others**	**(1,000)**	**(TAF)**
Office	1.6	1.25	0.17	-	3,788	3,788	-	5,360	5.92
Schools	1.6	0.94	0.31	0.94	1,289	2,199	5,952	7,476	6.61
Restaurants	1.6	1.25	0.17	-	891	11,150	-	2,970	5.32
Retail	1.6	1.25	0.07	-	1,421	10,512	-	2,478	4.44
Hospitals	1.6	1.25	-	-	428	95	47	536	0.96
Hotels	1.6	1.25	-	-	182	-	255	227	0.41
Laundries	1.6	1.25	-	-	44	-	-	55	0.06
Textiles	1.6	1.25	-	-	27	-	-	34	0.04
Metal Finishing	1.6	1.25	-	-	133	-	-	167	0.18
Preserved Fruit and Veg.	1.6	1.25	-	-	41	-	-	51	0.06
Dairy	1.6	1.25	-	-	16	-	-	20	0.02
Meat	1.6	1.25	-	-	19	-	-	24	0.03
Beverages	1.6	1.25	-	-	38	-	-	47	0.05
Paper and Pulp	1.6	1.25	-	-	30	-	-	37	0.04
Petroleum	1.6	1.25	-	-	13	-	-	16	0.02
High Tech	1.6	1.25	-	-	535	-	-	669	0.74
Total									**25**

[1] See Table D-2 for more detailed information regarding assumptions about the number of employees, visitors, and others in each industry.
[2] The number of times that employees use urinals daily is the average of two estimates (2 and 3) of the number of times male employees use urinals daily in office buildings divided by two (because only men, presumably 50 percent of the employees, use urinals) (Darell Rogers cited in Schultz Communications 1999 and Konen cited in A and N Technical Services, Inc. 1994). School employees were assumed to use urinals 25 percent less because we estimated that the average school day is approximately 25 percent shorter than other average workdays.
[3] The number of times visitors and others use urinals was calculated from the assumption that they use urinals once for every two times they use the toilet (Vickers 2001). For information on visitor and other restroom use, see Table D-2 above.

Faucets

The amount of water used by restroom faucets was calculated from three studies, summarized in Table D-5 below, on hand-washing in public restrooms. Without better information on restroom faucet use, we assumed that total water use from restroom faucets was related to the number of toilet and urinal flushes.[3]

Table D-5
Hand-washing in Restrooms

Study	Number of Observations	Washing Hands (percent)	Using Soap (percent)	Using Only Water (percent)	Using Soap (seconds)	Using Only Water (seconds)
ASM	8,000	66.5	n/a	n/a	n/a	n/a

[3] While restroom faucets are not used only after toilet or urinal use, insufficient data prevented us from calculating additional uses.

Wirthlin	6,000	67.5	n/a	n/a	n/a	n/a
Knights et al.	292	70	42	58	10.7	5.0

We used these findings to estimate that employees, customers, and others run the faucet for .11 minutes per flush.[4] We then applied this estimate to the use data below to determine annual faucet water use.

Table D-6
Restroom Faucet Use Water Use in the CII Industries (2000)

		Flushes/Day (1,000)			**Annual Use**
	gpf	**Toilets**	**Urinals**	**Total**	**(TAF)**
Office	0.11	11,099	5,360	16,459	1.3
Schools	0.11	16,011	7,476	23,025	1.4
Restaurants	0.11	6,029	2,970	8,998	1.1
Retail	0.11	5,096	2,478	7,574	0.9
Hospitals	0.11	1,399	536	1,934	0.2
Hotels	0.11	1,493	227	1,700	0.2
Laundries	0.11	115	55	171	0.0
Textiles	0.11	71	34	105	0.0
Metal Finishing	0.11	346	167	513	0.0
Preserved Fruit and Veg.	0.11	105	51	156	0.0
Dairy	0.11	42	20	62	0.0
Meat	0.11	49	24	73	0.0
Beverages	0.11	98	47	146	0.0
Paper and Pulp	0.11	77	37	115	0.0
Petroleum	0.11	34	16	50	0.0
High Tech	0.11	1,391	669	2,059	0.0
Total					**5.0**

Showers

Although showers may be present in some offices, manufacturing buildings, or schools, we calculated their water use only in hotels and hospitals. We used the assumptions shown in Table D-7.

Table D-7
Shower Water Use in the CII Industries (2000)

	gpm[1]	Minutes/Room or Patient/Day[2]	Number of Rooms or Patients/Day (1,000)	Gal/Room or Patient/Day (1,000)	Annual Use TAF
Hotels	2.20	16.20[3]	250	550	10.0
Hospitals	2.20	5.00[4]	47	104	.58

[4] Because penetration rates for non-residential users are unknown, we used the assumption that the average residential restroom faucet is rated at 2.0 gpm but, because people rarely run faucets at this maximum rate, they actually use only 1.34 gpm (Vickers 2001).

Total					**10.6**

[1] Showerheads, which usually operate at two-thirds their rated flow, typically use 2.2 gpm, implying that most installed showerheads are probably rated at 2.75 or 3.0 gpm (Vickers 2001).
[2] Shower water use in hotels is measured as minutes/room/day and in hospitals as minutes/patient/day.
[3] Brown and Caldwell 1990
[4] LADWP 1991

Comparison of Modeled Restroom Use to Use Based on GEDs

Using the methods outlined above, we modeled water use for restrooms. This modeled water use was lower than the restroom water use calculated with the less detailed GED approach for most industries. Unfortunately, we did not have enough information from either data set to determine which estimate is more accurate.

Table D-8
Restroom Water Use Comparison (2000)

Industry	**End Use Calculation**	**GED-derived Estimate**
	(Annual TAF)	
Office	30.2	88.0
Schools	34.6	43.3
Restaurants	26.7	55.4
Retail	22.5	36.6
Hospitals	6.5	9.2
Hotels	15.8	16.7
Laundries	0.3	1.5
Textiles	0.2	n/a[1]
Metal Finishing	0.9	n/a[1]
Preserved Fruit and Vegetable Processing	0.3	n/a[1]
Dairy Processing	0.1	n/a[1]
Meat Processing	0.1	n/a[1]
Beverages	0.3	n/a[1]
Paper and Pulp	0.2	n/a[1]
Petroleum Refining	0.1	n/a[1]
High Tech	3.8	n/a[1]
Total	155	n/a[1]

[1] Restroom water use for these industries is part of a larger category labeled “other” and cannot be quantified through the GED-derived method.

Restroom Conservation Potential

Using the assumptions made above, we estimated potential savings per flush for toilets, urinals, and faucets and per shower. Our findings are shown below in Table D-9.

Table D-9
Potential Savings per Flush and per Shower

	Potential Savings per Flush (gal)			Savings per
	Toilets	Urinals	Faucets	Shower (gal)
CII Industries	1.40	0.60	0.03	0.50

By multiplying the potential savings presented above by the number of annual flushes or showers in each industry, we calculated potential restroom savings, as shown in Table D-10.

Table D-10
Potential Savings in Restrooms (2000)

Industry	**Annual Potential Savings (AF)**					**Savings as a Percent of Use**
	Toilets	**Urinals**	**Faucets**	**Showers**	**Total**	
Office	10,729	2,221	341	0	13,291	49%
Schools	8,672	2,699	232	0	15,266	45%
Restaurants	9,454	1,996	302	0	11,752	46%
Retail	7,992	1,665	255	0	9,911	51%
Hospitals	2,278	360	69	133	2,840	47%
Hotels	2,309	153	57	2,268	4,865	32%
Laundries	111	123	4	0	313	49%
Textiles	68	14	2	0	85	49%
Metal Finishing	335	69	11	0	414	49%
Preserved Fruit and Veg.	102	21	3	0	126	49%
Dairy	40	8	1	0	50	49%
Meat	48	10	2	0	59	49%
Beverages	95	20	3	0	118	49%
Paper and Pulp	75	15	2	0	93	49%
Petroleum Ref.	33	7	1	0	41	49%
High Tech	1,345	277	43	0	1,664	49%

Landscape

Most of the state's commercial and industrial establishments have some irrigated landscaping. For each industry, we modeled water used for landscape irrigation and then used this estimate to crosscheck our GED-derived estimate of landscape water use.

Water Use

Landscape water use, which varies by industry type and region, was calculated from a combination of irrigated acreage, employment, and water use data. We used the following MWD data to calculate an average number of acres per employee for various CII sectors:

Table D-11
Irrigated Landscape Area per Employee

Industry[1]	Employees	Estimated Landscape Area (ft^2)	Irrigated Landscape (ft^2) per Employee
Food Processing, Textiles, Paper, and Petroleum	6,257	2,458,760	**393**
Metal, Electronics	29,695	5,545,166	**187**
Retail	18,751	4,654,088	**248**
Hotels, Laundries, and Offices	34,471	18,860,762	**547**
Hospitals and Schools	28,739	83,204,839	**2,895**

Source: MWD 2002
[1] The industries were grouped by the MWD.

The ratio of irrigated landscape area to employees was then applied to employment data to calculate irrigated acreage by region for each industry. Table D-12 shows an example of this application for office buildings.

Table D-12
Irrigated Landscape for Office Buildings

Office Buildings 2000	Irrigated Landscape (ft^2) per Employee	Employment 2000	Landscaped area (ft^2)	Landscaped area (acres)
North Coast	547	54,833	30,002,239	689
San Francisco	547	1,018,939	557,519,211	12,799
Central Coast	547	137,132	75,032,681	1,723
South Coast	547	1,927,690	1,054,748,330	24,214
Tulare Lake	547	148,557	81,283,945	1,866
San Joaquin	547	118,766	64,983,602	1,492
Sacramento River	547	321,091	175,687,064	4,033
North Lahontan	547	9,282	5,078,708	117
South Lahontan	547	65,696	35,946,001	825
Colorado River	547	41,316	22,606,323	519

TOTAL		**3,843,302**	**2,102,888,102**	**48,276**

Once we calculated the acreage of landscaped area for each industry, by hydrologic region, we were able to use information on landscaping water demands, adjusted by region. Because turf and other vegetation use different quantities of water, we had to estimate the ratio of turf region in the state. We averaged two estimates to calculate the ratio shown in Table D-13.

Table D-13
Type of Irrigated Landscape

	Turf as Percent of Irrigated Area	Other Vegetation as Percent of Irrigated Area
City of Santa Barbara UWMP	79	21
Contra Costa County UWMP	60	40
Average	**70**	**30**

Next, we looked at how much water turf and other vegetation uses. Once again, two estimates were available and we took the average, as shown in Table D-14.

Table D-14
Water Use by Vegetation Type

	Turf Water Use (AF/acre)	Other Water Use (AF/acre)	Use/acre (Assuming 70-30 Ratio)
City of Santa Barbara UWMP	2.0	1.7	1.90
Montecito Water	2.4	1.0	1.95
Average			**1.93**

Because Santa Barbara and the Montecito Water District are both in the Central Coast region, we assumed that their average use/acre ratios applied to the Central Coast region. Using this assumption and information about how plant water needs vary among regions (Costello and Jones 1999), we calculated separate use/acre coefficients for each of California's major hydrologic regions (Table D-15).

Table D-15
Vegetation Water Use by Region

Region	**Inches/Month**[1]	**Ratio**[2]	**Average Mix AF/acre**[3]
North Coast	2.40	1.01	**1.95**
San Francisco	3.00	1.26	**2.43**
Central Coast	2.37	1.00	**1.93**
South Coast	3.24	1.37	**2.65**
Tulare Lake	4.27	1.80	**3.47**
San Joaquin	4.27	1.80	**3.47**
Sacramento River	4.27	1.80	**3.47**
North Lahontan	3.70	1.56	**3.01**
South Lahontan	4.93	2.08	**4.01**
Colorado River	6.00	2.53	**4.88**

[1] Costello and Jones (1999) estimated water needs (in inches) in July for plants with medium water needs in various California cities. Because these estimates were vegetation type and season specific, we could not use the estimates to calculate generic water use based on our turf to other vegetation ratio. We did use these estimates, however, as a measure of how plant water use varies among regions.
[2] Using Costello and Jones' estimates (1999), we divided the inches/month for each region by the inches/month for the Central Coast region to get a ratio of how water needs vary between each region and the Central Coast region.
[3] Because we are using a generic mix of turf and other vegetation, we multiplied each region's ratio by 1.93 (the amount of water applied to an irrigated acre with this generic mix in the Central Coast region annually) to determine how much water every irrigated acre in every region was using.

We had one additional piece of information that provided a crosscheck for the calculations in this step: the city of El Toro, which is in the South Coast region, reported that water use per acre of irrigated landscape was 3.6 AF annually, which matches our estimate of 3.6.

Finally, for each industry, we multiplied irrigated acreage by use/acre for each region to get total use. An example for office buildings is shown below in Table D-16 and the total use for each industry is shown in Table D-17.

Table D-16
Landscape Water Use in Office Buildings (2000)

Region	Landscaped area (acres)	Use/Acre (AF)	Total Use (AF)
North Coast	689	1.95	1,344
San Francisco	12,799	2.43	31,102
Central Coast	1,723	1.93	3,325
South Coast	24,214	2.65	64,167
Tulare Lake	1,866	3.47	6,475
San Joaquin	1,492	3.47	5,177
Sacramento River	4,033	3.47	13,995
North Lahontan	117	3.01	352
South Lahontan	825	4.01	3,308
Colorado River	519	4.88	2,533
TOTAL	**48,276**		**131,778**

Upon calculating total use for each industry, the following results were found:

Table D-17
Landscape Water Use

Industry	Area/Employee (ft^2)	Employees	Landscaped Area (ft^2)	Use (gallons/day)	Total Use (TAF)
Office	547	3,843,303	2,102,888,649	117,816,907	132.0
Schools					
Restaurants	248	890,600	220,908,153	12,419,275	14.0
Retail	248	1,421,434	360,774,785	20,455,704	23.0
Hospitals	248	428,450	106,346,178	6,022,638	7.0

Hotels	547	182,639	99,932,136	5,509,615	6.0
Textiles	393	27,200	10,805,655	594,663	0.7
Metals	187	133,201	24,873,604	1,401,835	1.6
Food Processing	393	113,310	44,464,838	2,611,601	2.9
Paper and Pulp	187	4,110	768,580	43,945	0.0
High Tech	187	534,931	99,891,604	5,301,092	6.0
Laundries	547	44,310	24,237,570	1,356,573	1.5
Golf Courses		34,063	3,866,951,880		420.1

Comparison of Modeled Landscape Water Use to GED-derived Estimates

The comparison of our modeled water use in landscaping and our GED-derived estimate of water in landscaping is shown below in Table D-18.

Table D-18
Comparison of Modeled Landscape Water Use to GED-derived Estimates

Industry	**Thousand Acre Feet Per year (TAF) 2000**	
	End Use Calculation	**GED-derived Estimate**
Office	132.0	128.6
Schools[1]	n/a[1]	180.9
Restaurants	14.0	9.8
Retail	23.0	45.9
Hospitals	7.0	5.9
Hotels	6.7	3.0
Textiles	0.7	n/a[2]
Metals	1.6	n/a[2]
Food Processing	2.9	n/a[2]
Paper and Pulp	0.0	n/a[2]
High Tech	6.0	n/a[2]
Laundries	1.5	n/a[2]
Golf Courses	420.1	324.7

[1] School landscaping water use was calculated through a different method. See Appendix 4.B.8.
[2] Irrigation water use for these industries is part of a larger category labeled "other" and cannot be quantified through the GED-derived method.

Landscape Savings Potential

Potential savings from landscape irrigation comes from either switching the vegetation composition to less water-intensive plants or adopting more water efficient irrigation technologies. Water-efficient technologies include drip irrigation, automatic shut-off nozzles, and water-sensing devices (see Appendix C for a description of these devices). Additionally, improving irrigation scheduling can save water.[5]

[5] Because improved irrigation scheduling becomes irrelevant when water-sensing devices are used, we did not examine improved irrigation scheduling separately.

Precise information about the penetration rates of these technologies throughout the state does not exist (we recommend these data be collected). Using information available from published sources, we assumed the potential savings shown in Table D-19.

Table D-19
Potential Water Conservation in Landscaping

Measure	Typical Savings Range (percent)	Average Savings (percent)	Penetration Rate	Percent Conservation Potential
Reducing Turf	42-54[1]	48	30[2]	6.7
Assuming a Reduction to 54% Turf, 46% Other:				
Water Sensing – Turf	29-56[3]	43	10[4]	19.1
Water Efficient Nozzles- Turf	5-10[4]	8	25[4]	1.5
Water Sensing – Other[5]	29-56[3]	43	10[3]	23.4
Drip Sprinklers – Other[5]	25-75[3]	35	25[2]	
Efficient Nozzles - Other	5-10[4]	8	25[4]	1.3
Total				50

[1] Vickers 2001, Postel 1997
[2] This penetration rate equals the percent of total irrigated acreage that is not turf.
[3] Epstein 2000
[4] In the absence of published rates, we estimated these rates based on anecdotal information.
[5] Water Sensing devices are not always assumed to be effective by the irrigation industry. There is, however, a new technology, ET driven controllers, on the horizon that may provide greater saving in the future (Sweeten 2002).

Kitchens

Water Use
Water is used in kitchens for:
1. Food preparation
- Cleaning produce
- Cooking and water served to customers
- Contact cooling of rice/pasta/boiled vegetables and other foods

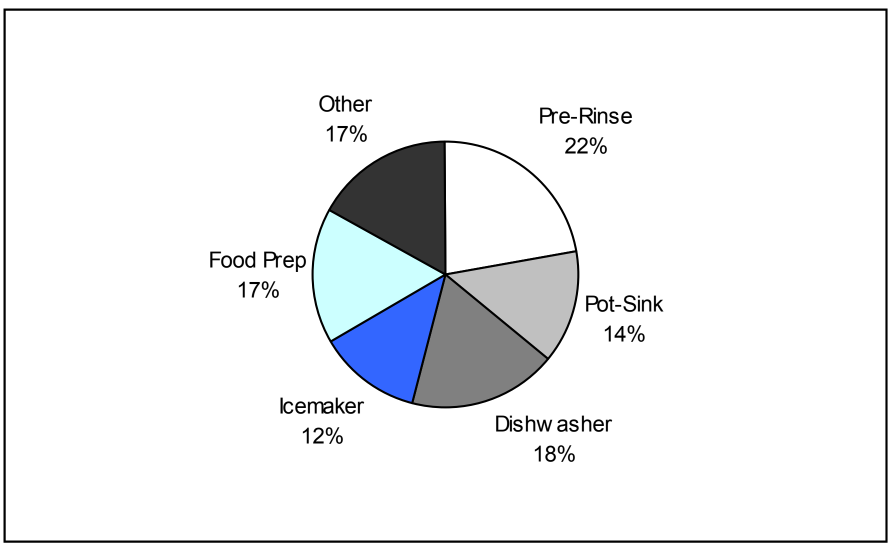
2. Dish Sanitation
- Pot sinks to soak pots and pans
- Pre-rinsing dishes
- Dishwashers
- Garbage disposal

3. Ice Makers

4. Sanitation
- Cleaning of floors and work areas
- Hand-washing

We calculated the following average breakdown of kitchen water use from a number of case studies of restaurants (see below and Appendix E for details).

Figure D-1
Water Use in Kitchens



Sources: Average of data from several case studies (LADWP, 1991 (a & b), MWD, 1992, MWRA, 1990)

Potential Savings: Kitchens

Estimating potential savings in kitchens involved calculating the typical savings possible from each technology for each sub-end use; estimating the amount of water used by the different sub-end uses; multiplying the savings from each technology by the amount of water used for the corresponding sub-end use; and adding up the savings from the different technologies.

Icemakers

Icemakers typically contribute to about 20 percent of all kitchen water use.[6] Assumptions used are shown below in Table D-20.

Table D-20
Water Conservation Technology in Ice Makers[1]

Type of Icemaker	Market Share[1]	Efficient Gal/100 lb of Ice	Inefficient Gal/100 lb of Ice	Savings (percent)[2]
Air-cooled	50%	13	Up to 45	
Water-cooled	50%	115	Up to 170	
Average Savings Possible				**20%**

[1] Pike et al. 1995

Dishwashers

Dishwashing contributes to about 25 percent of all kitchen water use.[7] The distribution of different types of dishwashers is shown below in Table D-21.

Table D-21
Water Conservation Technologies for Dishwashers

Type of Dishwasher	Establish-ments[1,2] (percent)	Racks/ Day[1]	Average Gal/Rack Efficient[3]	Average Gal/Rack Inefficient[3]	Savings (percent)[4]	Penetration Efficient Models[5] (percent)
Manual dishwashing	30%	25	N/A	N/A	20%	10%
Rack/under the counter	52%	100	1.1	2.1	48%	50%
Flight or conveyer	18%	330	0.5	1.0	50%	50%
Total					**40%**	**38%**

[1] Pike et al. 1995

[6] This percentage was calculated from a number of case studies.

[7] ibid

[2] We have used only the restaurants categorized under SIC code 58 which comprise 57,000 establishments in contrast to the 74,000 establishments captured by the California Restaurants Association which include cafeterias in hotels, hospitals, and office buildings in addition to restaurants.
[3] McCurdy (2002).
[4] Based on the following assumptions: an inefficient rack/under-the-counter dishwasher uses an average of 2.1 gal/rack; an efficient rack/under-the-counter dishwasher uses 1.1 gal/rack; an inefficient flight or conveyer dishwasher uses 1.0 gal/rack; and an efficient flight or conveyer type dishwasher uses 0.5 gal/rack (McCurdy 2002).
[5] The average share of inefficient dishwashers appears to be at least 50 percent based on discussions with experts on the percentage of the dishwasher rental market that is covered by the lease model. This estimate corresponds with the penetration rates in Koeller and Mitchell (2002).

Pre-Rinse Nozzles

Pre-rinse sprayers and nozzles contribute to about 15 percent of all kitchen water use.[8] The distribution of nozzles in establishments is shown below.

Table D-22
Water Conservation Technology in Pre-Rinse Nozzles

Make of Nozzle	Market Share[1] (percent)	High Flow (gpm)[1,2]	Low Flow (gpm)[1]	Savings[3] (percent)	Penetration Efficient Models[4] (percent)
Fischer	50%	2.7-2.9	1.5-1.6	45-50%	<10%
T&S	50%	4.5-6.0	1.6-1.8	65-75%	<10%
Average Savings Possible				**60%**	**10%**

[1]Bohlig, 2002
[2] Field tests by the PG&E Food Service Technology Center showed that the actual flows in the high flow models were sometimes slightly higher than the rated figures (Bohlig, 2002).
[3] Difference between high and low flow models.
[4] Estimated from conversation with Bohlig (2002).

Other Assumptions

Several other measures, such as faucet aerators and foot operated hands free faucets, can contribute to additional savings, but because these savings are assumed to be small, we omitted them from our analysis. Savings from behavioral changes such as running only full dishwasher loads and the prompt reporting of leaks were also excluded.

[8] ibid

Estimate of Savings in Kitchens

Table D-23
Potential Water Conservation in Kitchens (2000)

End Use	Percent Of Water Use by Sub-end Use (w percent)[1]	Typical Savings (x percent)	Penetration Rate (p percent)	Conservation Potential (c percent)[3]
Dishwashers	24%	40%	38%	29%
Pre-rinse nozzles	14%	60%	10%	55%
Pot sink	17%	0%	N/A	0%
Garbage disposal	8%	0%	N/A	0%
Food prep	9%	0%	N/A	0%
Icemaker	19%	20%	25%[2]	16%
General sanitation	9%	0%	N/A	0%
Weighted average conservation potential for kitchens				**20%[4]**

[1] Breakdown of kitchen water use by equipment and process was taken from our restaurant model (see details in Appendix 4.B.6).
[2] Pike et al. (1995) assume that the 20 percent savings was applicable to all icemakers in 1995. Assuming that some of these savings have been realized, we increased the penetration rate to 25 percent.
[3] Percent Savings Potential = Savings * (1-Penetration)/ (1- Savings*Penetration Rate)
(see Section 4 for derivation)
[4] SUM(wc).

Cooling

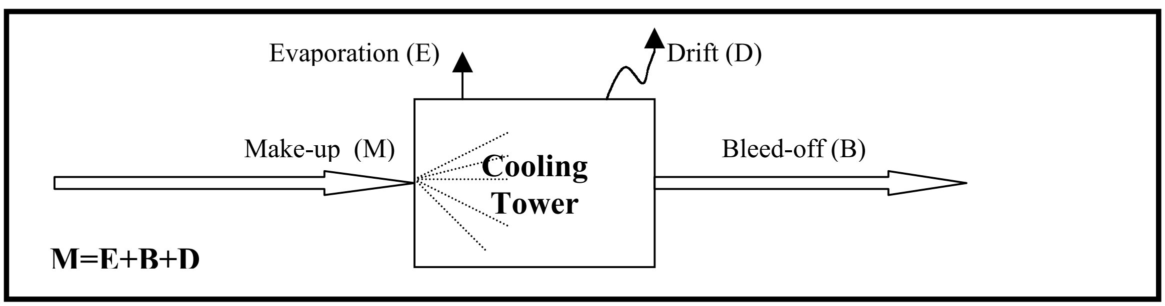
Water Use
Water is used for cooling in many different ways

- ~~1)~~ Cooling towers
- ~~2)~~ Single pass cooling of equipment
- ~~3)~~ Contact cooling of end products

There are more than 20,000 cooling towers in California (AWWA 1993). The majority of these towers are recirculating evaporative systems where temperature is reduced through evaporation. Evaporating cooling towers regulate temperature by using water to absorb heat from air conditioning systems or hot equipment. The heated water flows to the cooling tower where it sprays through a column of air. In this process, approximately one percent of the water evaporates for every 10 degrees F the water falls. As this water evaporates, natural salts from the water become increasingly concentrated and, because these salts can damage the cooling towers and heat exchangers, the water must be occasionally discharged through a process called "bleeding."

Thus, in a cooling tower water is lost through evaporation and bleed-off. To offset these losses, "make-up" water is added to the system. The less often water is bled, the less make-up water is required. As a rule of thumb, a 100-ton cooling tower uses almost 3,500 gallons of water when run continuously for 24 hours. Typical industrial cooling tower capacities range from 10 to over 1,000 tons.

Figure D-2



The evaporation and drift cannot be controlled, but water loss through bleeding can be minimized. The bleed-off is managed at a level so that the salt concentration is sufficiently high to conserve water but not enough to corrode the cooling system. The measure of the salt concentration in the bleed-off water to the make-up water is defined as the concentration ratio.

Thus,

$$\text{Concentration Ratio (CR)} = \frac{\text{Total Dissolved Solids (TDS) in bleed-off water}}{\text{Total Dissolved Solids (TDS) in make-up water}}$$

A recent innovation in cooling tower technology is to target the energy efficiency of the system as a whole, rather than the water efficiency. A cooling tower is part of a heat transfer system that typically includes coils, fan, chiller, compressor, and condenser.

Increasing the energy efficiency of any component of the system will increase the overall energy efficiency. Increasing the overall energy efficiency will reduce evaporation losses. Reducing evaporation losses will reduce the cooling tower make up water requirements.

Improving the overall system efficiency (coil cleaning, more efficient chillers and pumps, belt adjustments) involves investigating heat load reduction methods (cool roofs, trees, shades, awnings, energy efficient lighting) and installation of variable speed drives for fans, pumps, chillers, so that fans run only as fast as needed to dissipate the heat loss. A 10 percent decrease in fan speed, decreases energy and corresponding water use by 33 percent. For instance, running two fans at half the speed consumes only 25 percent of the energy required to run one fan at full speed. (Lelic, personal communication, 2003)

Potential Savings

Most industries with large cooling towers, such as office buildings, hotels, and commercial facilities with central cooling, have contracts with chemical companies to maintain their cooling towers. A facility is classified as small (<100 cooling tons), medium (100-1,000 cooling tons), or large (>1,000 cooling tons), depending on the size of its cooling towers. Chemical companies service specific facility sizes.

According to one industry expert, large and medium facilities (industrial facilities, large office buildings, hotels, hospitals etc.), which constitute 90 percent of the cooling market in California, typically hire cooling chemical companies to run the towers and about a third of these run at sub-optimal concentration ratios (Waldo, personal communication, 2002).

Small cooling towers comprise the remaining market share and they do not use chemical companies for service. These facilities, which generally consist of smaller offices and motels, often do not have conductivity controllers and run at concentration ratios as low as 2 to 2.5. Significant cooling savings are possible at these facilities. The problem is that the water saved per year at these facilities is of the order of about 50 to100 kGal so even though improvements can be made at little to no cost, the overall savings at these facilities is less than $250 per year. We used this information to estimate potential savings shown in Table D-24.

Table D-24
Potential Water Conservation in Cooling

Technology	**Typical Savings (percent)**	**Penetration Rates (percent)**
Cooling towers		
Conductivity controllers	20-50%	90%[1]
Optimize CR by using state of the art treatment	10-20%	70%[3]
CR Boost by chemical treatment	15%[2]	25-40%[3]
Boost Energy Efficiency of Fans, Pumps	15%[4]	{10%}[5]
Reused/reclaimed make-up water	100%	Low
Elimination of single pass equipment cooling	90% [6]	{90%}
Best Estimate of Water Conservation Potential		**25%[7]**

[1] Personal communication with a cooling tower company representative (Waldo, personal communication, 2002) revealed that "most" companies use some form of chemicals and conductivity controllers to optimize water use. We assume that 90% already do so.
[2] Preferred by companies using hard water and currently running at 3 cycles. These can potentially run at 6 cycles using sulfuric acid treatment. An increase of CR from 3 to 6 implies savings of 15 percent.

[3] Waldo, personal communication, 2002.
[4] Lelic, personal communication, 2003.
[5] This technology is relatively recent and has only been applied at a few places in California and Oregon in the last few years (Lelic, personal communication, 2003)
[6] Retrofitting equipment, such as x-rays, with single-pass cooling, and recirculating water systems can cut water to 10 percent of current use.
[7] The first four technologies in the table, improving energy efficiency, using conductivity controllers, optimizing the concentration ratio and boosting the concentration of cooling towers can be used conjunctively at a single location. So the savings are additive.

Laundry

Water Use

Water is the most important input to laundering operations, acting as a universal medium to remove soil and odors from textiles. Water is also used in boilers to generate steam, the primary medium for distributing heat through the plant. The industrial sized machines used in hotels, hospitals, and commercial laundries are much larger and typically use a different technology from those found at coin laundries.

Process Water Savings

The primary water conservation technologies in laundry systems include the use of ozone instead of laundry chemicals and the implementation of membrane-based technologies. Together, these technologies cut water use by 80 to 99 percent. Alone, the ozone systems can save about 30 percent of water use and when they are combined with recycling systems, they can save up to 80 percent.

Discussions with industry experts revealed that closed-loop systems (which recycle 99 percent of the wastewater) are not very cost effective because it costs about as much to recover the last 20 percent of water as the first 80 percent (Johnson, personal communication, 2002). Very few laundries in the state currently recycle significant amounts of their wastewater.

The following penetration rate data were available.

Table D-25
Water Conservation Technologies in Laundry

Technology	Savings (x percent)	Penetration Rates (p percent) [1]
Recycling portion of laundry wastewater /Counter current washing	20-50%[2]	18%
Reusing laundry rinse water in first wash		42%
Ozone laundry systems without recycling	30% [3]	
Ozone laundry systems with recycling	60%	
Membrane systems recycling 80% [4]	80%	{9 %[6]}
Closed loop systems	99%[5]	{1%[7]}

[1] Penetration rates are from an EPA survey (USEPA 1993) of industrial laundries across the U.S., except where indicated.
[2] Anderson (1993).
[3] This information was obtained from the websites, of many ozone system manufacturers (www.rgf.com, www.hospaa.org/ozone.html, www.niagaramohawk.com)
[4] Paschke et al., (2002), Johnson, personal communication, 2002.
[5] U.S. Water News (1999).
[6] "Very few" laundries currently recycle 80 percent of their water (Johnson, personal communication, 2002).
[7] California Linen Rental appears to be the only closed loop system in California.

We derived the conservation potential assumptions for laundries by reviewing the data presented in the table above and then making the following assumptions. About 10 percent of the market is currently recycling about 80 to 100 percent of its wash water and another 50 percent has cut water use by 30 percent using counter-current flow washers, ozonation, partial recycling of wastewater, or reusing cooling or rinse water. The remaining laundries do not currently recycle or reuse laundry wastewater. Two percent of laundry systems will eventually become “closed-loop,” 10 percent will recycle 30 percent of their water, and the remaining systems can technically recycle 80 percent of their wastewater.

Table D-26
Potential Water Conservation in Laundries

Technology	**Technology Savings[1] (s percent)**	**Penetration in 2000 (p percent)**
Currently closed-loop	0%	1%
Currently 80% recycling	0%	9%
Currently 30% recycling	50%	60%
Current no recycling	80%	30%
Conservation Potential		**54%[2]**

[1] Assuming 80% recycling is possible at all facilities
[2] Σ s%*p% (See Appendix C for derivation)