

NEXUS OF WATER AND ENERGY SERIES

EMBEDDED ENERGY IN WATER



Briefing for U.S. Senate Staffers

by

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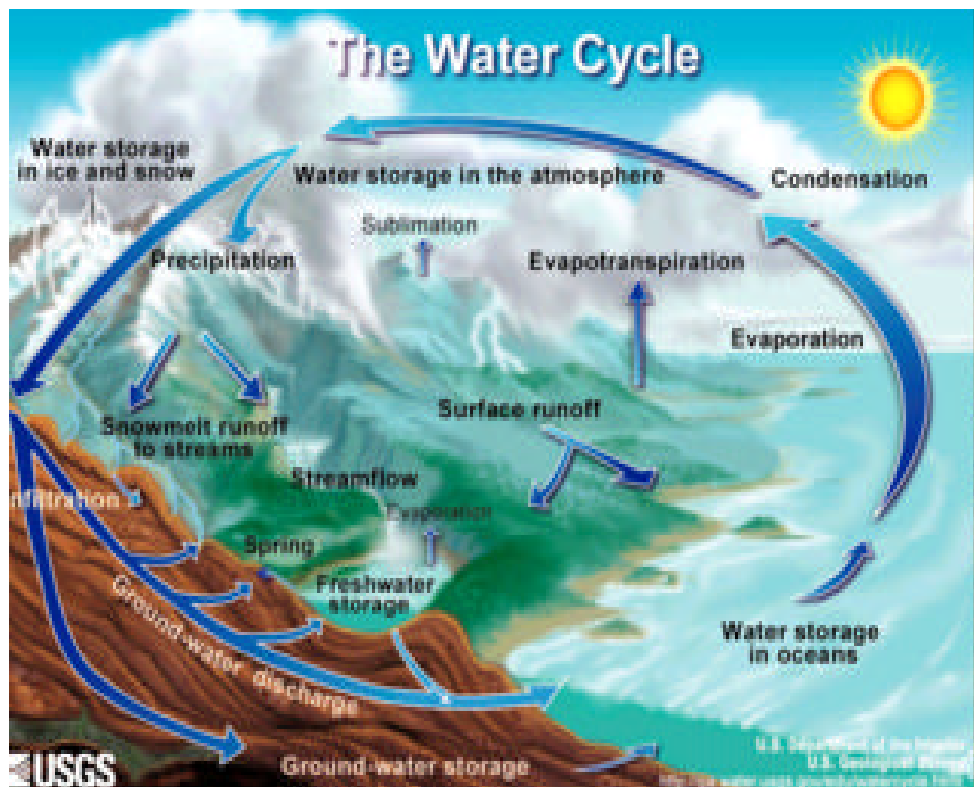
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Washington, D.C.

Water Characteristics

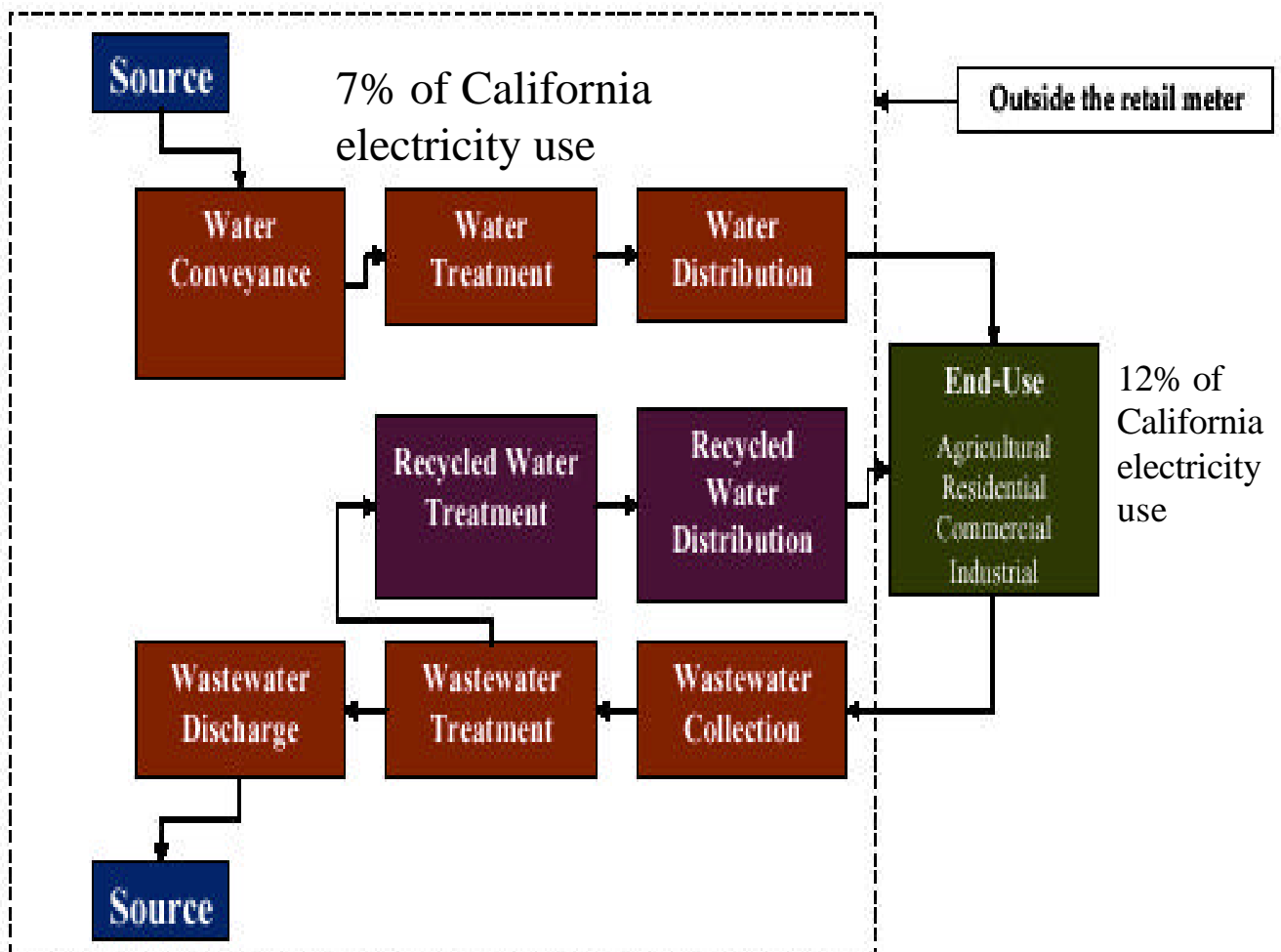
- There is exactly the same amount of water on earth as there has always been. *We are drinking the same water the dinosaurs drank.*
- We use energy to:
 - access water
 - groundwater
 - treat water
 - take out minerals / chemicals / contaminants
 - store water
 - move water to where we want to use it
 - treat water for end use
 - pressurize, add heat / cool or chemicals
 - collect wastewater
 - treat wastewater



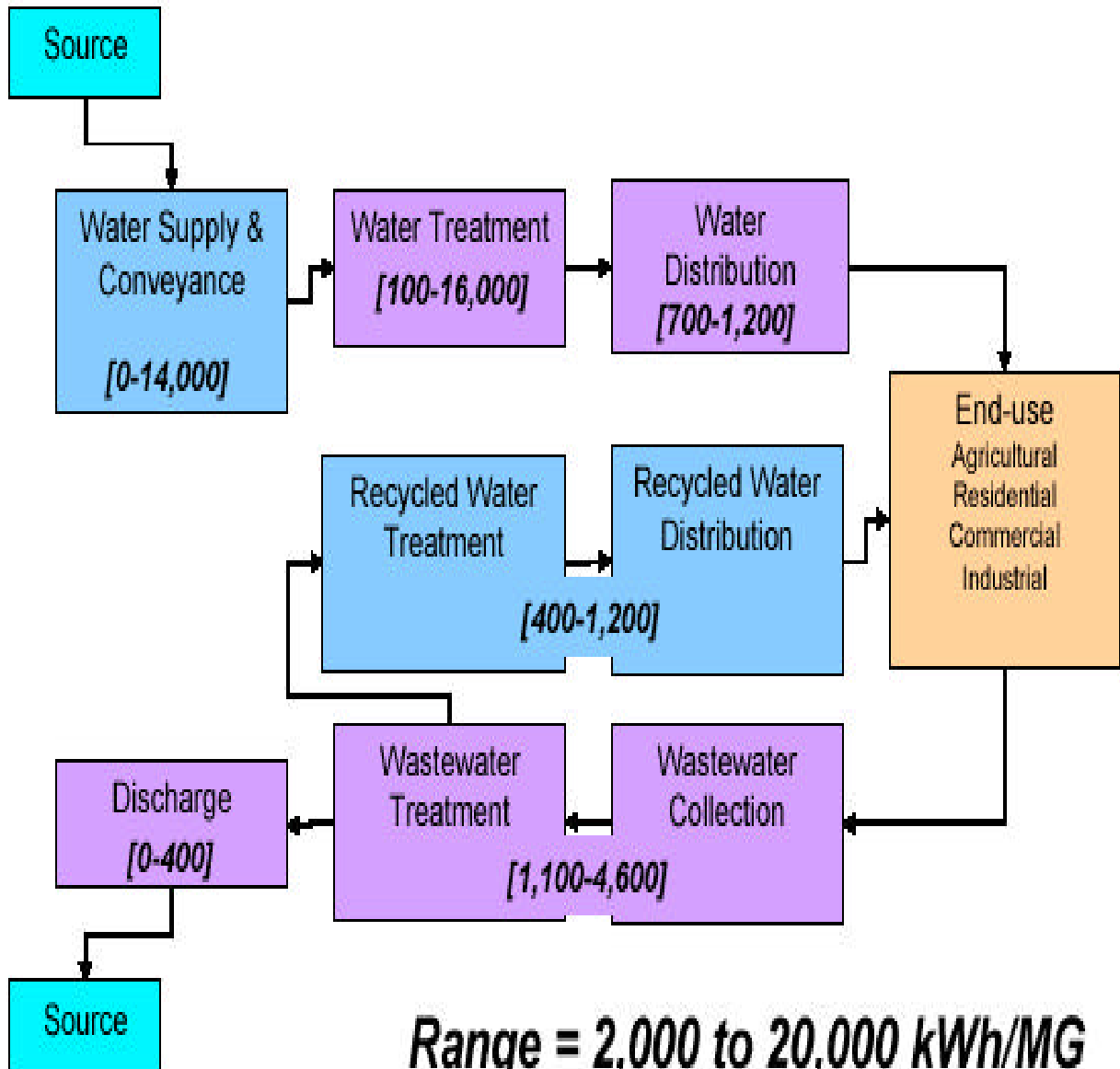
Principle Elements in Water Systems

(all require energy inputs)

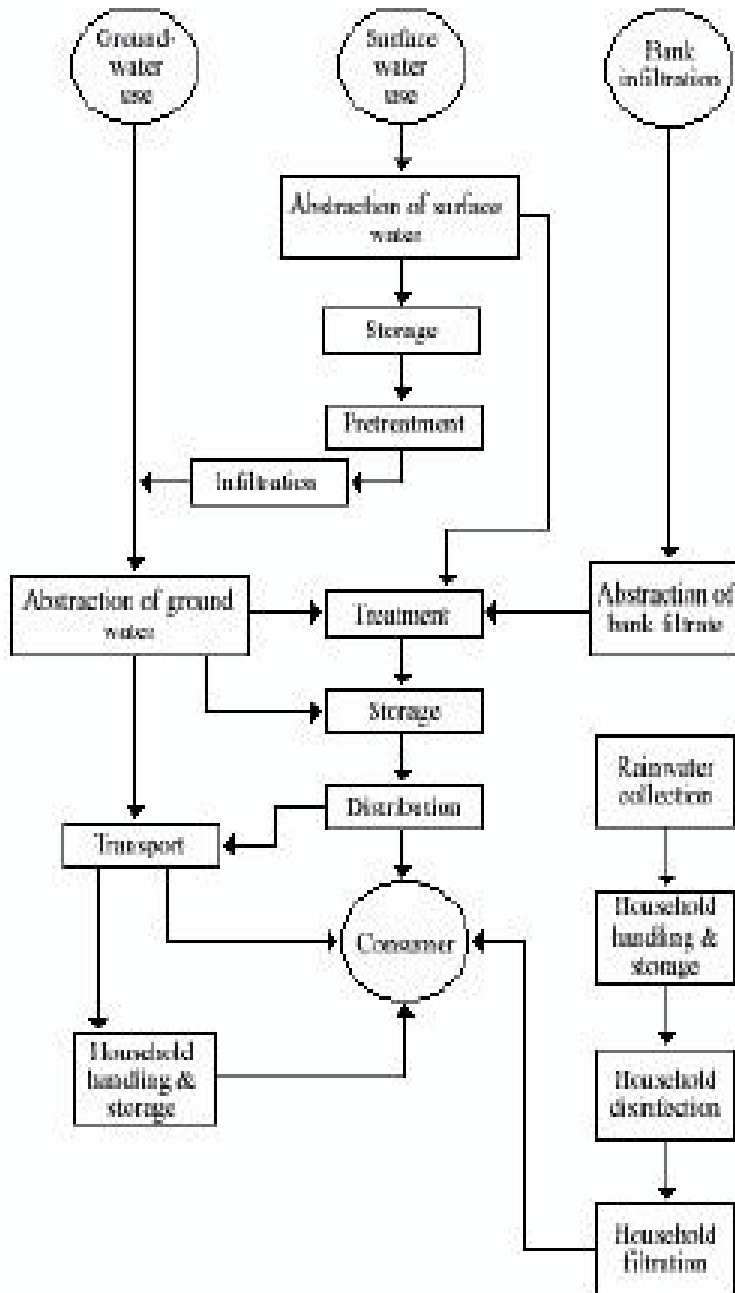
- Primary water extraction, conveyance, storage (in some cases) and supply delivery
- Treatment and distribution
- Customer on-site water pumping, treatment (chemicals), and thermal inputs (heating and cooling)
- Wastewater collection and treatment



Water System Energy Intensities Can Vary Significantly



Water System Design



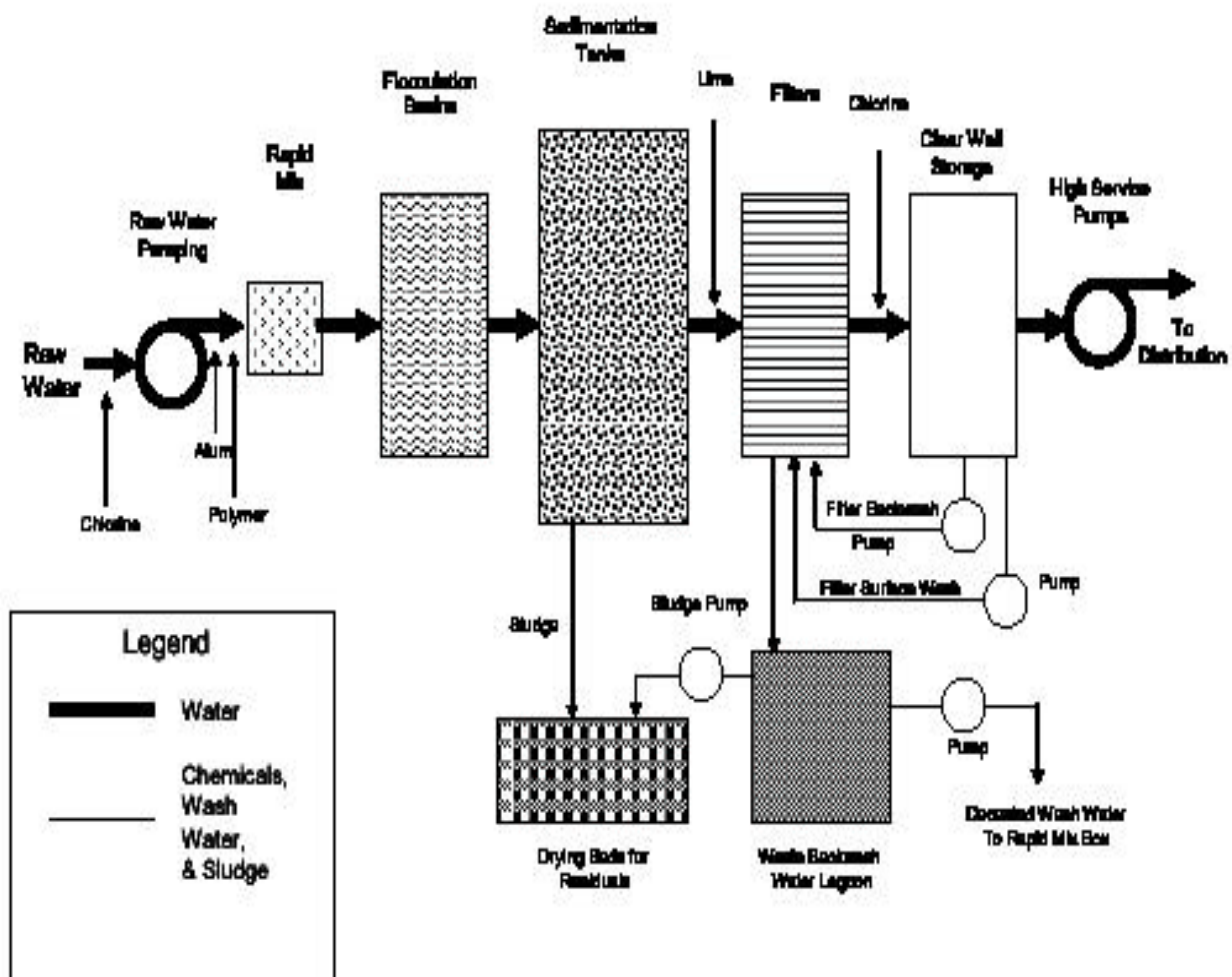
HOW WATER SYSTEM ELEMENTS ARE AFFECTED BY USAGE VOLUME

System Element	Design Criteria Based On			
	Average Day	Peak Day	Peak Hour	Fire Flow
Source Water Acquisition	√			
Raw Water Storage	√			
Water Pipelines			√	√
Water Treatment Plants		√		
Pumping Stations			√	√
Treated Water Storage		√		√

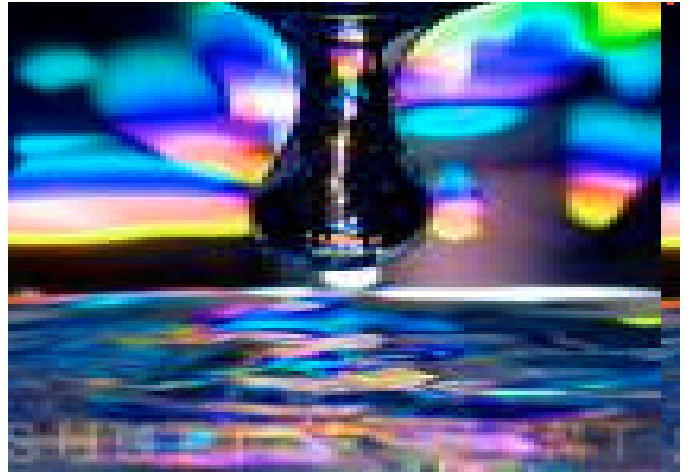
Initial Treatment

Figure 3-2: Sequence of Operations in Surface Water Treatment

Representative Water Treatment Plant



California Water Agencies

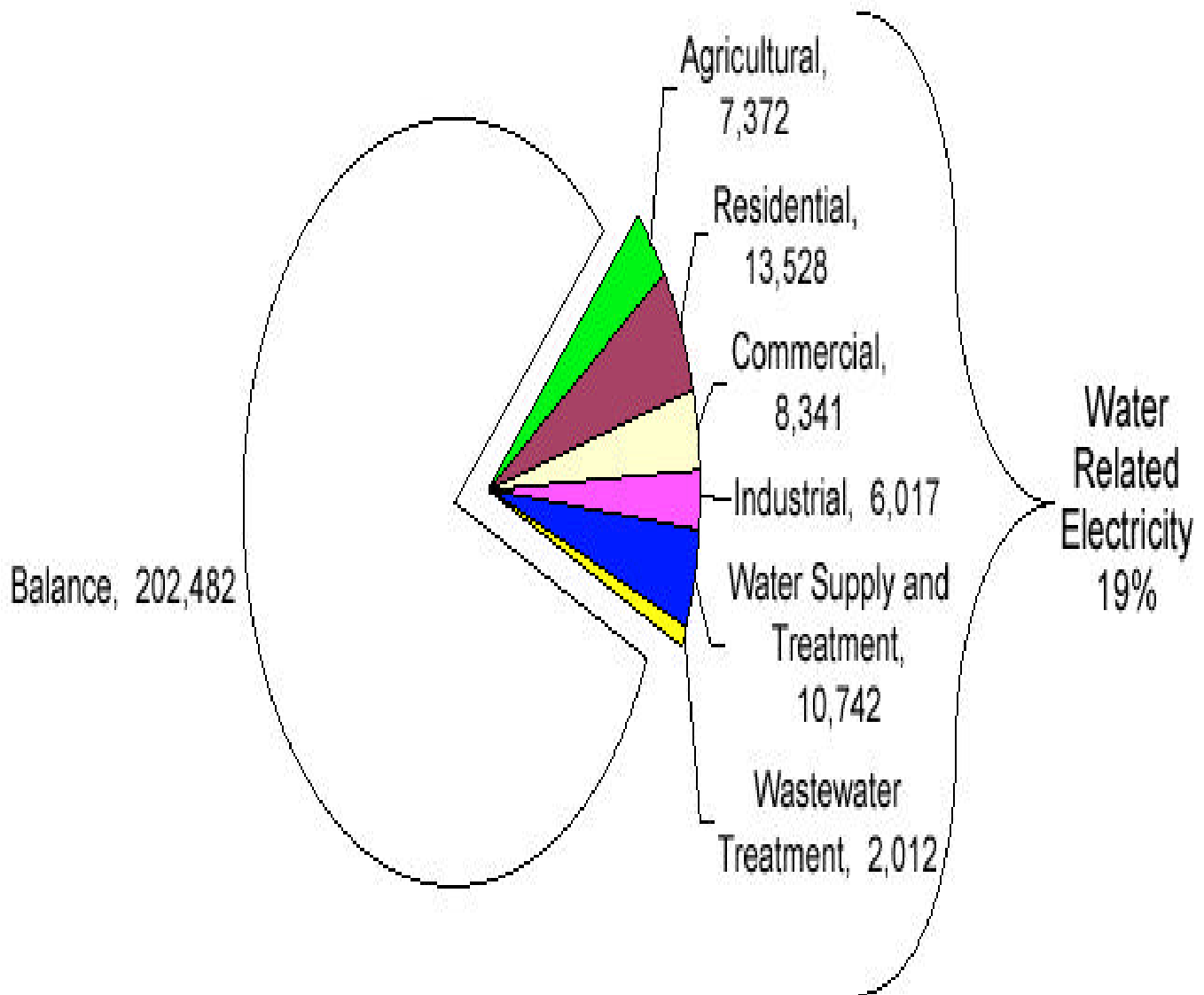


- Water agencies in California currently ~2,800+ MW maximum demand
 - Water agencies already curtail approximately 400+ MW of on-peak demand
- Water agencies potential for increased demand + ~3,575 MW (next 10 years)
 - Existing conjunctive use in drought/dry years ~350MW
 - Proposed conjunctive use development/drought ~ +1,350 MW
 - Desalinization ~250 MW salt water plus 250 MW desalting groundwater = +500 MW
 - Electrification of ag diesel pumps = +350 MW
 - Increased treatment requirements = +160 MW
 - Increased water marketing - +230 MW
 - Increased recycled water use - +685 MW
- Water agency generation
 - 500+ MW of standby generators available
 - Hydro - 2,547 MW existing, +255 MW new small
 - Biogas - 57 MW, 36 MW new potential
 - Natural gas engines - existing ~100 MW, +200 MW additional potential
 - Solar - 18 MW installed, +48 MW in process, +500 MW being reviewed by water agencies

California's Water System



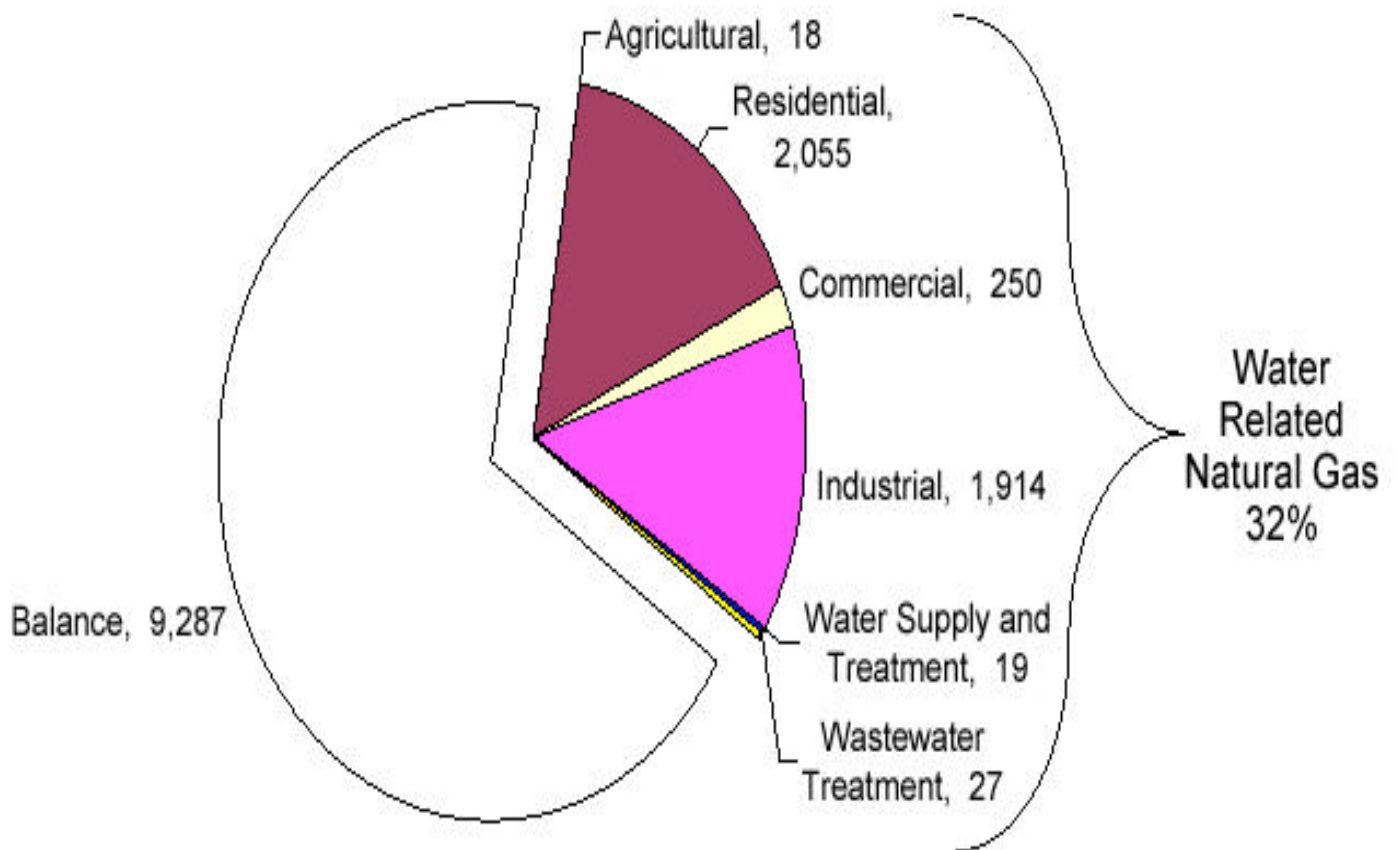
Total Water Related Electricity Use - California



Total Electricity Demand in 2001 = 250,454 GWh

The majority of water electricity use is by the end users (customers) for pressurizing, heating, cooling, and conditioning the water.

Total Water Related Natural Gas Use

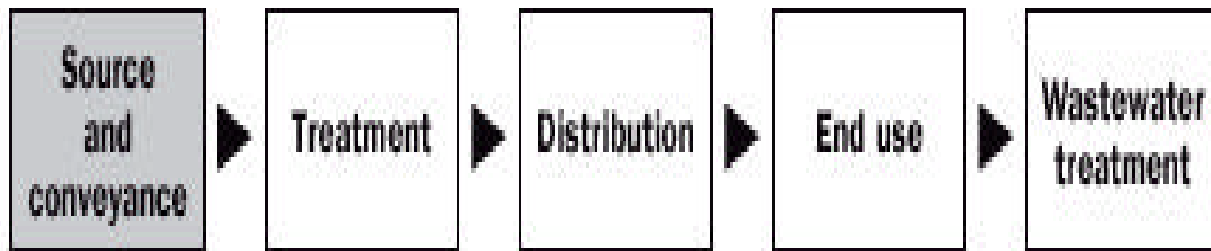


Total Natural Gas Demand in 2001 = 13,571 therms

Water systems use less than 1/2 % of natural gas use.

Savings Vary Depending Upon Where They Occur

SOURCE AND CONVEYANCE

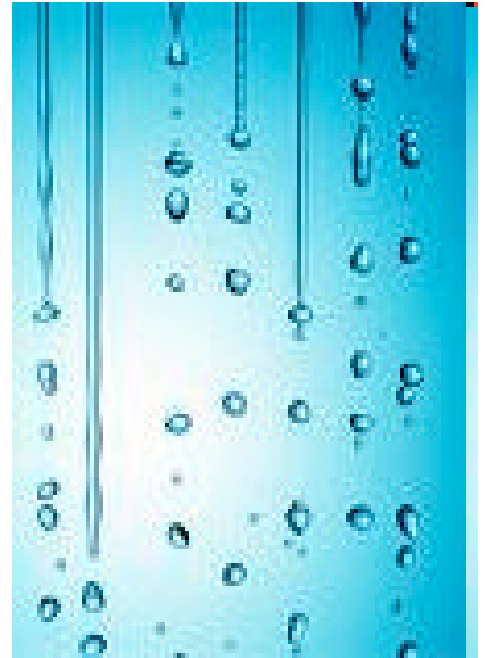


Saving water at the system level (conveyance, treatment, distribution) saves energy for all the water supplied.

End-use savings (customer savings) has potential to save even larger amounts of energy.

The key to efficiency in water is to address both the water system energy use and the consumer energy use.

Efficiency Improvements in Water Implementation Areas



- Energy efficiency in water system
- Reduction of peak electrical demand in water system
- Elimination of waste - primarily a customer area
- Understanding of timing and quantity of use through smart metering
- Utility de-coupling of water sales and total income to encourage conservation

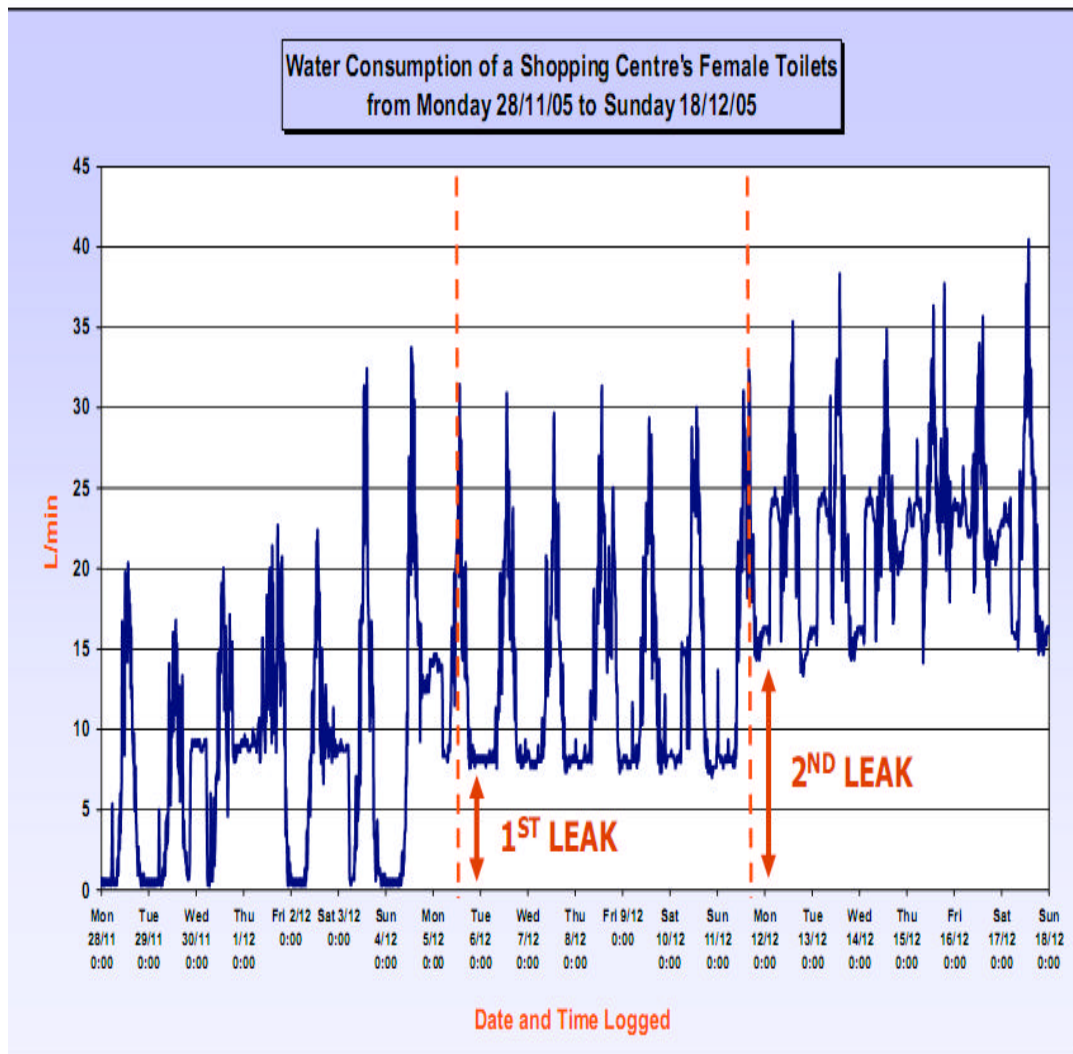
Water-Use Cycle Segment	Range of Energy Intensities (kWh/MG)	R&D Opportunities
Supply and Conveyance	0–13,800	<p>Reduce system losses to increase local supplies.</p> <p>Reduce outdoor use to increase local supplies.</p> <p>Reduce storm water diversions to increase local groundwater recharge.</p> <p>Increased water recycling to displace more energy intense marginal water supplies.</p> <p>Pursue technological advancement in desalination processes to decrease energy requirements and cost.</p> <p>Revise operations and systems to reduce total energy and peak energy use.</p> <p>Analyze coordinated operations and foster conjunctive use of supplies to decrease use of more energy intense marginal water supplies decrease peak energy use.</p>
Water Treatment	100	<p>Pursue technological advancements in response to more stringent water quality regulations.</p> <p>Reduce losses to increase local supplies.</p>
Water Distribution	1,200	<p>Reduce system losses to increase local supplies.</p> <p>Optimize pumping.</p>
Wastewater Treatment ²¹	1,100–2,450	<p>Increase biogas production.</p>

Some of the System Options

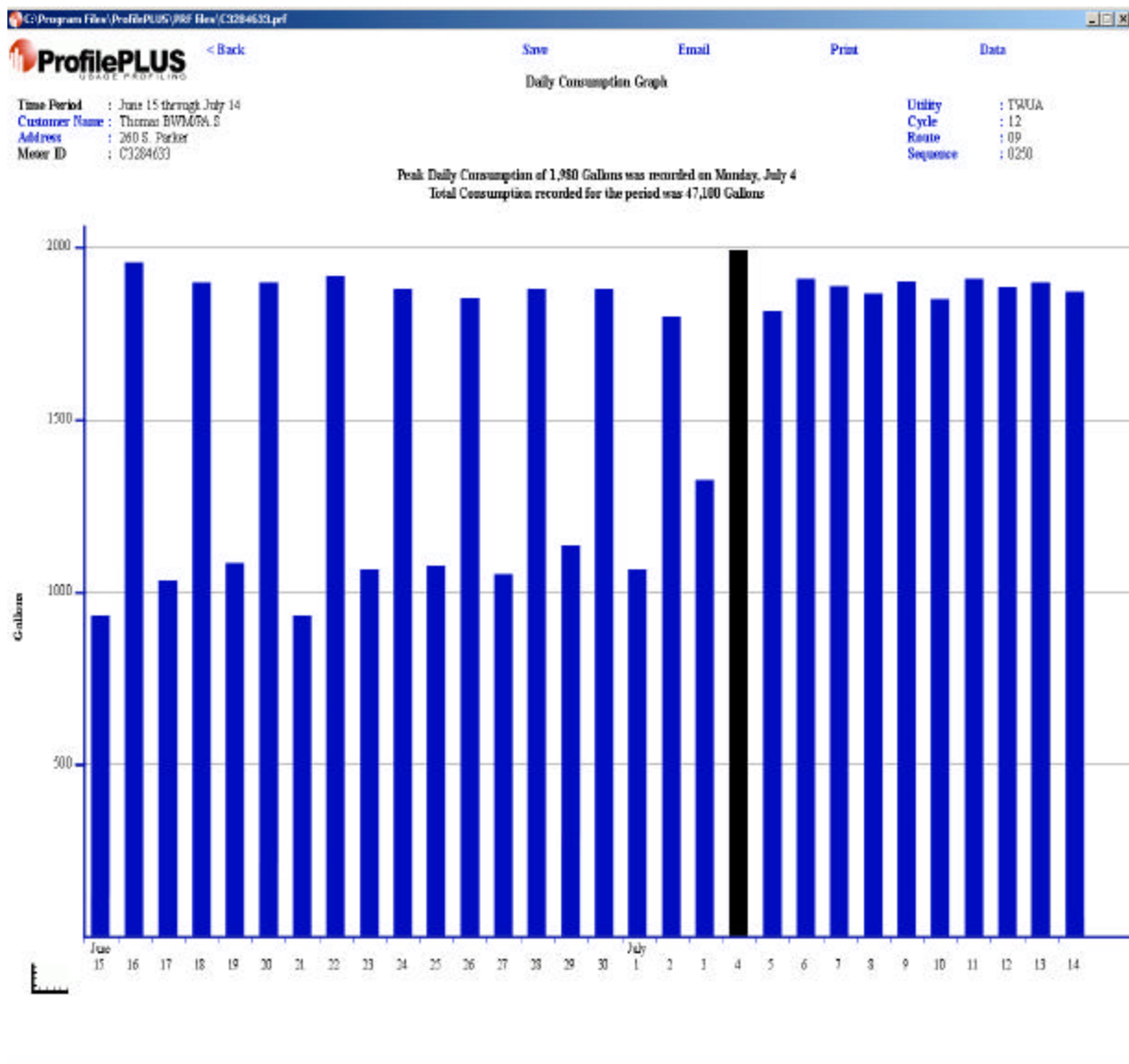
Water System Energy Efficiency Improvements

- Purchasers typically use lowest installed cost - not lifecycle cost, and purchase less efficient options
- Pumps - 25% of industrial electricity use and 50% of municipal and wastewater use is due to pumps
 - 20% more efficient pumps typically available
 - 15-20 year typical pump life
 - Variable Frequency Drives (VFDs) good option on pumps with varying demand
- Treatment -
- Chemicals -
- Losses - on both water system and customer side

AMR Meters Leak Detection



AMR Meters Even/Odd Day Conservation Program



Urban Best Management Practices (BMP)

California Urban Water Conservation Council - CUWCC

Box 22-1 Urban BMPs

BMP 1: Residential Survey Programs

BMP 2: Residential Plumbing Retrofit

BMP 3: System Water Audits

BMP 4: Metering with Commodity Rates

BMP 5: Large Landscape Conservation

BMP 6: High Efficiency Clothes Washers

BMP 7: Public Information Programs

BMP 8: School Education Programs

BMP 9: Commercial Industrial Institutional

BMP 10: Wholesaler Agency Assistance Programs

BMP 11: Conservation Pricing

BMP 12: Conservation Coordinator

BMP 13: Water Waste Prohibitions

BMP 14: Residential Ultra Low Flush Toilet

Replacement Programs

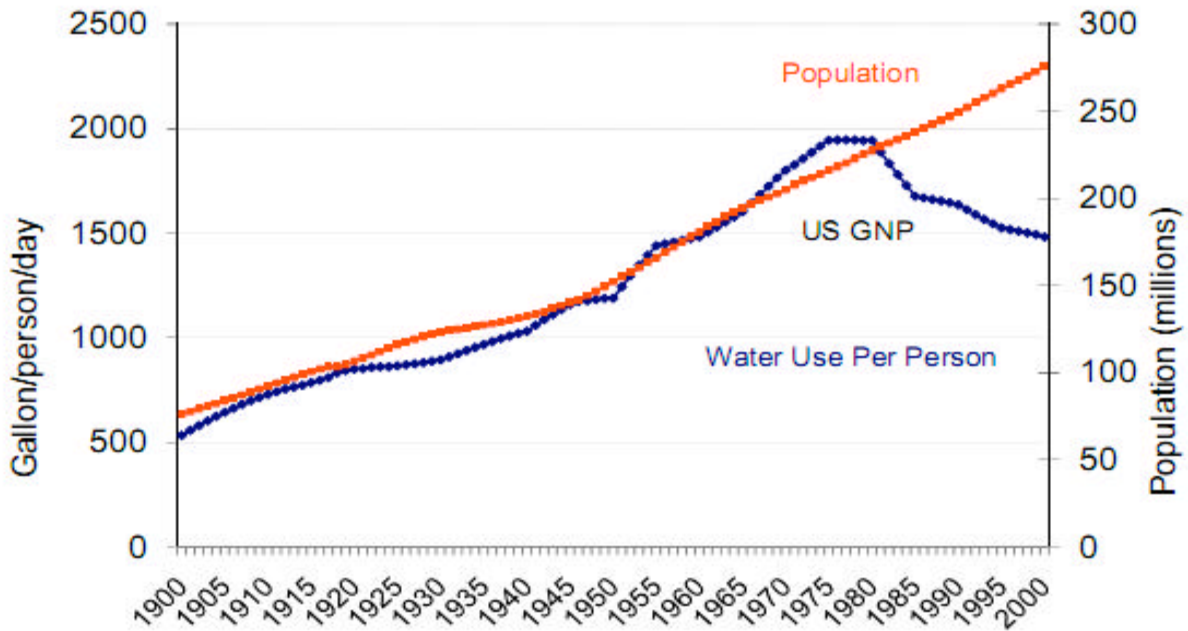
Why Water Savings Programs Are Better Than Energy Savings



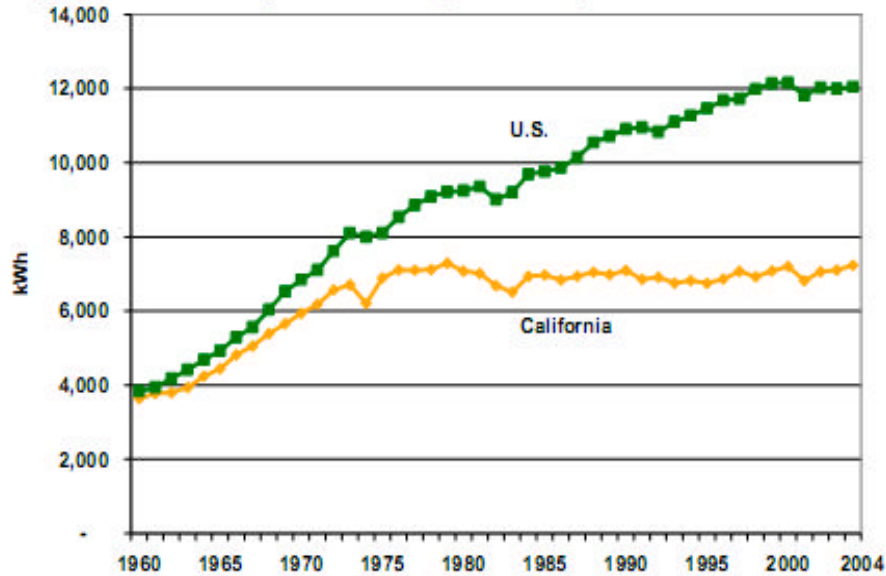
- *Less overhead*
 - Energy projects are typically run by the electric utilities, which pad them up with overhead (increased staff), public relations, and advertising. Water efficiency programs typically deliver much more of the dollars spent in the actual on-the-ground projects.
- *Water efficiency savings more permanent*
 - Energy efficiency tends to be much more transitory, due to the substitution effect. For example, the energy savings that come from a more efficient refrigerator are lost when the customer buys a new flat screen TV. When a customer buys a more efficient washer, they don't turn around and use that water somewhere else in their house.
- *Water efficiency saves both water and energy, energy efficiency savings save only energy*
 - Between 3-5% of all the electricity used in the U.S. is used to treat and distribute water (in California the number is over 7%). That means every time you save water you also are saving the energy that was previously used to treat and distribute that water. *This is why we have a big pilot water-energy savings pilot program going on here in California.* When you save energy (with a more efficient refrigerator) you only save energy, no water. Water savings gives you double bang for your buck.

Comparison of Water and Energy Per Capita Consumption

Figure 2. Total U.S. Population and Per-Capita Water Withdrawals: 1900 - 2000.

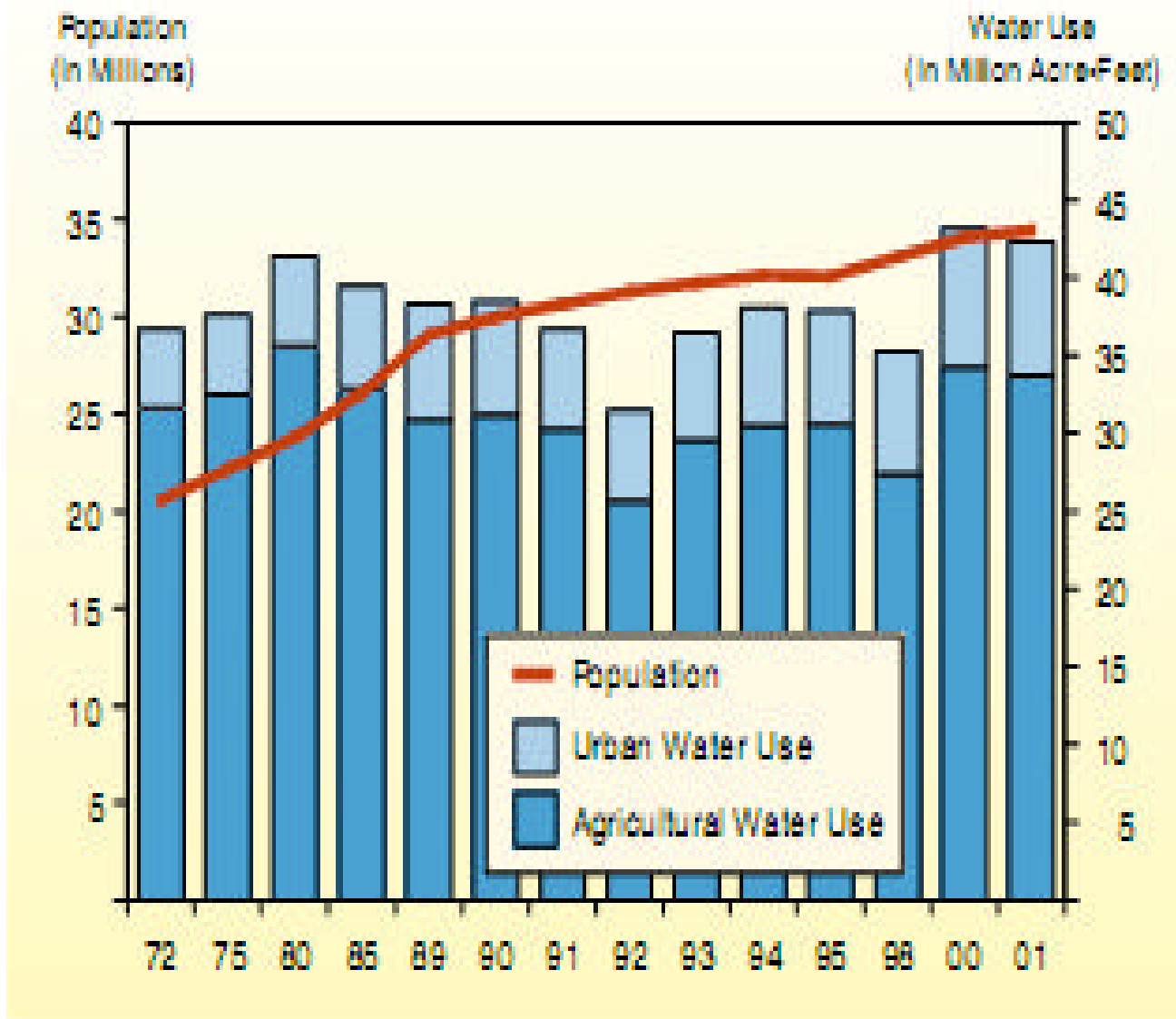


Comparison of Per Capita Electricity Consumption in U.S. and California



Source: California Energy Commission, 2005.¹⁰

California Water Use



Water used for urban and agricultural purposes has generally remained stable since the 1970's even though population has increased. Since the 1980s, the state has enacted multiple conservation measures to assist local entities, in reducing water consumption. These measures have included low-flow toilets, showerheads, landscape irrigation improvements, commercial and industrial efficiency improvements, and have resulted in decreases of approximately 50 percent in per capita water use.

California Water-Energy Pilot Program

The CPUC pilot allows the investor owned energy utilities (IOUs) to partner with a water provider to implement a jointly funded program designed to maximize embedded energy savings per dollar of program cost. This pilot focuses on efforts that would:

- Conserve water
- Use less energy-intensive water
- Make delivery and treatment systems more efficient
- Determine actual water savings and actual energy savings

The goal is to develop electric / gas utility programs that save water as a means to saving energy.

The Programs

- Multifamily High Efficiency Toilets
- Single Family High Efficiency Toilets
- pH and ET Controllers - commercial/industrial facilities
- Leak Detection Water Systems
- Large Customer - Ozonation
- Emerging Technology - water system SCADA systems
- Recycled Water
- Managed Landscape - ET controllers
- Natural Gas Pump Efficiency
- SDG&E Large Customer Audits

Water Infrastructure

Drinking Water ASCE 2009 Report

- America's drinking water systems face an annual shortfall of at least \$11 billion to replace aging facilities that are near the end of their useful life and to comply with existing and future federal water regulations. This does not account for growth in the demand for drinking water over the next 20 years.
- Leaking pipes lose an estimated seven billion gallons of clean drinking water a day.

Wastewater ASCE 2009 Report

- Aging systems discharge billions of gallons of untreated wastewater into U.S. surface waters each year. The EPA estimates that the nation must invest \$390 billion over the next 20 years to update or replace existing systems and build new ones to meet increasing demand.
- California Water agencies potential for increased demand + ~3,575 MW (next 10 years)
 - Existing conjunctive use in drought / dry years ~350MW
 - Proposed conjunctive use development / drought ~ +1,350 MW
 - Desalinization ~250 MW salt water plus 250 MW desalting groundwater = +500 MW
 - Electrification of ag diesel pumps = +350 MW
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California Recycled Water

- Water recycling = big savings. Reusing available water results in less fresh water being extracted, and reusing that water results in significant energy reductions compared to using more fresh water.
- 166 towns and cities in California now use recycled water
- California has a policy that no fresh water can be used for electricity production if there are feasible alternatives

RECYCLED WATER USE IN CALIFORNIA

06/2003

Types of Reuse	Volume of Recycled Water Use Within Region, Acre-Feet/Year											
	1	2	3	4	5F	5R	5S	6	7	8	9	Total
Agricultural irrigation	12,694	8,318	22,110	3,752	110,046	1,314	35,349	8,588	2,951	30,795	5,033	240,951
Landscape irrigation and	2,675	10,114	3,152	26,229	80	51	1,431	8,418	6,624	28,135	24,191	111,100
Industrial use	0	4,865	26	22,376	0	61	264	65	0	199	0	27,857
Ground water recharge	0	0	0	46,247	0	0	2,500	0	0	0	286	49,033
Seawater Barrier	0	0	0	10,651	0	0	0	0	0	15,000	0	25,651
Recreational impoundment	0	0	0	24,429	111	0	0	7,347	0	0	1,216	33,103
Wildlife habitat or misc.	1,977	6,198	5	6,437	0	0	1,009	0	172	4,361	41	20,200
Geysers/Energy Production	0	0	0	2,198	0	0	0	0	0	0	0	2,198
Other or mixed type	0	25	0	9,997	0	0	0	0	0	5,159	188	15,369
TOTAL	17,346	29,519	25,295	152,316	110,238	1,427	40,552	24,418	9,747	83,650	30,955	525,462

Source: Office of Water Recycling, California State Water Resources Control Board

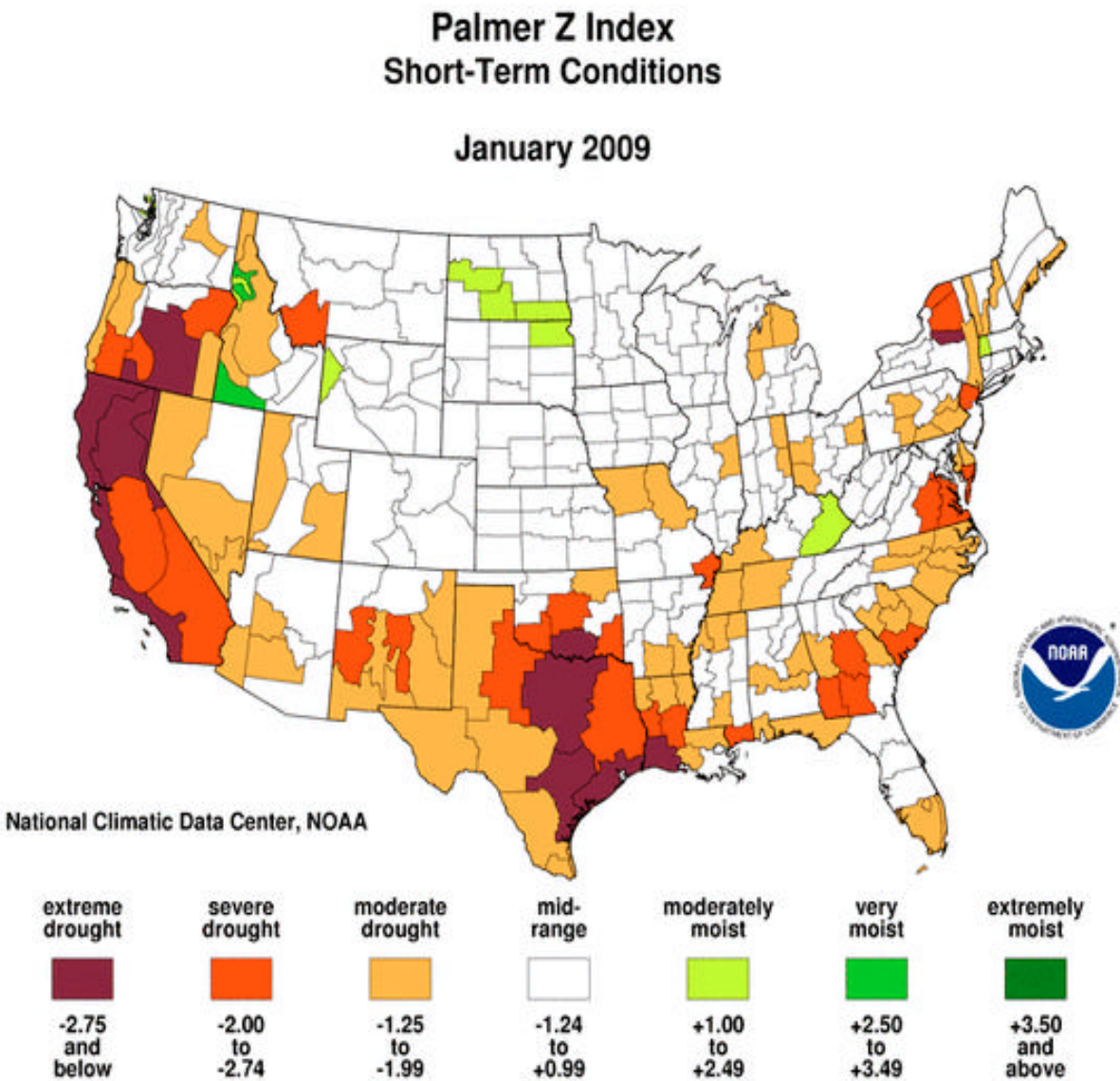
Water Treatment

There can be significant-and permanent -energy savings by employing more efficient treatment

Energy Efficiency Technology/Strategy	Description	Typical Payback (years)
High Efficiency Motors	Motors with lower internal losses; used for pumps, blowers, mixers, etc.;	variable
Variable Frequency Drives (VFDs)	Electronic controller that matches motor speeds to the required load; avoids running at constant full power	½ to 5
High Efficiency Pumps	Pumps with lower internal friction and head losses	variable
Variable Air Flow Rate Blowers	Variable rate blowers efficiently match air supply to aeration requirements	<3
High Efficiency Blowers	Air blowers with lower internal losses	variable
Dissolved Oxygen Controls	Maintains the dissolved oxygen (DO) level of the aeration tank(s) at a preset control point by varying the air flow rate to the aeration system	2 to 3
SCADA System	Supervisory Control and Data Acquisition system collects facility-wide data and allows control of equipment to more precisely meet required flows	variable
Fine-Bubble Aeration	Fine-pore diffusers generate smaller bubbles for aeration processes; improves oxygen transfer to wastewater	1 to 7
Staging of Treatment Capacity	Treatment systems designed and installed to operate efficiently at multiple "stages" (i.e. across a range of flow conditions)	<2
Recover Excess Heat from Wastewater	Excess heat from wastewater reused in low-temperature heating applications	<2
Efficient Mixing of Aerobic Digesters	Mechanical mixing used rather than aeration where possible; mechanical mixing uses less energy	1 to 3
Efficient sludge handling	Screw presses and gravity belt thickening use less energy for sludge dewatering and thickening	variable
Efficient Ultraviolet (UV) Disinfection Lamps & Controls	High efficiency UV lamps convert more of the power they consume into useful light; controls turn down lights when not needed	variable

Source: Wisconsin Focus on Energy (2006), PG&E (2006)

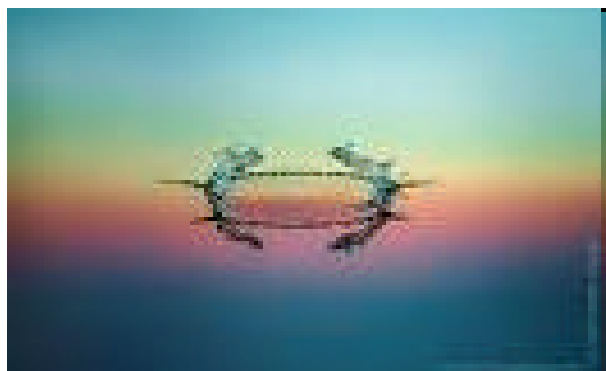
Current Drought Areas



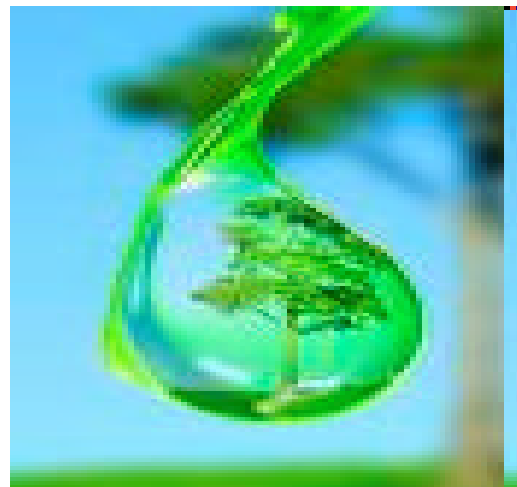
Drought impacts are forcing water systems to more energy intensive water: e.g., more groundwater use, more extensive treatment.

Conclusions

- There are a lot of new investments in the water systems currently, due to:
 - drought impacts
 - aging infrastructure
 - increased treatment requirements
- Virtually all of the solutions will require more energy than the current system
 - New water sources are more energy intensive than existing
 - lower quality water, further distances
 - New treatment uses more energy
- Any time a consumer saves water you will save energy
- Improving water systems energy efficiency has significant and long lasting impact



Recommended Policies



- Encourage water customers to increase their water efficiency
- Encourage water systems to invest in more efficient components
- Allow water systems to generate more of their own power
 - biogas, solar, wind, small hydro



A GALLON SAVED IS A WATT SAVED