Appendix C

Industrial and Commercial Water Use:

Glossary, Data, and Methods of Analysis

This Appendix presents a glossary of water-conservation technologies available in the commercial, institutional, and industrial sectors, our analysis of the data on industrial water use collected by the CDWR and others, and background on our methods of analysis for this group of water users. More details on specific end-uses and methods can be found in Appendix D and E.

The glossary in this Appendix is not a comprehensive list of every water conservation technology in existence – it is a compilation of technologies that are common across several industry groups. The technologies are classified by end use. For each technology, we present a brief discussion and list the industry groups (as defined in Appendices D and E) to which it applies. The manner in which these technologies are implemented will vary among industries.

We also describe our analysis of the extensive data of industrial water use collected by the California Department of Water Resources in the 1990s (DWR 1995a) and shows the data we collected on commercial water use from various other sources. To use these data, errors had to be identified and corrected, data gaps filled, and some entries updated. Below we describe the corrections and modifications applied to these data.

Restrooms

Ultra-Low Flush Toilet (ULFT). (Type: Efficiency. Industry Groups: All)

Prior to 1978, toilets used 5 to 7 gallons per flush (gpf). A 1977 state law required that all new residential toilets use 3.5 gpf or fewer starting on January 1, 1980. In 1992, the state updated this law, mandating that all new residential toilets use 1.6 gpf. These laws shifted the state's toilet stock toward more efficient toilets. And in 1992, the transition gained momentum when the federal government passed the National Energy Policy Act, which mandated that all toilets produced in the United States use 1.6 gpf or less. These 1.6 gpf toilets are commonly referred to as ultra-low-flush toilets or ULFTs.

Ultra-Low Flush Urinals (ULFU). (Type: Efficiency. Industry Groups: All)

Low-volume urinals use 1.0 gpf or less. These urinals operate the same way as high-volume urinals except that the orifice in the valve is small. Moderate to high-volume urinals in commercial establishments have flush rates of 2.0 to 5.0 gpf (Vickers 2001).

Faucet Aerators. (Type: Efficiency. Industry Groups: All)

eration, flow-control restrictors, or spray features achieve reduced flow in low-flow restroom and kitchen faucets. Low flow faucets use about 1.0 gpm compared to traditional faucet use of 1.3 to 3.5 gpm (Vickers 2001). Note that these are actual flow volumes, which are much lower than the rated flow volumes because people rarely run the faucets at the maximum volume.

Low-Flow Showerheads. (Type: Efficiency. Industry Groups: Hospitals and Hotels)
Low-volume showerheads use less water through improved spray patterns, aeration, and narrower spray areas. Actual flow rates in showers are at about 67 percent of rated flows. Low-flow showerheads use about 1.7 gpm (actual) while traditional showerheads use from 2.2 to 4.0 gpm (Vickers 2001).

Cooling and Cooling Towers

Conductivity Controllers. (Type: Efficiency. Industry Groups: Most Industrial Industries; Offices; Hotels; and Hospitals)
Improving water efficiency in cooling towers generally involves increasing the concentration ratio (CR) by installing a conductivity controller to measure the salt concentration in the cooling water (see Section 4). The technically achievable CR depends on the quality of the make-up water and varies among regions. In the Bay Area, which receives high-quality snowmelt from the Sierra Nevada, a CR of 6 to 8 is easily achievable, whereas in areas that use groundwater (high in salts), a CR of 2.5 to 3 is the maximum achievable (Lelic 2002).Table C-1 shows the percent of make-up water that can be saved with different concentration ratios.

Table C-1

Percent of Make-up Water Saved									
	New CR								
	CR	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Old CR	**2**	25%	33%	38%	40%	42%	43%	44%	45%
	3		7%	11%	14%	17%	18%	20%	21%
	4			6%	10%	13%	14%	16%	17%

Source: NCDENR 1998

Improvement of Concentration Ratio Using Chemical Treatments. (Type: Efficiency. Industry Groups: Most Industrial Industries; Offices; Hotels; and Hospitals)
Concentration ratios of cooling towers can be boosted to as high as 12 to 15 percent using various types of chemical treatments. Some common treatments (NCDENR 1998) include:

- Sulfuric Acid Treatment - Dissolves scale on cooling towers but is potentially hazardous and needs careful handling and skilled workers.
- Side-stream Filtration – Uses a sand or cartridge filter to remove suspended solids.
- Ozonation – Oxidizes some of the metals and precipitates them in the form of sludge.

Improving the energy efficiency of fans, pumps etc. Type: Efficiency. Industry Groups: Most Industrial Industries; Offices; Hotels; and Hospitals)

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.

Reused/Reclaimed Water for Cooling Tower Make-up. (Type: Efficiency and Reclamation. Industry Groups: Most Industrial Industries; Office Buildings; Hotels; and Hospitals)

A recent trend in cooling tower water conservation involves reusing waste streams from processes in cooling towers. Some streams, such as those from reverse osmosis, reject water when creating ultra-pure water and require no additional treatment. Other waste streams may need to pass through one or more stages of filtration before they are usable in cooling towers.

Some industries are also substituting reclaimed water for cooling tower make-up. Typically, a denitrification plant must treat reclaimed water before it is used in cooling towers, but because some industries, such as refineries, use large quantities of cooling water, it is economical to set up a denitrification plant at each facility. In the future, reclaimed water use should increase for cooling at refineries and industrial parks where these economies of scale can be exploited.

Equipment Cooling. (Type: Efficiency. Industry Groups: Hospitals and Several Industrial Industries)

Many facilities use once-through cooling to cool small heat generating equipment including x-ray film processors, welders, vacuum pumps, air-compressors, etc. In most cases it is possible to connect the equipment to a recirculating cooling system or to install a cooling tower. Recirculating systems typically consume only two to three percent of the water used by single-pass systems.

X-Ray Film Processors. (Type: Efficiency. Industry Groups: Hospitals and Dental Offices)

X-ray film processors use a stream of rinse water as a part of the film-developing process. An audit of 38 x-ray units in southern California revealed that the units used from 3.2 AF to as much as 7.5 AF annually. Past conservation recommendations have included installing a sensor to interrupt the flow when the unit is not in use and adjusting the flow to the optimal flow rate. A recent development has been the introduction of units produced by a Southern California company that recirculate what has traditionally been "once-through" flow. These units, called Water Saver/Plus™, can save 98 percent of water use (CUWCC 2001).

Vacuum Pumps. (Type: Efficiency. Industry Groups: Hospitals; Paper and Pulp; and Others)

Vacuum pumps are widely used in a variety of facilities, including hospitals, research labs, and food processing plants, to create sterile environments or to remove moisture through a dehydrating process. Liquid water-ring pumps still use single-pass water for cooling and sealing. In many applications, such as hospitals and research facilities, it is desirable as well as efficient to replace water-ring pumps by air-cooled oil-ring or oil-less pumps and, consequently, these pumps have become increasingly common. In other industries, such as paper and pulp, water-based vacuum pumps remain appropriate, but their efficiencies can be considerably improved (Britain 2002).

Irrigation

Auto-Shutoff Nozzles. (Type: Efficiency. Industry Groups: Most)

Nozzles designed to shut off automatically (when not in use) can be installed on hoses and save 5 to 10 percent (or more) of water use (Vickers 2001).

Drip Irrigation. (Type: Efficiency. Industry Groups: Most)

Drip irrigation systems can be used on non-turf areas of landscaping. These systems use plastic tubes and small nozzles to deliver water to plant roots. These systems are often considered the most water-efficient of irrigation system (Vickers 2001).

Moisture Sensors. (Type: Efficiency. Industry Groups: Most)

Soil-moisture sensors and controllers measure soil moisture and control irrigation based on how much water the vegetation needs. These sensors reduce water use compared to simple timers that provide water whether or not it is needed.

Reclaimed Water. (Type: Reclaimed. Industry Groups: Schools; Hotels; Golf Courses; Office Buildings; and Some Industrial Industries)

Overall withdrawals of water can be reduced by replacing freshwater use with the use of partially treated water from a reclaimed water plant. This water is particularly appropriate for irrigating landscapes.

Reused Water. (Type: Efficiency. Industry Groups: Most)

Overall withdrawals of water can be reduced by replacing freshwater use with the use of wastewater from other on-site uses, such as washing clothes. This water is particularly appropriate for irrigating landscapes.

Reducing Water-intensive Vegetation. (Type: Efficiency. Industry Groups: All)

Although reducing water-intensive vegetation often involves planting vegetation native to a region or climate, we only consider replacing turf with a typical mix of "other" vegetation. While the "other" vegetation may not be as efficient as native vegetation, it is still more efficient than turf (see Appendix D).

Kitchen

Low-Flow Pre-Rinse Nozzles. (Type: Efficiency. Industry Groups: All with kitchens)

Pre-rinse nozzles are used in kitchens to dislodge food particles from dishes before putting them into a dishwasher. Typical pre-rinse nozzles use 1.8 to 2.5 gpm for manual nozzles and 3.0 to 6.0 gpm for automatic nozzles. Efficient pre-rinse nozzles use a fan-like spray pattern that generates the same cleaning action but uses only 1.6 gpm.

Efficient Icemakers. (Type: Efficiency. Industry Groups: All with kitchens)

Water-cooled machines typically use ten times more water than air-cooled machines but use less energy and generate less heat, which reduces air-conditioning load. Whether a water-cooled or air-cooled icemaker is more appropriate depends on the individual site. Water conservation measures in icemakers involve retrofitting once-through water-cooled refrigeration units and ice machines by using temperature controls and a recirculating chilled-water loop system (Pike et al. 1995).

Efficient Dishwashers. (Type: Efficiency. Industry Groups: All with kitchens)

Small establishments use rack or under-the-counter machines that are similar to dishwashers found in the home while larger restaurants use either conveyor-type or flight-type machines. Conveyer-type machines have a conveyer belt with racks moving along this belt and a hook-type mechanism that lifts the racks and loads then into a larger machine that can usually hold four racks. Flight-type machines, which are much bigger and used in hotels or large catering establishments, have pegs onto which the dishes are loaded.

All of these dishwashers come in efficient and inefficient models. Studies indicate that efficient dishwashers typically use 50 to 70 percent less water and energy compared to inefficient machines (Sullivan and Parker 1999). Water efficiency features in the efficient models include recirculating the final rinse water, electric eye sensors, and extra-wide conveyers (NCDENR 1998).

Laundry

Closed-loop Laundry Systems. (Type: Efficiency. Industry Groups: Hotels; Hospitals; and Laundries)

Closed-loop laundries use membrane-filtration systems that can recycle 80 to 90 percent of the water used at the facility. The main purpose of the membrane system is to remove suspended solids (TSS), oil, and grease from the laundry effluent.

Recycling Laundry Rinse Water. (Type: Efficiency. Industry Groups: Hotels; Hospitals; and Laundries)

One or more pre-treatment processes may be used to recycle part of the laundry wastewater. The steps followed include:

<u>Stream Splitting</u> - Segregation of wastewater streams into high and low pollutant loading streams so that relatively clean streams can be reused.

<u>Gravity Setting</u> – Leaving the wastewater to stand in a basin for some period of time to allow the settling of suspended solids.

<u>Chemical Removal</u> – Removal of various organic solids and oils using emulsion, precipitation etc.

Ozone Cleaning Systems. (Type: Efficiency. Industry Groups: Hotels; Hospitals; and Laundries)

These systems generate ozone gas, which is injected into the wash water. As an unstable gas, ozone decomposes to release elemental oxygen, a powerful cleaning agent. At 100 degrees F, ozone systems provide an equivalent cleaning of 160 degrees F, eliminating the need for steam and hot water. These systems thus save energy and water. Ozone cleaning systems use 30 percent less water than conventional systems and can use up to 80 percent less with recycling.

Membrane Treatment and Recycling. (Type: Efficiency. Industry Groups: Hotels; Hospitals; and Laundries)

A number of laundries are experimenting with recycling laundry wash water with membrane systems. Laundries in California and Seattle have recently implemented a "Vibratory Shear Enhanced Processing" system that filters suspended and dissolved solids and also removes BOD, COD, and color. The system provides a vibratory shear force ten times greater than convention cross-filtration and produces a clear reusable water stream and a concentrated sludge. An added advantage of the system is that the effluent water is soft, a desirable quality in the laundry industry.

Resource-Efficient Clothes Washers. (Type: Efficiency. Industry Groups: Coin Laundries; Hotels; and Hospitals)

Since the early 1990s, manufacturers, energy and water utilities, and public interest groups have been promoting more efficient washer technologies as a means of pursuing water and energy savings. The Horizontal-Axis (H-Axis) washer has been a popular model. These washers use a washtub that spins about a horizontal axis and cleaning action is accomplished by tumbling the clothes in and out of the water that fills half the tub. In contrast, traditional clothes washers have a vertical axis and spin the clothes around in a full tub of water. Since most of the energy use in washers is for heating water, conserving water also greatly reduces energy use. Recently some manufacturers have sold water- and energy-conserving washers that are based on the standard vertical-axis design. They use spray rinses, lowered temperatures, and innovative agitation systems to achieve savings comparable to H-Axis washers (Pope et al. 2000). Typical savings in water and energy are about 40 percent. We refer to all efficient models as resource-efficient clothes washers.

Guest Laundry Cards. (Type: Efficiency. Industry Groups: Hotels)

Some hotels ask guests staying more than one night to consider not having their bed linens changed every day. Participating hotels reported saving five percent on utility costs along with 70 to 80 percent guest participation by using this option (Green Hotels Association 2002).

Process

Rinse Optimization. (Type: Efficiency. Industry Groups: Most Industrial Industries)

Optimizing rinse cycles can save water in several industries. This approach was originally developed and tested by the semiconductor industry and has since been transferred to other industries as well. Typical measures involve reducing the number of rinse cycles and rinse time as well as recycling water from dilute rinses. Optimization of rinses involves collecting and utilizing data on:

- ~~1.~~ Water flow rates for process and idle flows, transfer speeds from chemical baths to rinse baths, and fluid dynamics.
- ~~2.~~ Detailed conductivity, pH, mass-spectrometry measurements to determine the quantity and type of contaminants.
- ~~3.~~ Device electrical characteristics to determine the effect that optimized rinse processes have on yield.

Auto-shutoff Valves. (Type: Efficiency, Industry Groups: Most Industrial)

Automatic shutoff valves use solenoid valves to stop the flow of water when production stops, sometimes by tying the valves to drive motor controls. Other related water-efficiency measures include adjusting flow in sprays and other lines to meet minimum requirements, providing surge tanks for each system to avoid overflow, and turning off all flows during shutdowns (unless flows are essential for cleanup).

Cascading Rinses. (Type: Efficiency. Industry Groups: High Technology; Metal Finishing; and Textiles)

Not all rinses require the same quality water. By cascading rinses it is possible to use rinse water from a “critical” rinse (requiring highly pure water) in a less critical rinse, reducing overall water withdrawals.

Reactive Rinses. (Type: Efficiency. Industry Groups: Metal Finishing and Printed Circuit Board Manufacturing)

In some processes it is possible to reuse acid rinse effluent as influent for the alkaline rinse tank.

Counter-current Rinses. (Type: Efficiency. Industry Groups: Food Processing; Textiles; Metal Finishing; and High Tech)

This measure is employed frequently on continuous production rinsing lines for water and energy savings. Clean city water enters at the final wash box and flows counter to the movement of the product through the wash boxes. Thus, the cleanest water contacts the cleanest product, and the more contaminated wash water contacts the product immediately as it enters the actual process. This method of water reuse differs from the traditional washing method, which supplies clean water at every stage of the washing. Water and energy savings are related to the number of boxes provided with counter flow.

Counter-current rinsing is a common practice in a number of industries where the product goes through successive baths or wash boxes. In the Food Processing industry, for example, it is used to clean fresh produce.

Recycling Dilute Rinse Water. (Type: Efficiency. Industry Groups: Most Industrial)

If recycling all rinse water is found to be impractical, some industries may consider diverting only the last few rinses, which are relatively uncontaminated, to a membrane filtration system to generate a clean stream of water. This type of system is useful in "clean-in-place" systems where the rinse water usually flows directly to the drain.

Bubbled Accelerated Floatation (BAF). (Type: Efficiency. Industry Groups: Food Processing)

This technology is used to pre-treat effluent water before passing it through a membrane system. Air is bubbled into the effluent from a lower level and the bubbles bring solid particles to the surface, which are then removed. BAF systems are an improvement over earlier Dissolved Air Flotation (DAF) systems since they allow removal of suspended solids, fats, and greases and thus prevent fouling of membranes.

Ozone Cleaning. (Type: Efficiency. Industry Groups: Food Processing)

In the Food Processing industry, ozone can reduce or eliminate the need for chemical or high-temperature disinfection processes during clean-in-place (CIP) cycles, reducing water requirements, downtime, and chemical costs. Ozone CIP is far superior to any other cleaning method because of the high oxidation power of ozone.

Reusing Evaporator Condensate. (Type: Efficiency. Industry Groups: Dairy and Fruit and Vegetable Processing)

In many Food Processing plants, fruits, vegetables, or milk are evaporated to condense or dry them. This process produces evaporator condensate, a mixture of water and some volatile organic solids, that may be reused in applications such as cooling towers, boilers, and irrigation. Some dairy plants generate so much excess water that some of it is sent to the drain. The Dairy industry has been experimenting with passing this excess water through a reverse osmosis membrane to remove the volatile organic compounds. The process generates pure water, which can replace fresh water in all processes. To date, this process has not proven cost-effective.

Reusing Reverse Osmosis Backwash From Ultra-pure Water Production. (Type: Efficiency. Industry Groups: High Tech and Hospitals)

Many industries use extremely pure water, called ultra-pure water (UPW), for critical applications. UPW is produced by running potable city water through a reverse osmosis membrane to remove impurities. The waste stream that is left behind after passing the potable water through a reverse osmosis membrane (the "retentate") is fairly clean and can be reused in cooling towers or landscaping.

Reducing Drag-out. (Type: Efficiency. Industry Groups: Metal Finishing and High Tech)

Drag-out is the residual chemical that sticks to the component, which must be removed through rinsing. By employing techniques that reduce drag-out, less water is needed in rinsing. Typical techniques involve using agents to decrease surface tension, racking parts to drain them out, optimizing the temperature of the baths to reduce viscosity, and increasing “drip time” (when the component is placed on a draining panel).

Caustic Recovery. (Type: Efficiency. Industry Groups: Food Processing)

The Food Processing industry’s sanitation standards require that all equipment in contact with a fluid food product must be cleaned every 24 hours. Cleaning-in-Place (CIP) technologies using caustic and phosphate-based cleaning agents are commonly used to sanitize equipment. These technologies produce effluent that cannot be reused because of high chemical concentrations. Recent developments in membrane filtration technologies, however, have made it possible to recover some of the cleaning chemicals from the effluent stream. The resulting permeate is a relatively clean stream of water that can be reused in other processes.

Reused or Reclaimed Water in Scrubbers. (Type: Efficiency. Industry Groups: Metal Finishing; High Tech; and Textiles)

Many industries have scrubbers that spray water through exhaust air to strip it of pollutants before it leaves the facility. Wastewater from other processes can potentially be used as scrubber water make-up (Anderson 1993).

Maximize Efficiencies of Sterilizers. (Type: Efficiency. Industry Groups: Hospitals)

Many hospitals and research labs use autoclaves to sterilize equipment. Autoclaves use steam for sterilization and then freshwater to cool and recondense the steam. Typical measures for improving the water efficiency of autoclaves include: installing auto-shutoff valves to interrupt the flow when the unit is not in use; running the autoclave with full loads only; and reusing steam condensate and non-contact cooling water in cooling towers or boilers.

Digital X-Ray Machines. (Type: Efficiency. Industry Groups: Hospitals)

Digital x-ray machines are increasing in popularity because images can be stored on computers, digitally transmitted, or manipulated. Unlike conventional x-ray machines, the operation of digital machines requires almost no chemicals which significantly reduces the need for freshwater. Although digital x-ray machines are still very expensive and it will take several years before the conventional machines are replaced entirely, hospitals are gradually replacing their old machines with these more efficient models.

Future Conservation Technologies

Real-time Sensing of Contaminants. (Type: Recycling. Industry Groups: High Tech)

The High Tech industry has been a pioneer in developing water conservation technologies, but because most of its processes are extremely sensitive to water purity, recycling water has not gained widespread acceptance in this industry. Indeed, the mere suspicion that water may be contaminated may result in the destruction of an entire batch of components worth thousands of dollars. To address this issue, SEMATECH, a semiconductor industry association, has been researching use of real-time sensors, which can detect rinse water containing organic contaminants and then divert it away from the recycling loop. SEMATECH estimates that incorporation of such technology will decrease water consumption by 50 percent (SEMATECH 1994).

Dry Cleaning Technologies. (Type: Efficiency. Industry Groups: High Tech)

Researchers are exploring the possibility of using dry cleaning technologies, such as lasers or high-pressure gases, instead of chemical cleaning agents, in the High Tech industry. These processes will eliminate the need for ultra-pure water to rinse out chemicals.

Advanced Reverse Osmosis Treatments. (Type: Recycling. Industry Groups: High Tech; Food Processing; Metal Finishing; and Paper and Pulp)

A number of studies evaluating advanced reverse osmosis use on effluent are being conducted. While these systems appear to be in the demonstration stage, considerable potential exists for establishing closed-loop facilities that completely recycle process water.

Corrections and Modifications Performed on Data, Method A

Below we describe our analysis of the extensive data on industrial water use collected by the California Department of Water Resources in the 1990s (CDWR 1995a, b) and show the data we collected on commercial water use from various other sources. To use these data, errors had to be identified and corrected, data gaps filled, and some entries updated. Below we describe the corrections and modifications applied to these data. We thank Charlie Pike and other current and former CDWR employees, as well as a wide range of California water experts (listed in the Acknowledgements Section of the Report) for their help and diligence in both collecting and trying to understand these water-use data.

1. The average number of employees for the year was compared with the number of employees in any one month. Firms with any unusual deviations were checked visually for data entry errors and corrected.
2. Rows with zero water use or zero employees were eliminated.
3. Rows with coefficients of gallons per employee per day (GED) > 400,000 or < 5 were eliminated. A ceiling of 400,000 gallons was chosen because firms with higher GEDs did not exist in the literature or other surveys. The five-gallon minimum was selected based on the assumption that this is the minimum amount of water used for sanitary purposes for each employee.
4. All firms with GED coefficients greater than 10,000 were examined individually. Each firm's location, SIC code, and description were taken into consideration and if we had additional corroborating data from the firm's water supplier, then the water use was crosschecked. The following possibilities were examined: the data for the firm were erroneous and should be discarded; the firm's GED was representative of firms in that 3-digit SIC code and should be included in the sample; or the data could be correct, but the firm was not representative of the industry in general (in such cases, the firm was eliminated from the sample when computing the GED coefficient average but its water use was added to the industry total).

Table C-1
Water Use Coefficients by SIC Code, Industrial Sector

SIC	Description	Gallons per employee per day (GED)[1]
20	Food and kindred products	1,967
21	Tobacco manufactures	N/A
22	Textile mill products	1,530
23	Apparel and other textile products	37
24	Lumber and wood products	2,144
25	Furniture and fixtures	53
26	Paper and allied products	1,000
27	Printing and publishing	98
28	Chemicals and allied products	833
29	Petroleum and coal products	11,399
30	Rubber and misc. plastics products	120
31	Leather and leather products	32

32	Stone, clay, glass, and concrete prod.	1,304
33	Primary metal industries	1,318
34	Fabricated metal products	738
35	Industrial machinery and equipment	110
36	Electrical and electronic equipment	284
37	Transportation equipment	228
38	Instruments and related products	142
39	Misc. manufacturing industries	86

[1] Based on a 225-day year

Table C-2
Water Use Coefficients by SIC Code or Establishment Type in the Commercial Sector
gallons per employee per day (ged)

SIC	Description	Method A, Dziegielewski et al. 1990[1]	Davis et al. 1988[1]	Establishment Type[2]	Dziegielewski et al. 2000
41	Local and interurban passenger transit	32.6	42.2	O	221
42	Motor freight transportation and warehousing	470.9	137.2	O	221
43	U.S. Postal Service	8.3	8.3	O	221
44	Water transportation	993.6	573.9		
45	Transportation by air	326.7	278.4	O	221
46	Pipelines, except natural gas	0.0	0.0	O	221
47	Transportation services	105.0	64.6	O	221
48	Communications	79.3	76.7	O	221
49	Electric, gas, and sanitary services	52.4	82.7		
50	Wholesale trade--durable goods	32.3	47.0	W	
51	Wholesale trade--nondurable goods	389.5	140.6	W	
52	Building materials, hardware, garden supply, mobile	91.7	56.1	R	
53	General merchandise stores	57.6	75.9	R	
54	Food stores	213.0	158.8	S	284
55	Automotive dealers and gasoline service stations	101.6	79.3		
56	Apparel and accessory stores	87.6	109.8	R	
57	Furniture, home furnishings and equipment stores	128.8	67.6	R	
58	Eating and drinking places	331.3	253.4	R	
59	Miscellaneous retail	449.5	214.5	R	
60	Depository institutions	72.8	95.5	O	221

[1] Figures were converted into 225 days per year. Most of method 1 data came from Dziegielewski et al. (1990) with the exception of information on state and federal government employees.
[2] O=Office, E=School, R=Retail, W=Wholesale, M= Motel/Hotel, L=Laundromat, S = Supermarket, H= Hospital.

61	Nondepository credit institutions	169.0	253.7	O	221
62	Security, commodity brokers, and services	221.1	221.1	O	221
63	Insurance carriers	212.8	212.8	O	221
64	Insurance agents, brokers, and service	162.1	144.2	O	221
65	Real estate	987.9		O	221
66	Combined real estate and insurance			O	221
67	Holding and other investment offices			O	221
70	Hotels, rooming houses, camps, and other lodging	301.7	373.6	M	1083
72	Personal services	1,090.5	749.6	L	
73	Business services	161.7	93.9	O	221
74	Automotive repair, services, and parking	0.0	351.4		
75	Miscellaneous repair services	255.8	114.7		
78	Motion pictures	126.9	183.1		
79	Amusement and recreational services	732.8	692.9		
80	Health services	155.2	147.0	H	
81	Legal services	123.8	123.8	O	221
82	Educational services	236.5	187.9	E	553
83	Social services	341.2	172.6	O	221
84	Museums, art galleries, botanical & zoological garden	342.8	337.4		
86	Membership organizations	670.5	344.4		
87	Engineering and management services	0.0	141.3	O	221
88	Private households	0.0			
89	Miscellaneous services	178.1		O	221
90*	State govt. employees	171.5	171.5	O	221
91*	Federal govt. employees	171.5	171.5	O	221

Table C-3
Comparison of Estimated Statewide CII Water Use to Other Studies, 1995 (TAF)

Source	Commercial/ Institutional	Industrial	Total
Method A	2,002	675	2,677
Method B	2,203	763	2,966
DWR[1]	1,843	619	2,462
USGS[2]	1,544	919	2,463

[1] DWR 1994
[2] Solley et al. 1998

Note: We also compared our estimates to a statewide industrial use estimate from 1979 (CDWR 1982) and CII water use estimate for the South Coast region (MWD 2000) to resolve specific questions we had about our calculations.

Uncertainties Inherent in the Data

The full report extensively discusses uncertainties in the data, especially CII data. We add here some specific data issues related to the two approaches taken in this report.

Method A
Geographical Bias: Each industry's average GED was applied to all hydrologic regions in both the industrial and commercial sectors. This approach ironed out regional differences in industrial mix, price elasticity of demand, and aggressiveness of conservation programs, but it produces a lower degree of confidence in the regional estimates. This was particularly relevant in the commercial sector where the estimates are based on studies of the South Coast region, which we suspect to be more efficient than inland regions (see Section Four of the full report). Thus, there may be greater conservation potential than our results show.

GED Issues: The CDWR survey was biased toward more water-intensive facilities. Although this problem was corrected to some extent by estimating GEDs at the three-digit level, considerable variability was found within three-digit SIC codes in some cases. In the commercial sector, the sample sizes were fairly small and, therefore, the GED estimates have a higher degree of uncertainty than the industrial estimates. Moreover, the GED estimates were based on surveys collected in the late 1980s mostly from Southern California and may not accurately reflect the state average in 1995.

Method B
Sampling Issues. The sample used in Method B was small for several regions and may not have accurately represented a region's overall CII use per capita.

Self-Supplied Water: In the absence of survey data for the commercial sector, we applied the commercial estimate of self-supplied water recorded in the USGS report "Estimated Water Use in the United States in 1995" (Solley et al. 1998). Since we did not have access to other primary source data, we are less confident in our estimate of self-supplied water for the commercial sector.

Extrapolation: We extrapolated agency data to the state level based on population served. Population may be a fairly accurate indicator of commercial water use, but we are less confident about how well it reflects industrial use since "population served" data are known to be less reliable.