A Sustainable Water Plan for the University of California Berkeley

A Professional Report,

For the Chancellor's Advisory Committee on Sustainability

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A Sustainable Water Plan for the

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Chapter 1: Introduction

The University of California Berkeley has taken important steps towards sustainability through officially recognizing the need to plan every new project as a model of resource conservation and environmental stewardship in their Long Range Development Plan (LRDP, 2005). The LRDP includes the goals of "minimizing water consumption and wastewater production" for all new buildings and major renovation projects. Minimizing water consumption and wastewater production in new development is integral to sustainable water planning. However, much of UC Berkeley's future water use and corresponding wastewater production will not be from new development but already occurs in the existing campus infrastructure. As of 2002, eighty-five percent of the planned campus infrastructure in 2020 has already been built (LRDP, 2005). Therefore, in order for UC Berkeley to meet its goals of minimizing water consumption and wastewater production, it is important that UC Berkeley have a plan that outlines how to accomplish these important goals in the already existing infrastructure as well as in new development.

Committing to a policy calling for a sustainable campus and specifically for water conservation are important steps towards becoming a sustainable university. Another important step has been the formation of the Chancellor's Advisory Committee for Sustainability (CACS). CACS's purpose is to promote environmental management and sustainable development at UC Berkeley, and to advise the Chancellor on issues of sustainability (CACS charter, 2004). CACS was founded in Spring 2003 and is comprised of an integrated team of staff, faculty and students, who are appointed through specific campus departments. CACS is charged with fulfilling the following three goals: (1) engage the campus in an ongoing dialogue about working towards environmental sustainability, (2) integrate environmental sustainability into existing campus programs, and (3) institute a culture at UC Berkeley of sustainable long range planning and design (CACS charter, 2004).

One of the first projects of the committee was to authorize a Campus Sustainability Assessment. The Campus Sustainability Assessment uses indicators to assess current conditions, documents past achievements towards sustainability, and highlight opportunities for improvements. The assessment highlights opportunities for increased sustainability and resource efficiency for the interconnected systems comprising the UC Berkeley campus. The systems include energy; water; built environment; transportation; purchasing and waste; land use; food; health and wellbeing; academics and culture. While UC Berkeley was subdivided into separate systems to facilitate evaluation, it was recognized in the report that separate systems are artificial; all the systems are interconnected.

The UC Berkeley sustainability assessment is one of the important components of becoming a sustainable campus. However, to implement UC Berkeley's goals of resource conservation, as well as address the opportunities highlighted in the campus sustainability assessment report, a more in-depth analysis of the constraints and opportunities of each of the campus systems is required. This report for the Chancellor's Advisory Committee on Sustainability, "A Sustainable Water Plan for UC Berkeley", provides a vision of stewardship of UC Berkeley water resources and the detailed analyses necessary to implement the goals and capitalize on the opportunities highlighted in the UC Berkeley Sustainability Assessment.

Restroom water-using fixture replacement programs were not believed to have a large potential to cost-effectively reduce UC Berkeley water use. However, there were preliminary indications that in fact significant savings could be achieved from such programs. Therefore this report primarily focused on evaluating the potential water and monetary savings available through improving restroom water use efficiency on the UC Berkeley main campus and adjacent Residence Halls. A water audit of main campus restrooms shows the potential for UC Berkeley to reduce its water consumption and wastewater production on the main campus by 13% (166,191 gallons per day (gpd)), resulting in over $235,000 dollars in reduced utility spending with payback period of 4.5 years. The subset of the residence halls audited shows water conservation potential of 28,789 gpd and over $47,000 dollars a year from toilet maintenance and low-flow toilet replacement with a payback period of 3.4 years. This report also uses case studies to illustrate the steps UC Berkeley could take to build new buildings that will consume 30% less water than comparable buildings. If UC Berkeley main campus chooses to improve its restroom water use efficiency as well as reduce new building water use by 30% on the main campus, it will save $366,000 a year in water and wastewater charges based on the planned development through the year 2020.

How This Professional Report Adds to the Body Of Literature:

This professional report adds to the growing body of literature in the field of campus ecology and sustainable water planning, and specifically to the body of literature about UC Berkeley. It highlights the constraints and opportunities for sustainable campus design and increasing resource use efficiency on the existing campus. This report provides historic and current campus water use data to UC Berkley staff, faculty, students, and community. Awareness of how much water one uses is an integral component of successful water conservation programs. Currently, campus water users never see their monthly water bill, nor are they provided with their current or historic water consumption records. This report helps to provide a context for understanding the constraints and opportunities for UC Berkeley to move forward as a steward of water resources. The case-study of UC Berkeley's potential for conserving and reusing water resources can also be used as a how-to-manual for other students or citizens to create sustainable water plans for their University or other institutions, or to advocate on behalf of sustainable water planning for their community or city.

Necessity of Sustainable Water Planning

The world faces a serious water crisis, in both developed and developing countries. The World Health Organization estimates that there are currently more than a billion people without access to clean drinking water, and more then 2.6 billion people without access to basic sanitation (WHO, 2004). Three to four million children die each year (10,000 to 20,000 children each day) from preventable water related diseases (Worlds Water, 2003-Gleick). Water is a renewable but finite resource and its efficient use and protection from pollution is required for there to be sufficient water to meet the needs of an increasing population. Water availability and sanitation is one of the most pressing threats facing humanity today. In 1995, Ismail Serageldin, vice president of the World Bank, made the much quoted statement: "If the wars of this century were fought over oil, the wars of the next century will be fought over water". Water wars are not the only solution to growing water scarcity; we can address water scarcity by using the water we do have more efficiently, as well as protecting it from pollution and contamination.

Water shortages are not just a problem in the developing world. Water scarcity is a problem for many parts of the United States and particularly for California. California has had regular occurrences of severe multi-year droughts in the past century: 1912-1913, 1918-1920, 1922-1924, 1929-34, 1947-1950, 1959-1961, 1976-1977 and 1987-1993 (California Water Plan Update, 1998), and based on California's past drought history, future droughts should be anticipated. Water shortages in California during non-drought years have also been predicted based on expected population growth and global warming. Consistent with previous California Water Plans, the 1998 California Water Plan Update Bulletin 160-98, written by the Department of Water Resources, predicts water shortages of at least 2.4 million acre-feet for California in year 2020 (California Water Plan Update, 1998).

The predicted water shortage does not include additional water scarcity issues as a result of climate change (Gleick, 2000). It is increasingly believed that the specific impact of climate change on California will be in an increase in temperature which will likely impact California's water supply and demand in two ways (Gleick, 2000). First, there is expected to be a direct increase in water demand due to the increases in temperature. As the temperature rises increased water is needed for outside irrigation. Second, the water supply in California does not primarily come from the capture of rainfall runoff, but rather is stored in snowmelt, and captured as the snow slowly melts in the spring. A hotter average climate will cause a shift in the pattern of precipitation and runoff. More rain will fall instead of snow, and the water will run off earlier in the year, instead of being stored and gradually released as snow melt later in the spring and summer (Berk et al, 1993, Gleick 2000). The snow pack will melt earlier in the season, and California will lose some of its "natural" water storage capability. Therefore, it may be even more essential than previously thought to develop strategies to decrease California's long-term demand for water.

There are two different approaches that can be taken to augment predicated water supply shortages in California: increase the available water supply (supply side management) or decrease the demand for water through water conservation (demand side management). Historically, water supply planning in California has focused primarily on supply-side management. California has spent a great deal of time and money developing the infrastructure of dams, aqueducts and reservoirs necessary to transport water from where it occurs in the mountains, to the cities and farmlands where the majority of the water demand exists (Figure 1.1). Developing new water supply and storage structures is not only extremely capital intensive, but also has serious environmental repercussions. The increased public awareness of the environmental repercussions from building dams and reservoirs, and development of new water supplies, has made such types of development plans increasingly controversial and politically unacceptable (Berk et al, 1981).

Recent analysis by the Pacific Institute indicates that it is possible for California to mitigate potential water shortages, and to provide adequate water supply for its cities, agricultural industry, institutional uses and the natural environment, without increasing the current water supply or investing in new expensive infrastructure (Gleick, 2003). The difference between the California Department of Water Resources and the Pacific Institute analyses concerning the future of California's water supply is that the Pacific Institute predictions are based on California business, residents and institutions implementing currently available cost-effective technologies that reduce water waste and save money without sacrificing use.

All Californians directly benefit from water conservation, through deferred/avoided need to develop additional water supply sources, storage and wastewater treatment facilities, reduced energy required to distribute the water and reduced pollution from discharging out "treated" wastewater effluent. Conservation by bay area water users reduces water needs, and can postpone and/or avoid the need to enlarge the reservoirs and infrastructure required to transport, store and deliver the water supply and treat the wastewater as the population of the San Francisco Bay Area continues to grow. However, in order to reduce water consumption, residents, institutions, government and industry must implement these water conserving cost-effective technologies that decrease water waste. Doing so will reduce their water and sewer bill, reduce their energy bill due to a reduction in the use of heated water, as well as reduce the costs of building additional dams, reservoirs and aqueducts necessary to capture, store and transport water (Abrahamson et al, 1992).

What is Sustainability?

"Sustainability equals conservation plus stewardship plus restoration" (Sim Van der Ryn, 1994)

While the modern term "sustainability" was not used until the 1970's, the underlying principles are not new (Wheeler, 1995). Current sustainability discourse stems from historical thinking and actions, and has been especially influenced by intellectual movements that recognize the ecological and resource limits to developing our planet, past environmental movements (Wheeler, 1995) and by the current environmental justice movement. There is not one clear decisive definition of what sustainability "is". Sustainability has no one clear end state of achievement at which point one stops; instead it is a continual process of learning to live with nature and within the carrying capacity of our ecosystem. One

Figure 1.1 Water Aqueducts in California
Transport the surface water from where it falls in the mountains to the cities and Farmland

Modified from the Department of Water Resources 1998 Water Bullitin of the most well known definitions of sustainability comes from the Brundtland Commission (World Commission on Environment and Development), which was a commission initiated by the United Nations Secretary-General. The commission received input from thousands of individuals and organizations from around the world to develop their consensus, non-confrontational definition of sustainable development (Wheeler, 1995). *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland Commission, 1987). CACS' definition of sustainability modifies the Brundtland definition to include the import concept of carry capacity of the earth's ecosystems. [Sustainability is]*"The ability to meet the needs of the present while living within the carrying capacity of supporting ecosystem and without compromising the ability of future generations to meet their own needs"*. The carrying capacity refers to the biophysical characteristics of what the local bioregion can support (Birkeland and Schooneveldt, 2002).

Why UC Berkeley should have a Sustainable Water Plan

"What contemporary institutions are better situated to take the lead in solving problems than colleges and universities?" (David Orr (Ecodemia), 1995)

UC Berkeley, whose mission is to "deliver programs of instruction, research and public service of exceptional quality to the State of California" (LRDP, 2004) should become a university that not only teaches and researches sustainability principles and sustainable development, but demonstrates how to cost-effectively incorporate sustainability into all areas of its operation.

UC Berkeley, as well as all universities, educates tomorrow's leaders and thinkers. The university is a microcosm of the larger community, especially in terms of resource consumption. UC Berkeley houses students and provides food and beverage for students, faculty and staff. It provides transportation both around the campus and between the University and the surrounding communities. It purchases large amounts of products (cleaning supplies, paper, computers, etc) and consumes large amounts of natural resources, such as water, energy and food. As a result, it produces large amounts of solid waste and wastewater. UC Berkeley could be the perfect example of how communities can live sustainability on the earth, not only by teaching about sustainability but by incorporating sustainability practices into its everyday operations.

As the population of UC Berkeley and California continue to expand, and water shortages in California and the world become more severe, UC Berkeley, as a domestic and international leader, has a responsibility to demonstrate that it is feasible to implement a sustainable water plan. UC Berkeley should demonstrate how the efficient use of water resources can result in a decrease in overall water usage as well as monetary savings, even as UC Berkeley continues to expand and grow. UC Berkeley's example of institutional water use efficiency could provide the role model for other public and private institutions, to show that it is possible to save money while conserving water resources.

When students study water supply

challenges and water use efficiency in a building with water guzzling, leaking toilets, and leaking pipes, which lesson is stronger – what the professor teaches, or what they see in practice? When students study about health in a building that has significant off-gassing problems (use of manufactured materials in the building that release toxic chemicals in the air and cause poor indoor air quality) and has no natural light, and thereby is unhealthy and makes students unhealthy, what lessons do they learn? In the University we talk about health, but our classrooms tells us the way the world truly is. Universities have the opportunity to demonstrate by example – not just to teach great ideas, but to show how to put those great ideas into practice. In the case of teaching about sustainability, they have the opportunity to show how to live sustainably. As David Orr pointed out, "the crisis that we face is first and foremost one of mind, perception and values, hence, it is a challenge to those institutions presuming to shape minds, perception and values" (David Orr, 1994). UC Berkeley is beginning to recognize and respond to these challenges. This professional report provides tools and simple steps to help us on our way.

Chapter 2: Historic and Current Water Use and Disposal

Site Context

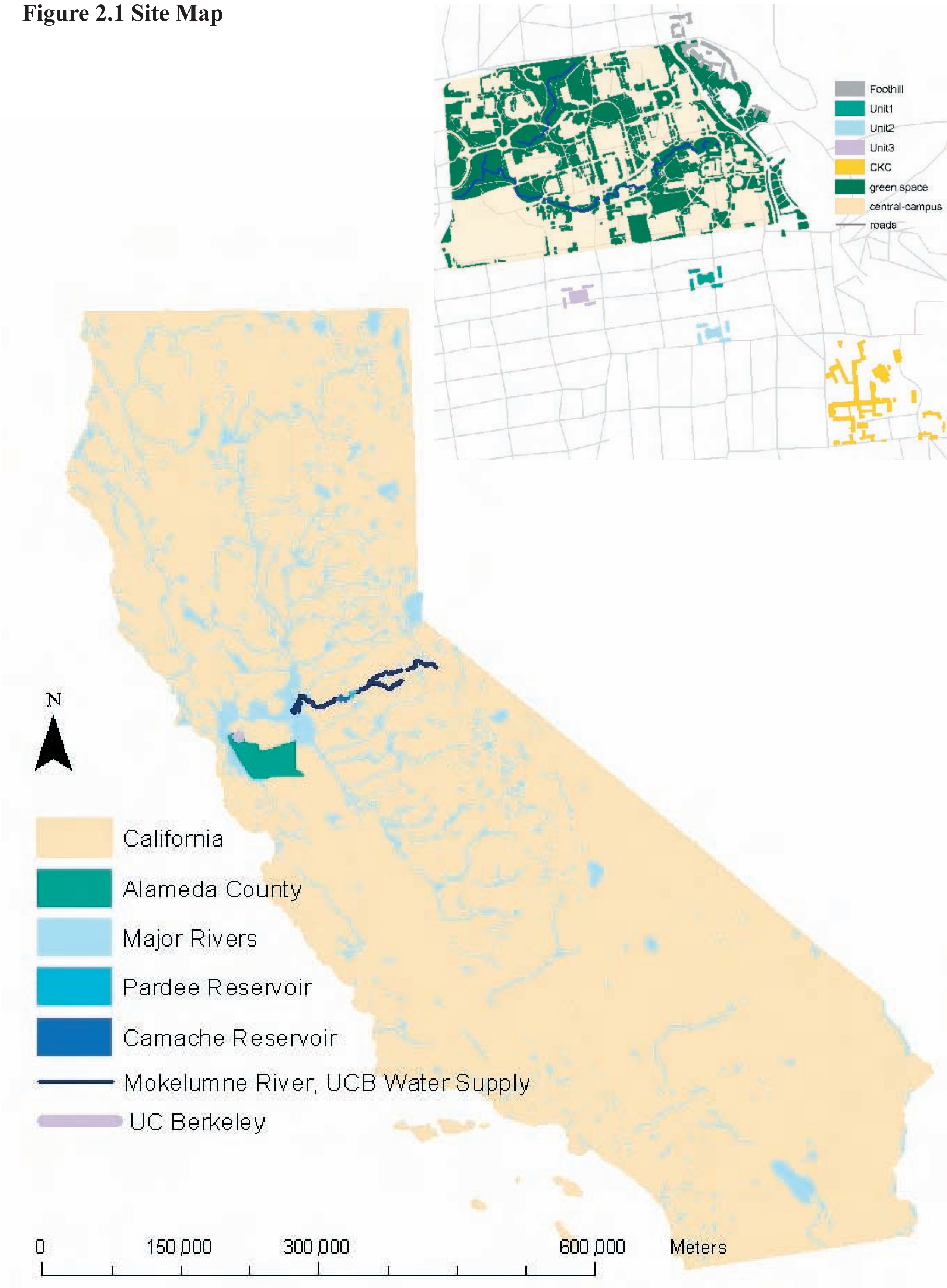
UC Berkeley, founded in 1868, is the oldest of the ten campuses of the University of California. It is located in the Strawberry Creek watershed in Berkeley, California (Figure 2.1). The founders of the College of California (the predecessor to the University of Berkeley) chose the site, in part, due to the beautiful landscape and available water from Strawberry Creek that runs through the campus (Dawkins, 1983). Strawberry Creek, while heavily impacted from urbanization of the campus and the upper watershed, is still a beautiful amenity to the campus and a living laboratory for UC Berkeley students. Strawberry Creek originates in the hills just east of UC Berkeley and runs mostly above ground throughout UC Berkeley Main Campus (Figure 2.1). Strawberry Creek is forced underground just west of campus, where it flows mostly underground in culverts to the San Francisco Bay.

UC Berkeley has a Mediterranean climate with the majority of the average annual rainfall of 2.08 feet (25 inches) occurring from October through April (LRDP, 2005). If the University captured and stored all of the precipitation during an average rainfall year, the amount of water collected would provide 255,384 gallons of water per day (gpd) (160 acres x 2.08ft = 333 acre-feet year). In 2003, UC Berkeley main campus used 1.3 million gpd of water. The available rainfall, if captured and stored, would have provided 19% of UC Berkeley's 2003 water needs. Currently, UC Berkeley is using 81% more water than rainfall that naturally occurs on its site. However, UCB does not capture and store any rainfall, and therefore is obtaining 100% of its water supply from offsite.

UC Berkeley's water supply, except for a very small amount of groundwater used in construction, is 100% provided by East Bay Municipal Utility District (EBMUD). Approximately 95% of the EBMUD water supply is from the 577-square mile Mokelumne River Watershed in the Sierra Nevada Mountains. The water is transported through 91 miles of aqueducts from its source in the Mokelumne River to the East Bay (EBMUD Urban Water Management plan, 2000, Figure 2.1). EBMUD is responsible for the pipes necessary to transport water from its source in the Sierra Nevada up to the main campus boundary, as well as to the off campus buildings sites such as the campus Residence Halls. However, once the water reaches the main campus site, UC Berkeley is then responsible for the pipes and infrastructure to transport the water throughout the campus and transport its wastewater to its campus boundary where it connects to the City of Berkeley sewer system. The campus wastewater flows through the City of Berkeley pipes to EBMUD Special District No. 1 (SDF-1) Wastewater Treatment Plant. The plant discharges the treated wastewater via a submerged outfall pipe under the Bay Bridge into the San Francisco Bay (LRDP, 2005).

The Mokelumne River water reaches the campus through 20-inch diameter water mains that run along the streets that border

Figure 2.1 Site Map



the campus (Hearst Avenue, Gayley Road, Piedmont Avenue and Bancroft Way), with nine major connection points to the campus distribution system, each of which contains water meters (LRDP EIR, 2005). The water meters are read by UC Berkeley staff and are entered into a water data file. The campus also has 50 smaller connections to campus buildings, each with its own individual water meter. All meters are read by UCB on a monthly basis and added to a database (Black, 2004). The January meter readings are used to prepare the annual wastewater discharge report to EBMUD, who then calculates the wastewater charges for the year based on this data (Black, 2004). UC Berkeley pays EBMUD wastewater charges based on a percentage of the potable water that it purchases, as well as paying the City of Berkeley a flat fee for the use of its sewer lines. Currently, only the January-to-January water readings are verified, due to limited staff time (Black, 2004).

Building water readings through the school year 2002/2003 can be found on the space management website. However, this website can only be accessed from a UC Berkeley computer (http://fasdi.vcbf.berkeley.edu/Data/PPSview/PPSView.cfm). It is difficult to find out that the building water data is available, because the information will not come up in searches on the UC Berkeley web site, and no one interviewed on campus for this project ever mentioned the data. Physical Plant is working on adding real-time building water meters to the process automation monitoring and control system (SCADA). This will eventually allow real-time-water data to be tracked. If there are adequate personnel to analyze the real-time data, leaks will be detected more rapidly, based on abnormal high nighttime water use. Currently, there are not enough staff to verify all the monthly water readings. Therefore if the real-time water data will be useful there will need to be additional staff time devoted to analyzing the data. Real-time water data could also be posted to a website, allowing building occupants to see their current and historic water consumption data.

Currently no feedback on building water use is provided to the building occupants. Nor do departments directly pay for their water and wastewater usage. Therefore, currently, most water users on campus do not know how much water they are using nor do they have any financial incentive to conserve. Awareness of how much water one uses is an integral component of successful water conservation programs. Water consumers need to know how much water they are using in order to understand their individual impact, as well as to see the documented results of reductions in water use from behavior changes and or technology upgrades. Without documentation and feedback to building water users they have no way of seeing whether any changes in their behavior impact water use results.

UC Berkeley Main Campus Past, Current, and Future Water Consumption

From 1979 to 2003, UC Berkeley main campus annual water consumption has decreased by 17% (134,037 Hundred Cubic Feet (CCF), 1CCF = 748 gallons) even as the campus gross-square footage (gsf) increased by 19% (1,477,303 gsf) (Figure 2.2, 2.4). This reduction in water use can mislead one into thinking that UC Berkeley is meeting its

Figure 2.2 UC Berkeley Total Water Consumption 1979-2003

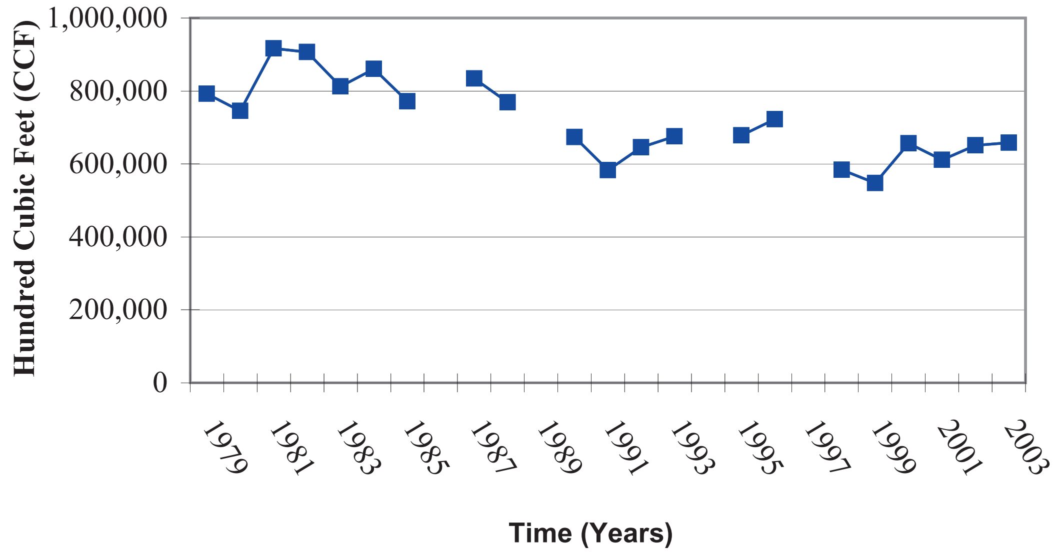


Figure 2.3 US Water Withdrawals 1990-1996

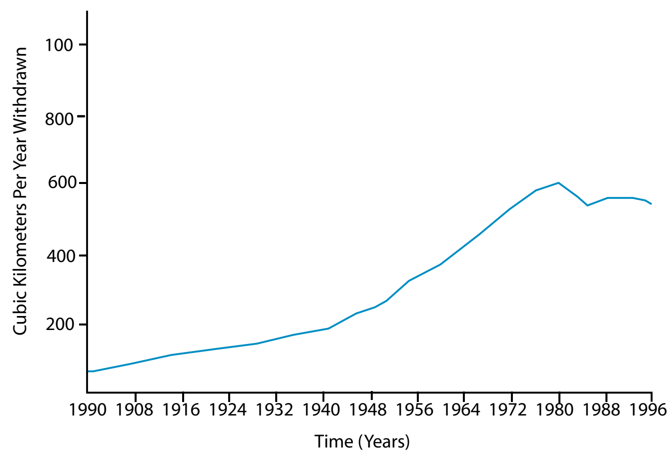
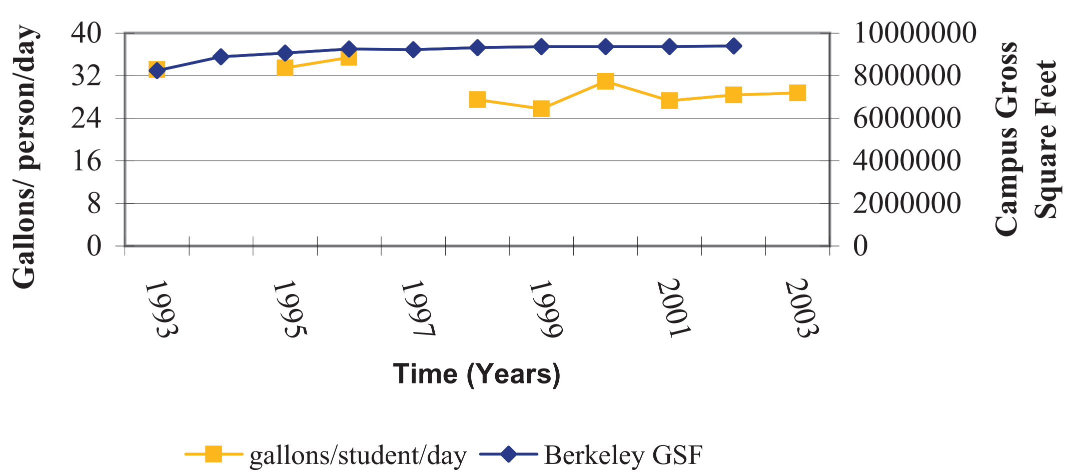


Figure 2.4 UC Berkeley Per Capita Water Consumption 1993-2003



goals of water conservation. However, it is important to place UC Berkeley's decrease in water use within the context of United States water withdrawals, which have also decreased since the mid-1970s even as the United States population has continued to expand and grow (Figure 2.3). Water use in the United States has decreased in part as a result of natural attenuation – as older water using fixtures break, they are replaced with more water efficient fixtures. In addition, manufacturing processes and mechanical systems (such as heating and cooling systems) have become more water efficient over time. UC Berkeley water use has also decreased from natural attenuation. Water use decreased in the 1980s, in part due to upgrading of some high-use restrooms with low-flow toilets and urinals during seismic and other major retrofits, as well as renovations of heating and cooling systems in some buildings (LRDP EIR, 2005 and Black, 2004). Therefore, when examining UC Berkeley water use, it is important to not just look at its overall history, but to conduct a water audit to determine the potential for further reduction in water consumption and wastewater production.

In recent years, UC Berkeley trend of decreasing water use has been reversed. From 1999-2003, the main campus water use has increased by 20% (110,310 CCF) while the campus gsf remained relatively constant (increase of 0.4%, or 39,000 gsf) (Figure 2.4). Normalizing usage to campus population of students, staff, and faculty full-time equivalents (FTE), from 1999-2003, per capita water use still shows an increase from 26 to 29 gallons/person/day (Figure 2.4).

UC Berkeley's Long Range Development Plan, the campus legal planning document that specifies UC Berkeley's land use and physical development plan, anticipates a potential 20% increase in water consumption above 2002 levels by 2020 (LRDP, 2005). If the planned development is completed without additional guidelines for conserving water, UC Berkeley will increase its water consumption to 782,036 CCF/year, an increase of 20% above 2002 water consumption levels. However, if all new development uses 30% less water than an average building of its size, such as many LEED certified buildings have accomplished,

Figure 2.5 In 2002 85% of UC Berkeley's Planned Buildings in 2020 have Already Been Built

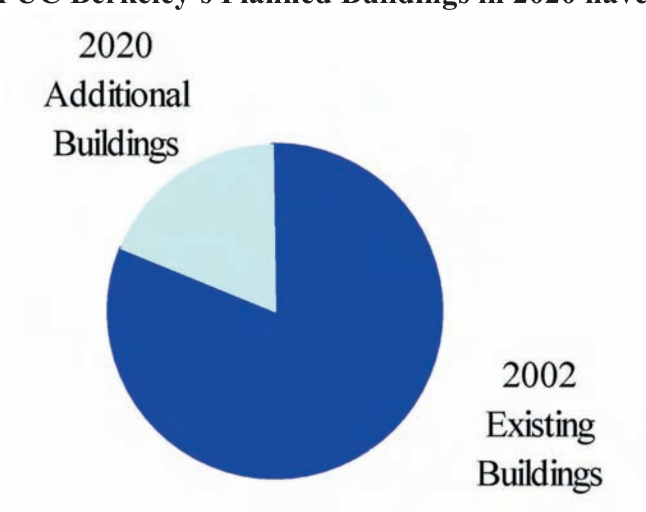
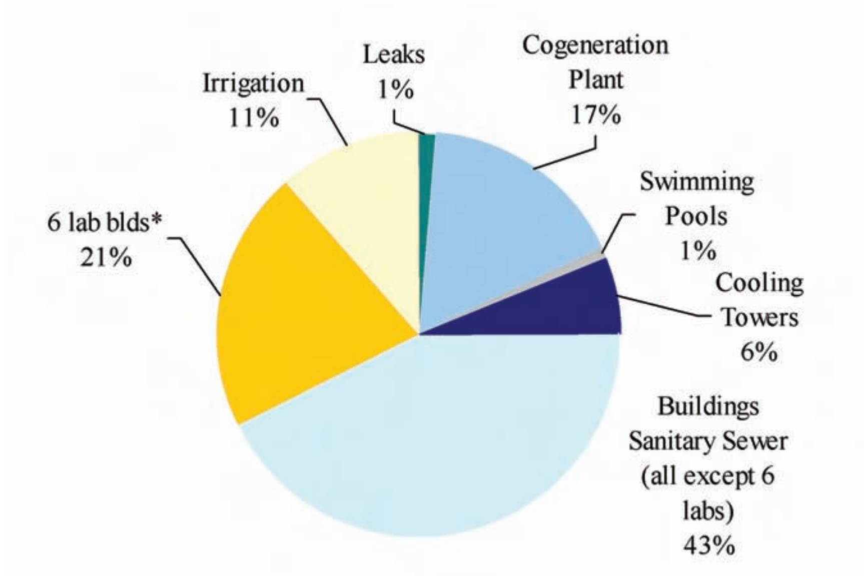


Figure 2.6 UC Berkeley Main Campus 2003 Water Consumption Distribution



* Life Science Annex, Latimer, Koshland, Cory, Valley Lice Scicne Building, McCone

UC Berkeley water consumption would only increase to 742,657 CCF/year, a 14% increase over 2002 water consumption levels. Reducing water use in new buildings is only part of what is necessary to be a responsible steward of water resources. 85% of the campus gross square feet planned for in 2020 is already built (Figure 2.5). Therefore, if UC Berkeley is committed to its goals of minimizing water consumption and wastewater production, it will not only have to decrease its water use in new development, but also improve water use efficiency in the already developed campus infrastructure.

Distribution of Water Consumption

The distribution of water use on the main campus for 2003 is from the UC Berkeley 2004 Annual Wastewater Discharge Report to EBMUD (Figure 2.6). In 2003, 64% of the all water use on the main campus went into the sanitary sewer. However, almost one third of the water was used by just six of the main campus buildings (21% of the main campus total water consumption). The building sanitary sewer water use includes all the restrooms, water fountains, cooking water and cleaning water in campus restaurants, reverse osmosis, and process and equipment cooling water that is not hooked up to the cooling towers. The cogeneration plant uses 17% of the water on the main campus, and is run by a private contractor. It provides steam to the University and pays the University for its water consumption and wastewater production. The cooling towers account for 6% of the total water consumed on the main campus. Swimming pools and pipe leaks are estimated to each account for 1% of the main campus total water use.

Buildings Sanitary Sewer

As mentioned previously, UC Berkeley has upgraded some of its toilet fixtures in high use areas. However, the University still has a substantial number of pre-1992 and pre-1980 toilets that use at a minimum 3.5 gpf and up to 7 gpf (see chapter 4 water audit results). UC Berkeley currently has no systematic plan or policy for upgrading older non-conserving restroom water using fixtures such as toilets and urinals. They are replaced on an as needed basis. Current seismic and deferred maintenance projects are not guaranteed to upgrade toilets. In fact, deferred maintenance budgets cannot be spent on new toilet fixtures (Anglim, 2004). However the new ADA-compliant program is upgrading some main floor bathrooms in high occupancy buildings, to make them handicap accessible. While that program would plan to upgrade bathrooms only on the main floor of high occupancy buildings, it is the first program that is systematically looking at the bathrooms on campus. This is a very important step towards improving water use efficiency, as currently there is not even a count of the number and locations of toilets and urinals on the campus (Black and Courter, 2004 and 2005).

UC Berkeley currently has no systematic toilet maintenance program. There is currently not sufficient plumbing staff to be proactive; they are completely occupied with responding to and fixing problems when they occur (Courter, 2005). However, many toilets can leak and waste substantial amounts of water without the problem being visible to the user or a problem being called in. Flush-valve kits, the part inside the toilet controlling the flush volume, wear out and stay open for longer than is necessary, causing them to stop functioning as a 1.6 gallons/flush toilet (see chapter 4 and 5 for more information on toilet leakages and the potential savings from toilet maintenance).

Laboratories

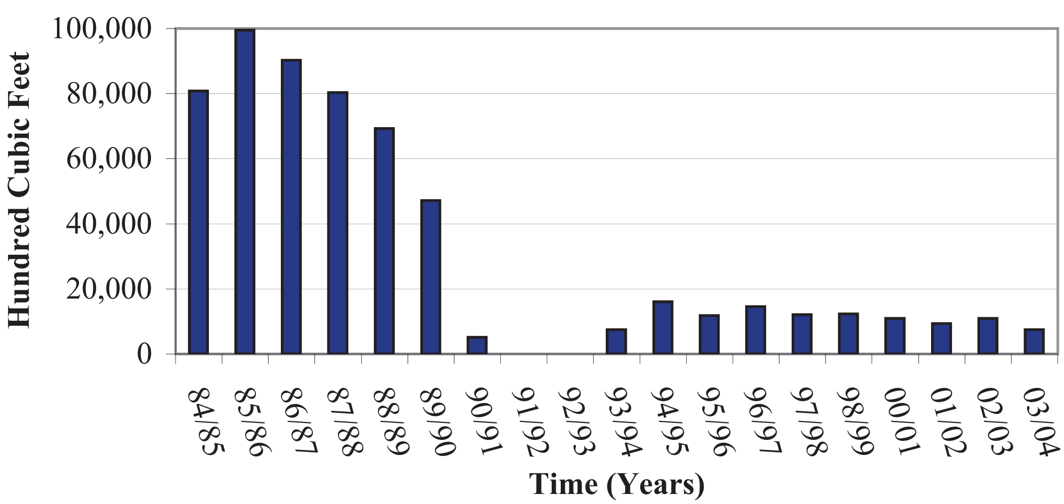
Labs are the most water intensive buildings on campus, primarily due to the need to keep the laboratory and computer equipment cool, to process water, and to sterilize and clean laboratory supplies. Older labs are less water efficient per gross-square feet compared to newer laboratories. Some of the older labs still have once-through cooling systems for lab equipment, as well as older and less efficient heating and cooling systems. Many UC Berkeley labs were built 20 to 60 years ago and contain old inefficient cooling systems. When these labs were built, it was not anticipated that the buildings would have the additional cooling loads from all the computer equipment as well as other new laboratory technology that requires water-cooling.

In 2002, six labs accounted for 21% of the main campus water use and 13.8% of the gross square feet of the state funded buildings (Figure 2.6, utilities database metered building water use, Paul Black, 2003). Life Science Annex, Latimer, Koshland, Cory, Valley Life Science and McCone Hall were singled out of the main campus building water use data because they were some of the highest water consuming buildings on campus, as well as because their were no apparent errors in the monthly water meter readings. By 2020, the LRDP anticipates an additional 700,000 gsf in campus lab space, corresponding to an additional 224,000 gallons per day (131,263 CCF/ year) of water use and 201,600 gallons per day (98,374 CCF/year) of wastewater. UC Berkeley estimates that laboratory buildings use an order of magnitude more water than non-lab buildings (0.30 per gsf vs. 0.03 per gsf; LRDP, 2005).

New and renovated laboratories are much more water efficient then older labs because once-through cooling is eliminated, as exemplified in the recently renovated Stanley Hall and the Hearst Mining and Valley Life Science Building (Black, 2004). Although elimination of once-through cooling equipment was already usually included in laboratory renovations, it is now official policy as it is a requirement of the UC Reagents Green Building Policy that calls for LEED and or Labs21 equivalency (see chapter 3). Labs21 includes a prerequisite that no domestic water shall be used for once-through cooling of laboratory equipment, unless it has to be used as direct contact process water. Valley Life Science Building (VLSB) lab renovations resulted in a significant decrease in water use. VLSB, built in the 1920s, reduced its water use by 80% after completing its renovations in 1994-1995 (Figure 2.7). The internal infrastructure of the lab was completely redone, and only the building shell was left intact. In terms of the mechanical systems that run the building, it can be thought of as a new building. (Eric Ellison, 2004). As a "new laboratory", it is able to function using only 20% of its previous water use. Renovations of laboratories require high capital expense. However, laboratory renovations not only supply state of the art laboratories for Berkeley's researchers and students, but also lower the operation costs of the building via the tremendous amount of resource savings in terms of water and energy. However, the bathrooms were not renovated and still contain high-flow rate fixtures.

Although new labs are much more water efficient, they are faced with the same potential problem as older labs in possible migrating to once-through cooling of new equipment in the future. Due to the changing nature of science research, departments often get new equipment. Sometimes it is easier and less expensive for departments to hook up their new equipment to an industrial water line (thereby creating a once-through cooling system), than to fill out a service order and pay for having the equipment hooked up to the cooling tower. Because the departments do not pay their own water bills, there is no financial incentive for departments to be sure to hook new equipment up to the cooling tower.

Figure 2.7 Valley Life Science Water Consumption Before and after Renovations



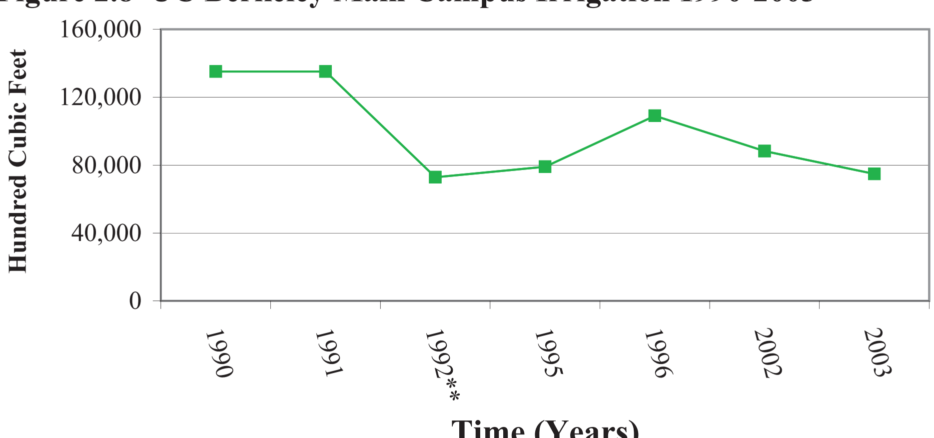
Heating and Cooling

UC Berkeley is the oldest UC campus, with over half of the buildings constructed more than 40 years ago (New Century Plan). The age of UC Berkeley infrastructure hinders efficient maintenance of the physical infrastructure system. The age of the infrastructure, in combination with the delayed maintenance backlog, means that the systems are not working at optimal capacity. The campus has more than half a billion dollars in delayed maintenance. There is a substantial amount of leaks in the heating and cooling systems. There are not sufficient staff or resources to identify and repair leaks. As an example, one facility maintenance person estimates that the leak he was fixing at the time of the audit survey for this report was leaking about 3 gallons per minute, and had probably been leaking for two years. That would translate to over $6,000 a year in water and wastewater costs (525,948 minutes/year x 3 gallons/minute)/748 x 2.9 water and wastewater charges) for just that one leak. The reason that the leak was finally being fixed was that it had begun to visually affect the landscape by damaging the overland vegetation health. He also mentioned that the leaks in the underground tunnel were even worse and likely leaking for years at a rate of over 5 gallons a minute. In addition leaks in the heating plant condensate return system contribute significantly to water and energy loss. Finding and fixing these leaks is labor-intensive and requires budget allocations. A water audit of the campus heating and cooling systems is necessary to identify the potential water conservation measures available from improving the campus heating and cooling systems.

Irrigation

UC Berkeley began metering irrigation water use in 1992. Over that time, use fluctuated from a low of 72,899 CCF in 1992 to a high of 109,037CCF in 1996 (Figure 2.8). According to official released reports, UC Berkeley is currently reducing the amount of water needed for landscape irrigation (UC Berkeley campus baseline documentation, 2005). Physical Plant Grounds Services and Technical Service Group began a project to bring all the primary

Figure 2.8 UC Berkeley Main Campus Irrigation 1990-2003



** Irrigation metering began in 1992 (previous years irrigation consumption are estimates) campus irrigation controllers under the same supervisory control and data acquisition system (SCADA). SCADA allows remote station control via radio, internet or phone dial-up (from off campus sites). All program changes are made in minutes from the central system without needing to go into the field and manually turn off the irrigation. Before adding controllers to SCADA, it took one or two days to manually turn valves off if it was raining, and when weather required a shut down or restart of the irrigation system, it took two persons two days to reprogram each controller. The controllers that are on the system can now be reprogrammed in minutes. In the first year, 8 controllers were added to SCADA, and in the second year 4 more controllers were added. There are currently 18 controllers on the central control system, which serves approximately 75% of the irrigated area on the UC Berkeley campus. This has reduced the water used for irrigation by 15%, as measured for July 2003- June 2004 compared to the previous year. This reduction occurred when only 30-50% of the system was hooked up to the SCADA controller. There are still a number of manually programmed controllers used on the campus, and these are in the process of being changed out and added to the central control system as part of new construction and major re-modeling projects. Currently, the system runs through time-managed control, though the system will allow future operation via flow control (LRDP EIR, 2005). In addition, the system will allow for the addition of moisture sensors to the irrigation system. In addition, since the 1980s, UC Berkeley has installed automated irrigation controllers with repetitive cycles and low-volume heads (LRDP EIR, 2005).

There is some concern that a centralized system will take irrigation decisions out of the hands of the grounds-keepers who work with the landscape every day, and place irrigation decisions into the hands of someone at a desk who does not know the landscape nor see the reaction of the landscape to the watering decisions. This concern highlights the potential problems of moving to a centralized system, and highlights the need for a communication plan that includes people on the ground who relay important water decisions to the central system managers.

The campus is not currently working with EBMUD on improving its irrigation efficiency. However, EBMUD provides free water audits as well as financial rebates to help improve irrigation efficiency, such as the purchasing of moisture sensing irrigation controllers.

Restaurants and Dinning Halls

The restaurants on the UC Berkeley main campus site are included in the main campus water consumption profiles. The off-campus dining halls, such as Unit 3, Unit 4, CKC and the new Crossroads facility are not part of the main campus water consumption. They are either metered as part of the residence halls or, as in the case of Crossroads, have their own water meter. The new Crossroads dining hall facility conserves water by using efficient faucets, resulting in water savings of about 30,000 gallons/day (Berkeley news website, 2004). UC Berkeley's Dining Services is working to improve their water use efficiency. In 2003 they replaced 35 pre-rinse spray nozzles in 35 campus restaurants, creating an estimated savings of as much as 10,500 gallons per day and savings in water utility costs of $9,300 year. This does not included additional savings from reduced energy costs (LRDP, EIR, 2004-letter from Leann Gustafson). The University's dining services is also interested in modifying all the other dining halls on and off campus into "green buildings" with water-efficient features. The new CKC dining hall will also be redone to be water efficient.

Residence Halls

The Residence Halls are metered separately from the main campus, pay their own water and wastewater bill and are not included in the main campus water consumption totals (see Chapter 5 for the Residence Halls water use characteristics).

Wastewater Quantity and Quality

Overall UC Berkeley wastewater production has decreased by 26% from 1980 to 2003 (or 11.3% from 1979-2003) (Figure 2.9). However, between the years 1999 to 2003, UC Berkeley's wastewater discharge has increased by 10% (roughly 83,600 gallons/day). The LRDP anticipates a continued increase in wastewater production of up to 27% above 2002 levels by the year 2020, as a result of new development. This corresponds to an additional 237,600 gpd of wastewater, and an additional cost of $130,000 dollar a year.

UC Berkeley's wastewater fees are based on the percentage of the total water purchased from EBMUD that is returned to the sanitary sewer (Pine, 2004). The University's sewage is not metered but calculated as a percentage of the water the purchased by the campus. The total water returned to the sewer, divided by the total water purchased, is the discharge ratio. From 1990 to 2003, the discharge ratio has ranged from 66-76% (annual discharge reports, 1990, 1991, 1992, 1995, 1996, 1999, 2002, 2003). The factors that contribute to the change in discharge ratio include the following (1) Water used for irrigation. All irrigated water that is not absorbed by the plants runs off into the storm drains and Strawberry Creek, and not into the sanitary sewer. (2) The water that evaporates from the cooling tower. This is estimated from the amount of make-up water that is needed to run the cooling towers. (3) Evaporated pool water. The estimation of evaporated pool water has remained relatively constant from 1990 to 2003. Therefore, the change in the discharge ratio primarily depends on the irrigation and the cooling tower evaporation. From 1990 to 1996, the amount of make-up water for the cooling towers remained relatively constant, around the 22,000 CCF range. By 1999, the make-up water increased to 33,142 CCF, and by 2003 the make-up water requirements rose to 39,861 CCF. It is not yet known whether efficiency has also increased, and therefore the cooling requirements have gone up in a greater ratio than the amount of make-up water. The increase in cooling water and the corresponding increase in water that is evaporated from the cooling towers cause the discharge ratio to decrease. More purchased water is evaporated and therefore does not end up in the sanitary sewer. Some of the factors for increased cooling water usage are increased campus gross square feet requiring cooling, as well as increased laboratory and computer equipment that must be cooled. Improving the cooling tower efficiency would save not only water but energy as well.

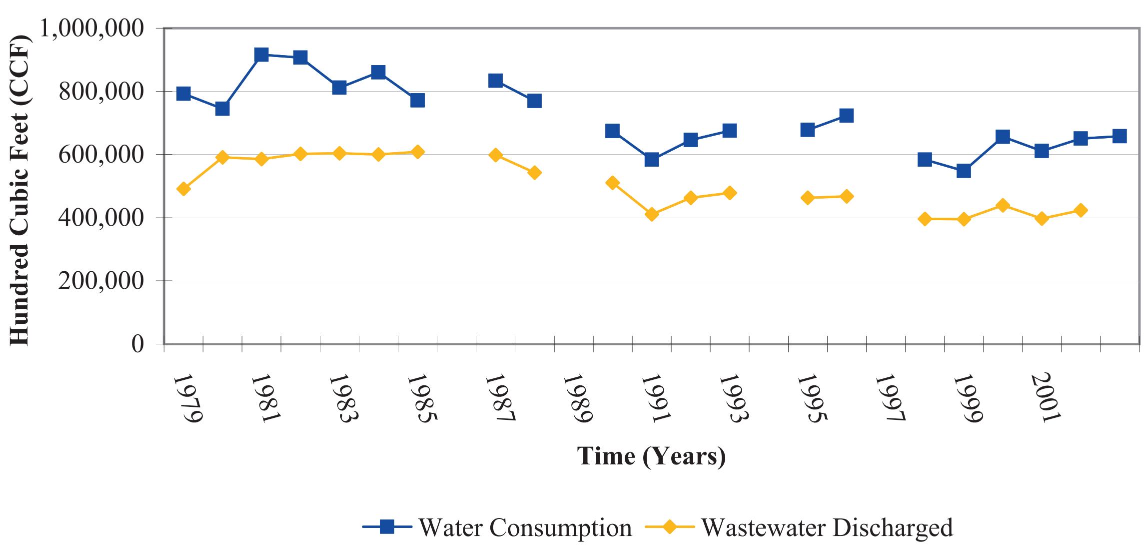
UC Berkeley has improved its wastewater "toxicity", through reducing the chemical constituents that end up in the drains and enter its sanitary sewer system. UC Berkeley has implemented Drain Disposal Guidelines and Hazardous Waste minimization programs that advise campus laboratories and other facilities (art studies, paint waste and debris, etc) on safe and appropriate disposal of chemicals. Chemicals in wastewater harm the biological wastewater treatment process, corrode the pipes and end up being transported into the San Francisco Bay. These guidelines have fostered regulatory compliance. In 1999, EBMUD added a new condition to the UC Berkeley Wastewater Discharge Permit. It required the campus to maintain and implement a Slug Discharge Prevention and Contingency Plan (SDPC Plan) to eliminate or minimize the potential for a slug discharge of any pollutant that could interfere with the EBMUD Wastewater Treatment Plant. The Environmental Health and Safety (EH&S) department on campus provides the documents and training for all campus chemical users, which include faculty, visiting scholars, staff, and students.

UCB has recently received two awards for its wastewater quality. One was a Certificate of Merit for Outstanding Achievement in 2004 from the California Water Environmental Association (CWEA), for its recent water pollution prevention efforts (Berkeleyan March 12th 2004; Tim Pine, 2005). CWEA is a wastewater industry trade group comprised of wastewater treatment professionals, equipment manufacturers, and consultants. The campus accomplishments included reducing the amount of chlorinated hydrocarbons entering the sanitary sewer, developing campus drain disposal guidelines, implementing outreach and education programs, and establishing a mercury reduction program. They also recognized the work that has been done and continues to be done to help restore Strawberry Creek. UC Berkeley was nominated by EBMUD, and is the first University to receive this award.

UC Berkeley Main Campus Water Recycling

UC Berkeley does not currently use recycled water on campus. However,

Figure 2.9 Main Campus Water Consumption and Wastewater Production 1979-2003



Albany Village will be using recycled water for irrigation after completion of the I-80-recycled water distribution system in the spring of 2006 (draft EBMUD recycling water proposal). In addition, EBMUD and UC Berkeley are working towards installation of an onsite Satellite Recycling Water Treatment Plant (Laurence, 2005). UC Berkeley supported EBMUD's applications for grants for the project, and is currently working with EBMUD on the facility layout and design for the package water recycling plant to be installed below the Edwards track bleachers. The area is currently used for recycling storage. The facility would be small (1,000 square feet, which includes 300 square feet for faculty research) and would treat 25,000 gpd . The recycled water would be used for irrigating campus lawns and athletic fields. This represents only 1.8% of the total wastewater generated on the main campus and 14% of the water needed for current campus irrigation. The project is currently in the feasibility analysis stage.

The potential benefits associated with the project include education, cost savings to the University, and environmental benefits from the reduction in treated wastewater dumped into the bay. The facility could provide first-hand demonstration of water treatment and the use of recycled water, and could be used as a learning laboratory for students at UC Berkeley. It would decrease the volume of potable water used for irrigation and thereby increase the availability of potable water for drinking water and in-stream enhancements. It would also decrease the amount of wastewater discharged into the S.F Bay and decrease the strain on the EBMUD wastewater treatment plant. EBMUD is predicting that the facility would save UC Berkeley $7,500 annually from reduced water and wastewater costs, as well as provide reliable water for irrigation even during a serve drought. One driver that EBMUD has used to influence UC Berkeley to consider this offer is that, under the LRDP environmental impact report, UC Berkeley is required to obtain a Water Supply Assessment (WSA) from EBMUD which states that there is enough available water for the expected increase water use. EBMUD approved the WSA under the condition that the University implements Best Management Practices, which include evaluating the opportunities to use recycled water.

While the project would be a first for both EBMUD and the University, it would only supply a small amount of the water needed for irrigation. However, it might provide the experience and understanding necessary to do a larger scale project on campus. The primary difficulties at this time seem to be EBMUD funding for the project and finding a physical location on the campus for the facility.

Next Steps

The water audit of the main campus in the following chapters identified the utility savings available to UC Berkeley through toilet maintenance and or upgrading to low-flow toilets. Through implementation of only these restroom water conservation measures, UC Berkeley can mitigate the projected increase in water consumption and wastewater disposal, and cost effectively maintain its current water consumption levels for the next fifteen years water use, even as the campus population and infrastructure continue to expand and grow. However, there are many other areas where UC Berkeley can also decrease its water use, especially in improving irrigation efficiency and improving its cooling systems. A more detailed analysis of these systems is necessary to achieve an even higher level of water use reduction.

Chapter 3: UC Berkeley Sustainability Policies

"*As one of the world's great research Universities, UC Berkeley has a special obligation to serve as a model of how creative design can both minimize resource consumption and enhance environmental quality. Each new capital investment at UC Berkeley has the potential to advance the state of the art in responsible, sustainable design, and thereby contribute to our mission of public service.*"
(New Century Plan, 2003, Long Range Development Plan, 2005).

UC Berkeley's New Century Plan and Long Range Development Plan

UC Berkeley's New Century Plan, completed in 2003, is the University's strategic plan for its capital investment program, which includes policies to guide the development of UC Berkeley's landscape and built environment. As one of the components of sustainable design, the plan includes the goal of minimizing water consumption and wastewater production, as well as preserving and restoring the integrity and biodiversity of natural systems on campus.

UC Berkeley's 2020 Long Range Development Plan, passed by the University Regents in January 2005, provides the policy and guidelines for land use and capital investment for UC Berkeley. The LRDP integrates the design framework of the New Century Plan with the academic goal expressed in its Strategic Academic Plan. Although UC Berkeley has additional campus plans to guide its physical and academic development (New Century Plan, Strategic Academic Plan, The Landscape Master Plan and Landscape Heritage Plan), the LRDP is the only legal planning document, and it specifies UC Berkeley's land use and physical development plan. As a legal and regulatory document, the LRDP requires an environmental impact review (EIR) that assesses the environmental repercussions of UC Berkeley proposed development. The EIR also mandates that there be an opportunity for public comments, which requires the University to hold public hearings on its development plans, and address the public's written comments.

UC Berkeley's first LRDP was written in 1956 in response to an anticipated growth to 25,000 students (Landscape Heritage Plan, 2004). The plan committed to the "private automobile as the principle means of circulation and access to the campus" (Landscape Heritage Plan, 2004). While subsequent LRDP's (from 1962 on) shifted from encouraging automobile transport on campus to pedestrian and public transportation, the campus is still struggling to remove the automobile from the center of campus. This highlights the importance of forethought in the campus LRDP, as UC Berkeley has spent the last half-century trying to overcome the challenges associated with this now shortsighted planning choice.

The 1956 LRDP also proposed a plan for a continuing replacement of aged and dying trees. Although a systematic maintenance and replacement program was called for, and included in the 1956 LRDP, the tree replacement program was never carried out (Landscape Heritage Plan, 2004). This lack of follow-through, even when there is an official policy, highlights that although the regulatory and planning document might have a specific goal, unless a corresponding plan for "implementation" is also developed, sustained, and supported with staff time and budgetary allocation, there is a potential that the goal will not be reached. The lack of follow-through with the 1956 LRDP tree replacement program could also befall many of the sustainability goals, including water conservation, called for in the LRDP if UC Berkeley does not develop a plan including staff and funding support to implement its sustainable development goals.

The LRDP promotes incorporation of sustainable design principles into the capital investment decisions as the method to achieve its goals of sustainable design and resource conservation.. All capital investment decisions are to go through a strategic investment requirement, where the project must be evaluated in terms of alternative solutions, including whether a new building should be developed, and/ or an old building should be renovated. The strategic investment decision now calls for sustainability to be a factor in determining whether to build a new building or renovate an existing building. This means the analysis of alternative solutions will now reflect the life-cycle costs of building a new building or renovated an existing building.

Currently, however, other than some energy efficient features, life-cycle costing is not yet part of the decision making structure for what components to put into new buildings. Buildings on the UC Berkeley campus have life-spans of 50 to 100 years. Therefore, the focus on minimizing new construction costs at the expense of long-term operation and maintenance costs, can result in unnecessary long term financial burden for the University.

The policy calls for ensuring that every new project is shaped by design and performance guidelines that incorporate the principles of sustainable design. The performance guidelines for sustainable design are included in the campus park guidelines of the LRDP and NCP. . The campus park guidelines section of the LRDP and NCP provide the implementation plan for the campus goals and vision statements. However, while the LRDP has explicit guidelines for conserving energy, it does not currently include any specific guidelines or recommendations for how the campus will achieve its goals of minimizing water consumption and wastewater production for new development or existing infrastructure (LRDP, 2004). It is imperative that UC Berkeley develop campus park guidelines, including construction and design standards, that encourage or mandate water-conserving features.

While guidelines for how the campus can minimize water use and wastewater production are not mentioned specifically in the campus park guidelines, there is a possibility that these goals could be implemented through the UC Regents UC Green Building Policy and Clean Energy Standards which was passed in June 2004, and included as official policy in the UC Berkeley LRDP. This report develops some specific cost-effective new construction and design guidelines that could be incorporated to fulfill UC Berkeley's goals of minimizing water consumption wastewater production.

The UC Green Building Policy and Clean Energy Standards

The UC Green Building Policy and Clean Energy Standards passed by the regents in 2004 have been incorporated into the UC Berkeley LRDP, and is official policy of the UC Regents and UC Berkeley. The UC Green Building Policy and Clean Energy Standards require that: (1) all new buildings and major renovations are designed to a LEED 2.1 standard equivalency, (2) all new laboratories, buildings and major renovations are designed to a standard equivalent to LEED 2.1 certification and labs21 environmental performance criteria, and (3) UCB should strive for a standard equivalent to LEED Silver wherever feasible based on program needs, site conditions, and budget parameters.

What are LEED™ and Labs21 Green Building Rating System?

The LRDP specifically refers to LEED™ equivalency. The US Green Building Council developed the Leadership in Energy and Environmental Design (LEED™) rating system as a national standard for evaluating and certifying "green buildings". It was developed as a means of accelerating the development and implementation of green building practices (Reiss and Stein, 2004, reader). From its inception in March of 2000 through November 2003, there have been over 91 buildings certified and over 1,000 more have been registered (Reis and Stein, 2004). The LEED™ system is a scoring system. There are a few prerequisites that must be fulfilled, and a total of 69 points are available for the following categories: Sustainable Sites (14 possible points), Water Efficiency (5 possible points), Energy and Atmosphere (17 possible points), Materials and Resources (13 possible points), Indoor Environmental Quality (15 possible points), and Innovation and the Design Process (5 possible points). 26-32 points are required for basic certification. Silver is 33-38 points, Gold is 39-51 points and Platinum is 52-69 points. Labs21 Environmental Performance Criteria is a rating system for laboratories that helps to evaluate laboratories for their environmental performance (Labs21 Version 2.0). The framework of Labs21 builds on the LEED™ rating system, but incorporates laboratory specific aspects.

The advantages of the LEED™ rating system include but are not limited to a green building rating system that is nationally recognized and respected. It has an outside verification system that buildings are "green" and environmental harm has been reduced. The rating system is becoming increasingly recognized and those buildings certified with LEED™ can market themselves as "green" buildings. The drawbacks to the system are primarily the cost of registration and certification. The cost of registration usually ranges from $750 to $3,000, and the fee for certification usually costs $1,500 to $7,500 per building (Reis and Stein, 2004). There is also a handicap in terms of the system being a national program vs. a regionally based program, in that some issues and problems which are dependent on regional issues are not given higher priority than other green design choices. For example, water conservation is much more important in the arid west then on the East Coast, but water conservation is weighed the same in all locations. Buildings in locations prone to significant water shortages should not call themselves "green" without dealing with this place-specific issue.

The major drawback for UC Berkeley with using a LEED™ "equivalency" vs. a real LEED™ rating is not obtaining outside third party verification. Greater recognition and credibility is achieved when an outside party verifies that UC Buildings are truly green, as compared to verification by the UC Office of the President (UCOP) that the buildings have meet LEED™ equivalency.

UCSB has decided to forgo internal verification and obtain external LEED™ verification. However, UCSB will have to acquire the money to do so from donors and not from state funds. UC Merced and UC Irvine have also committed to certifying all new buildings LEED™ silver or higher. The LA Community College District requires LEED™ silver or higher certification for the large number of buildings it is constructing, and obtained funding through a bond issue. UC Colorado at Boulder has mandated that all new buildings be certified LEED™ Gold or higher. The University of Florida's new School of Building Construction has also been certified LEED™ Gold. This building is projected to use 30% less water and 47% less energy than a similar conventional building. The additional costs for this LEED™ Gold building is predicted to pay for itself within six years based solely on the reduced energy bills.

While $10,000 dollars for registration and certification is an additional expense, it is a very small percentage of the budget for new buildings, most of which cost million of dollars to construct. If expense is the primary concern, then UCOP might try to work with the UCGBC Green Building Council to develop a cheaper certification process for non-profits such as schools and NGO's. The UC Campuses could be test studies for how to decrease the cost for verification oftheir buildings. When David Gotfield, founder of USGBC, spoke at UC Berkeley in the Fall of 2004, he mentioned his concern for the cost of certification and his desire to reduce the cost. He was very excited to be speaking at Berkeley, and he should be contacted by UCOP to work with them on establishing a college green rating system.

In evaluating the verification/ certification expense, UC Berkeley and UCOP must also consider the true cost of creating an internal system to verify the green building practices of the different Universities. If UCOP is truly serous about its green building policy, then the process of developing a procedure for verification as well as the staff time necessary to verify the compliance of each new capital project and major renovations with green building practices will likely be at least as expensive as an external certification process. UC Berkeley and UCOP will have to develop a transparent verification process to demonstrate compliance with its own green building policy. UC Berkeley is still in the process of developing the documentation and verification that guarantees that each of our new buildings meets our green building goals. In addition, they also still need to formalize a plan regarding how each new project will achieve the equivalent of LEED™ Silver certification, a goal that was called for in its new Green Building Policy.

LEED™ Equivalency: UC Berkeley Baseline Points System

Each UC campus was asked by UCOP to develop a base-line system of points that they would guarantee to include in their design of any new building. The predetermined "base-line" points would be sufficient to meet basic LEED™ certification (26 points). The buildings would not be registered or certified, but would meet LEED™ equivalency by following at the minimum its predetermined base-line points. While having a base line of pre-determined points goes against the grain of an interdisciplinary green design that is flexible and looks at the specific site situation, it does guarantee that those base-line points are always included in any new building. For UC Berkeley, the 26 necessary points for basic LEED™ certification have already been determined and submitted to UCOP (Chess, 2004). UC Berkeley baseline points include (1) the campus current best practices that the University believes fulfill current campus design and construction procedures, (2) points that require only slight changes to the design and construction standards, and/or (3) points that are extremely cost-effective. Only one of UC Berkeley baseline points includes points from the water efficiency section (WE1.1 Water efficient landscaping, which reduce water use by 50%), (Chess, 2004).

UC Berkeley's points were chosen for their baseline based on cost effectiveness and ease of implementation. One reason the water efficiency points were not chosen is the unknown factor of what would be required to meet these points (Chess, 2004). The case-studies provided in this report (Chapter 5) gives examples of building projects that have successfully met the 20% and 30% water use reduction LEED™ points, and the steps were taken to achieve them.

The water efficiency credits for Labs 21 include all LEED™ water efficiency points, as well as a water efficiency prerequisite (Process Water Efficiency), Credit 4.2 (document baseline water use) and 4.2 (20% reduction in water use). The water efficiency prerequisite requires that no domestic water shall be used for once-through cooling of laboratory equipment (unless it has to be used as direct contact process water). It is relatively easy when constructing a new building to make sure that all equipment is on a closed loop cooling system. However, it would be prudent to design the system to have capacity for new and future additional equipment to be easily hooked into the closed loop water-cooling system, to avoid the common problem of having new equipment hooked into the potable water line (see Chapter 2 for more details).

UC Berkeley is also considering meeting credit 4.1, which requires the installation of water meters to document annual process water use and process wastewater generation (St. Clair, 2004). Metering is a very important step in water conservation efforts. Metering is absolutely essential to know how much water is being used for different purposes. Metering, in combination with the manpower to read and analyze water meter data on a timely basis will greatly shorten the amount of time it takes to recognize leaks. Currently, UC Berkeley is not considering reducing their process water by 20%.

Impediments to Resource Conservation and Sustainable Design on Campus

The three major obstacles to resource conservation and sustainable design for the

UC campus system, and for UC Berkeley in particular, are (1) the separation of the budget for building design and construction from operation and maintenance, (2) the absence of life-cycle cost analysis in the university's funding process (outside of some energy efficiency features), and (3) the lack of additional funding to support the mandate for green building and clean energy policy.

UCOP has not allocated any additional funds to cover any increase in first costs from building greener buildings. Therefore, if green building designs have life-cycle costs that would lower overall operations and maintenance costs, but have an initial increase in first cost, there is currently no additional funding mechanism available. UCOP has not accepted additional cost per square feet funding to fund green building features, even those with short life-cycle payback periods. A recent cost study has documented that the cost of a green building is not substantial higher (only about 2% increase in construction cost) yet this increased first cost typically yields life-cycle savings of over ten times the initial investment (Kats, 2003). The University is both the developer and the tenant and, hence, it would make financial sense for the University to invest in the upfront cost to lower the lifetime cost and expense of operation of its new buildings. Buildings last more then 50 years on the UC Berkeley campus. UCOP should define what is an acceptable increased first cost for an acceptable payback period.

State funded buildings have two budgets set by the state of California; one is for capital projects (to design and build the building) the other is for operation and maintenance (O&M). The state has allowed the O&M funds to be used for the capital cost of the buildings. However, this is only allowed if the O&M has funds to spare. Because O&M has been running in long-term deficit, UC is not allowed to use O&M money to apply to design and construction of new buildings, even if it would lower operation and maintenance cost for the life-span of the building. A breakout group at the UC Green Building Conference at Santa Barbara in June 2004 developed possible solutions to overcome the separation of budgets for Capital costs and Operation and Maintenance. The solutions considered include (1) Institutionalizing a 3rd party financing of loans to pay the initial upfront cost of green design and construction; (2) UC has bond money set aside for new buildings, which could possibly be channeled into existing building energy and water efficient retrofits, as well as other green retrofits; (3) Change legislation to allow the use of operation and maintenance funds to lower operations costs of new buildings; (4) Include lifecycle costing in the funding and approval process for new buildings; (5) Integrate maintenance and operation staff into the design and construction process of new buildings; (6) Change UC design standards to incorporate lifecycle costing; and (7) Float a bond measure specifically for the additional upfront costs of products, materials, and soft costs of green buildings.

Chapter 4: UC Berkeley Main Campus Water Audit

What a difference a toilet can make

Efficient water-using fixtures can have a substantial effect on water consumption in the urban sector. As mentioned previously, the Pacific Institute documented the ways in which California could mitigate the anticipated water shortage in 2020 through technology upgrades to currently available water-using fixtures in the urban sectors (Gleick, 2003). One such example is replacing heavy use high flush volume toilets, such as university toilets, which have many users throughout the day, and can literally flush substantial amounts of water down the drain.

The federal government recognized the water savings and societal benefits of decreased need to obtain additional water supply and wastewater treatment plants and, in 1992, passed the U.S Energy Policy Act (EPAct). The EPAct required that, by January 1st 1994, all toilets, showerheads, and faucets that were to be manufactured would have a maximum allowable flow rate of 1.6 gallons/per/flush (gpf,) 2.5 gallons/per/minute (gpm), and 2.5 gpm respectively (Vickers, 2002). This was not the first time that water using fixtures have increased in efficiency; the water use requirements for fixtures such as toilets, faucets and showerheads also decreased significantly in 1980 (Vickers, 2002).

California, acutely aware of its own water supply challenges, had already required that all toilets installed from 1992 onwards be low-flow 1.6 gpf toilets. Although "low-flow" 1.6 gpf toilets have been installed nation wide for more then 12 years, a belief still persists that they do not function well, and that water is not saved due to the need to double-flush. There were problems when low-flow toilets first came on the market, including a few models that had significant problems, which has had the result of a lingering perception that "low-flow" toilets do not function well (Vickers, 2002). However, since the requirement of low-flow toilets, numerous studies have documented the equivalent performance of low flow toilets (Vickers, 2002).

The perception that "low-flow" toilets do not work properly has caused some users to modify low flow toilets to flush at 3.5 gallons/flush. This is relatively easy to do. One small part, the diaphragm inside flush-valve kits, controls how much water is flushed into a toilet or urinal (Figure 4.1). While it is not advisable to put a 1.6 gpf flush valve kit into a 3.5 gpf toilet and modify the toilet to use less water due to the design of the older toilet bowls, it is possible to put a 3.5 gpf flush valve kit into 1.6 gpf toilet. When this is done, it modifies the toilet to more than double the amount of water used for each flush. The modification of the "low-flow toilet" wastes 1.9 gallons of water with every flush. However, a 3.5-gallon flush-valve kit in a 1.6 gpf toilet does not increase performance of the toilet, as the toilet bowl is designed for a lesser amount of water and the extra water volume can cause splashing and increased noise (Dan Muir, 2004).

Flush-valve kits also wear out and need to be replaced over time. When the flush valve kits age, they stay open for longer than is necessary and stop functioning as a 1.6 gallons/flush toilet. In the field, water conservation experts test this by counting the seconds it takes for a toilet to flush (Dan Muir 2004, Leann Gustason, 2004). A 1.6 gpf toilet should flush in about four seconds. When the toilet takes 7-20 seconds it means one of three things: (1) the inside diaphragm part is incorrect, and is a 3.5 or 4.5 gpf diaphragm part instead of a 1.6.gpf part, (2) the correct flush valve kit has aged, sticks open longer than is necessary, and needs to be replaced, or (3) the control stop valve needs to be adjusted. The control stop valve is on the outside handle of the flushometer toilet (Figure 4.2) and must be properly adjusted when the toilet is originally installed and each time the diaphragm parts are replaced. If the control stop is not adjusted correctly, a greater amount of water than the toilet is designed for can also be used with each flush.

The EPAAct required that all newly installed water-fixtures be "low flow". However, the policy does not apply to the substantial amounts of older water using fixtures that are already installed. The life span of water fixtures can be quite long (e.g., toilets may be used for 25-50 years). Therefore, many utility providers established successful rebate programs to encourage the exchange of water-guzzling toilets to low-flow toilets (Vickers, 2002). One example is Santa Monica's toilet-rebate program. Almost 60% of the residential high flush volume toilets were replaced, resulting in a 15% decrease in the Santa Monica's water consumption and wastewater flows (Vickers, 2002).

UC Berkeley's water suppler, EBMUD, has a toilet rebate program for both tank toilets and flushometer toilets (Figure 4.2 and 4.3). EBMUD offers a $25/toilet rebate for upgrading to regular "low-flow" tank toilets or $100/toilet if upgrading to a

Figure 4.1 Flush Valve Diaphragm Parts of a Toilet: Controls How Much Water is Flushed

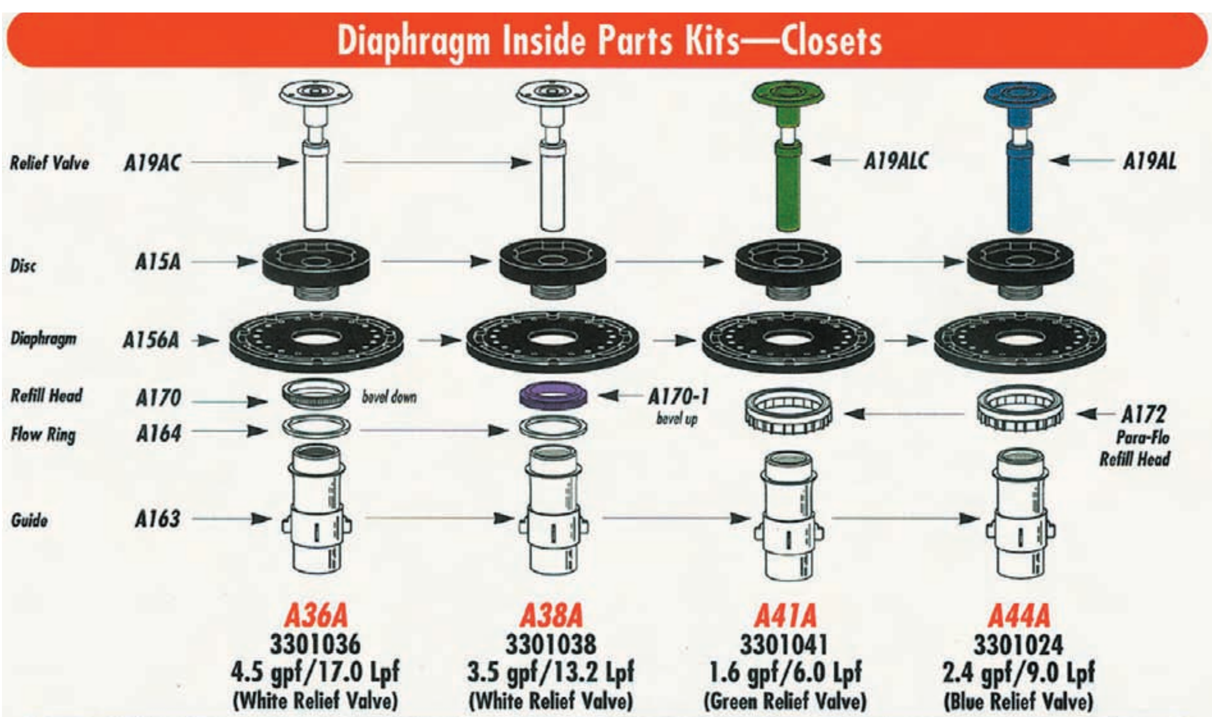


Figure Courtesy of EBMUD

Figure 4.2 Flushometer Toilet

Figure 4.3 Tank Toilet

dual flush toilet. Dual flush toilets use 0.8 and 1.6 gpf, depending on which button you push. For flushometer toilets EBMUD provides financial incentives that often reduce the cost of upgrading to low-flow toilets to a two-year payback period (Lean Gustasfon, 2004).

Main Campus Water Audit

Water Audit Methodology

A restroom water audit was conducted on 33% of the male and 45% of the female restrooms of the state funded buildings on the UC Berkeley campus (Table 4.1). The author of this report conducted approximately half the audits. The other half of the audits was conducted by students in undergraduate course EPS80 using a detailed water audit guidance document written by the author of this report (see appendix A). The EPAct mandates that the flow rate for toilets be marked directly on the fixture (Vickers, 2002). Toilet brands, type, and flush volume, if labeled on the toilet, were recorded during the audit. For all low flow 1.6 gpf toilets, the flush duration times (determined as "seconds to flush") were recorded. The seconds to flush was used to estimate if the toilets were leaking and determine more accurate flush volumes (non-leaking 1.6 gpf toilets should flush within 4-6 seconds, while the leaking toilets took between 7 to 25 seconds to flush). Detailed bathroom maps were drawn which included a fixture count, toilets, faucets and urinals.

Water Audit Results

The water audit results show that 81% of the male and 69% of the female toilets on the main UC Berkeley campus are not 1.6 gpf low-flow water conserving toilets, and therefore use at minimum 3.5 gallons of water with every flush (Figure 4.4 and Table 4.2). Toilets installed between 1980 and 1992 use from 3.5 to 4.5 gpf. Toilets purchased from 1950 to 1980 use 5 or 5.5 gpf, and toilets purchased prior to 1950 consume 7 gpf. Without examining the flush-valve parts being used in each toilet, or estimating its volume from the replacement parts stored in the stockroom, it is not possible to determine the exact water volume usage of these toilets. The older toilets could be using anywhere from 3.5 to 7 gpf. To be conservative in the estimates of potential reduction in water use and utility spending, all non-low flow toilets were assumed to be 3.5 gpf. UC Berkeley currently does not have a program for replacing flush-valve kits. Many of the older toilets are likely to have had the same

Table 4.1 Audited Restrooms

Male Restrooms	GSF	Floor of Audited Restrooms	Type of Toilet	Total toilets bld	1.6/ bld	=>3.5 bld	# of 1.6 gpf leaking toilets	# of urinals	1.0 gpf	# > 1.0 gpf
Cory Hall	206,054	2,3,4,5	Tank/Flushometer	17		17		19	0	19
Zellerbacker	153,118	1,2	Flushometer	5		5		17	0	17
Moffitt	130,581	2,2,3,4	Flushometer	9		9		10	0	10
Davis Hall	189,144	1,4,6,7	Flushometer	7	1	6	0	7	1	6
Barker Hall	86,063	3,5	Flushometer	3	1	2	0	4	2	2
Dwinelle Hall	300,064	F/G 7230, F/G 373, D 4230	Tank	7	4	3	3	8	5	3
Barrows Hall	193,232	G,1,4,6	Flushometer	18	5	13	5	16	0	16
Doe Library	168,861	1,2,4	Flushometer	7	0	7	0	10	0	10
Warren Hall	78,526	1,2	Flushometer	5	0	5		4	0	4
Wheeler	137,297	B, 1, 4	Flushometer/Tank	9	3	6	0	9	3	6
Sprawl Hall	117,804	B	Tank	3	0	3	0	3		3
Cambell Hall	63,719	2,4	Flushometer	3	1	2	0	5	0	5
King Student Union	106,557	B	Flushometer	3	3	0	2	3	3	0
Hass Pavilion/Hearst Gym	237,845	1,1,2	Flushometer	16	16	0	2	16	16	
VLSB	418,707	2,3,4,5	Flushometer	12	0	12		12		12
Mulford	93,420	1,2,3,	Tank	7		7		7		7
Genetics Plant Biology	26,321	1	Flushometer	4		4		6		6
Koshland	153,700	1,2,3,4	Flushometer	8	0	8		8		8
Tolman	240,884	B,G,1,3,3,4,5,5	Flushometer	18	4	14	1	24	4	20
Haviland Hall	51,020	B,3	Flushometer	5		5		4		4
Wurster	221,293	1,3,3,51/2,71/2,91/2	Flushometer	17	7	10	4	15	5	10
Total audited GSF	**3,152,917**			**183**	**45**	**138**	**17**	**207**	**39**	**168**
% of State Funded GSF Audited		**34**								

Female Restrooms	GSF	Floor of Audited Restrooms	Type of Toilet	Total toilets bld	1.6/ bld	=>3.5 bld	# of 1.6 gpf leaking toilets
Cory Hall	206,054	1,2,3,4,5		12	1	11	1
Zellerbacker	153,118	1,1 ,2	Flushometer	24	6	18	0
Moffitt	130,581	2,2,3,3,4	Flushometer	20		20	
Barrows	193,232	G, 1	Flushometer	12	2	10	1
Dwinelle Hall	300,064	F/G 7230, F/G 373, D 4230	Tank	12	9	3	7
Campbell Hall	63,719	2,4,6	Flushometer	7		7	
Davis Hall	189,144	2,3,4,5	Flushometer	6	1	5	0
Doe Annex	161,930	1	Flushometer	4	1	3	1
Doe Library	168,861	1,1,2,3,4	Flushometer	19	4	15	1
Etchevery Hall	177,281	3,5	Flushometer	5		5	
Hearst Minning	141,461	1.2.3.4	Flushometer	10	10	0	2
Hildlebrand	127,494	B, D, 2,4	Flushometer	10	4	6	1
LSA	201,824	1,2,3,4,5	Flushometer	16		16	
McCone	123,612	1,2,3,4,5	Flushometer	16		16	
Wheeler Hall	137,297	B, 1,3, 4	Flushometer	22	12	10	7
Tan	116,121	1,2,3,4,5,6,7	Flushometer	15	15		0
Sprawl Hall	117,804	B	Tank	7		7	
Koshland Hall	153,700	1,2,3,4,5	Flushometer	15	1	14	0
VLSB	418,707	1,2,3,4,5	Flushometer	31		31	
King Student Union	106,557	B,4	Flushometer	12	3	9	3
Hass Pavilion/Hearst Gym	237,845	1,1,2	Flushometer	30	30	0	2
Mulford	93,420	1,2,3	Tank	9		9	
Warren Hall	78,526	B,1,2,3,4	Flushometer	11	2	9	2
Genetics Plant Biology	26,321	1	Flushometet	7		7	
Tolman	240,884	B, G, 1,2,3,4,5,5	Flushometer	29	9	20	0
Haviland Hall	51,020	1,2,3	Flushometer	9		9	
Wurster	221,293	1,3,4,61/2,81/2	Flushometer	15	8	7	0
Total audited GSF	**4,337,870**			**385**	**118**	**267**	**28**
% of State Funded GSF Audited		**46**					

Figure 4.4 Distribution of Water and Non-Water Conserving Restroom Fixtures

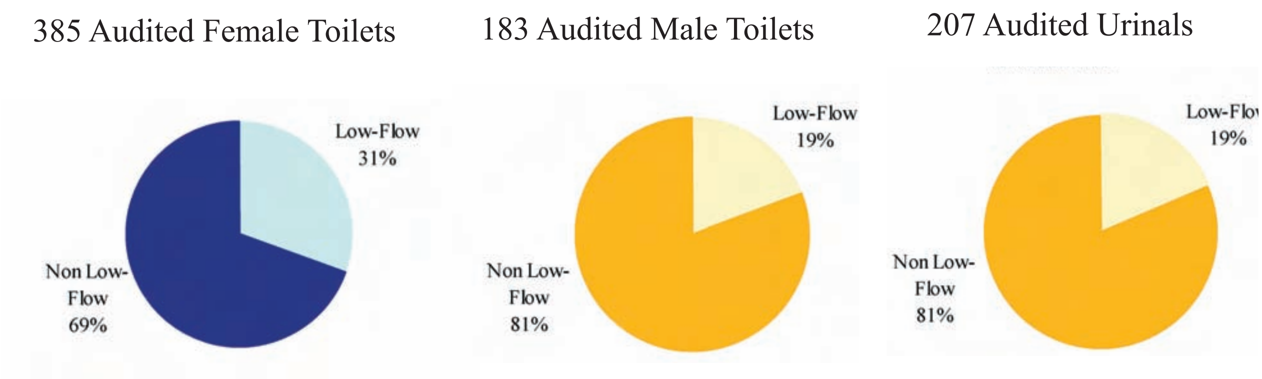


Table 4.2 Summary of Audited Restroom Fixtures

	Audited Fixtures						Extrapolated Total Number of Fixtures			
	Audited Water Use Fixtures	# of 1.6 gpf/toilets or 1.0 gpf urinals	% leakage of 1.6 gpf/toilets	# of non low-flow toilets and urinals	% non-low flow toilets and urinals	amount of total state funded gpf that was audited	# of leaking 1.6gpf toilets on campus	# of 1.6 gpf toilets and urinals on campus	# of non low-flow toilets and urinals on campus	total number of toilets and urinals
Female Toilets	385	118	0.24	267	0.69	0.45	62	262	593	856
Male Toilets	183	45	0.38	138	0.75	0.33	52	136	418	555
Urinals	207	39		168	0.81	0.33		118	509	627
Total	775	202		573			114	517	1521	2037

Table 4.3 Savings Available from Replacing High Flow-Rate Toilets and Urinals

	total population	female/male population	population using non low-flow toilets and or urinals*	water consumption 3.5 gpf toilets, 2.0 urinal*	water consumption 1.6 gpf toilets, 0 gpf for urinals**	annual water savings CCF	water savings gallons/year	$ annual savings	hardware costs ($400/ fixture)	labor costs $74/ hour 4 hours/fixture	hardware and labor costs	payback period years without EBMUD rebate
Female Toilets	47,034	23517	16,227	68,334	31,239	37,096	27,747,708	107,578	237,200	177,900	415,100	3.9
Male Toilets	47,034	23517	17,638	25,089	11,469	13,441	10,053,518	38,978	167,200	125,400	292,600	7.5
Male Urinals	47,034	23517	19,049	30,937	0	30,560	22,858,524	88,623	202,400	151,800	354,200	4.0
Totals				124,360	42,708	81,096	60,659,750	**235,178**	606,800	455,100	1,061,900	4.5

Assumptions

Water and Wastewater costs $2.9/CCF
Restroom User Rate- Females 3 times a day,
Males 1 a day for Toilets/ Twice a day for Urinals (Vickers, 2002)
Year = 300 days:
Toilets/Urinals Hardware Costs $400/Fixuture,
Labor = $74/Hour, 4 Hours to Replace each Fixture
Hardware and Labor = $700/Fixture

flush valve kit for many years and are likely leaking, and therefore using considerably more water than 3.5 gpf. These two factors suggest that the estimates of monetary water savings from replacing the older toilets with water efficient toilets are likely to be highly conservative and underestimate the potential savings.

The water audit indicates that UC Berkeley can save 27.7 million gallons of water and $107,578 a year if it chooses to upgrade its non-conserving toilets in female restrooms (Table 4.3**).** Even without applying for the available rebates from EBMUD, the payback period would be 3.9 years. The savings from upgrading toilets and male restrooms is slightly less as males use both toilets and urinals. The water audit indicates the potential to reduce water use by 10 million gallons of water and $38,978 a year with a payback period of 7.5 years. However, financial rebates provided by EBMUD would substantial reduce the payback period.

Only 19% of the urinals audited were "lower flow" 1.0 gpf urinals. 81% of the urinals on the main UC Berkeley campus used greater than 1.0 gpf. Urinals installed from 1980 to 1992 can use anywhere from 1.5 to 5 gpf (Vickers, 2002). Urinals installed prior to 1980 use 5 gallons per flush. Actual urinal flow rates would need to be determined from inspection of flush-valve kit parts in urinals or the replacement parts in the stockroom in each bathroom and/or building. To estimate potential savings from upgrading high-flow rate urinals, all non low-flow urinals were conservatively assumed to be 2.0 gpf. With this assumption, upgrading all high-flow rate urinals to waterless urinals would save 22.9 million gallons of water and $88,623 dollars a year, with a payback period of 4 years (Table 4.3).

The water audit results indicate that only 19% of the men's and 34% of the women's toilets on the UC Berkeley campus are "low-flow" (1.6 gpf toilets) (Table 4.2, Figure 4.4). However, not all the low-flow toilets are functioning as low flow: 38% of the audited men's 1.6 gpf toilets and 24% of the women's audited 1.6 gpf toilets are, in fact, leaking when flushed (Table 4.4, Figure 4.5).

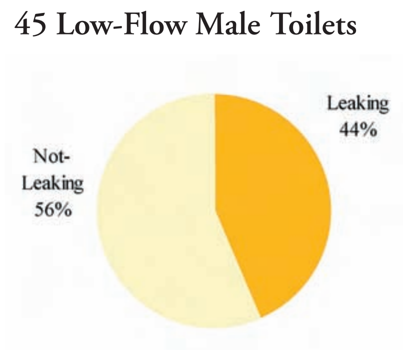
UC Berkeley currently does not have a proactive program for checking and repairing leaking toilets. Toilets are only fixed when a user calls in a broken toilet or malfunctioning toilet. Among audited buildings containing low-flow toilets, the newer buildings such as Tan Hall or Hass Pavilion, have much lower leak rates. This indicates that it takes five or more years for the toilets to begin to leak and lose their water savings. UC Berkeley could reduce its water use by 4.3 million gallons and save $16,537 a year as a result of replacing the faulty flush-valve kits on 94 leaking 1.6 gpf toilets. Even with labor and hardware costs of $15 per kit, $75 per hour labor, and fixing one flush-valve kit an hour, the payback period is 0.5 years for the female toilets and 0.9 years for the men's toilets (Table 4.4). Maintenance, labor and hardware costs would decrease in subsequent years because maintenance on each toilet would only be needed approximately once every five years, whereas the $16,537 dollars a year reduction in water usage and wastewater fees would be realized annually. There is also an even greater savings likely from replacing the older non-conserving toilets' flush-valve kits. Many of these older toilets have likely had the same flush valve kits for many years.

If UC Berkeley chooses to perform

Table 4.4 Water and Monetary Savings Available from Maintenance of Low-Flow Toilets

	total population	female/male population	population using leaking 1.6 gpf toilets	water consumption w/leaks	water consumption w/ maintenance	annual water savings CCF	annual water savings gallons	$ annual savings	hardware costs ($15/ kit)	labor costs $74/hour 1hour/kit	hardware and labor costs	payback period years
Female	47034	23517	1,750	7,368	3,368	4,000	2,991,927	11,600	930	4,588	5,518	0.5
Male	47034	23517	2,234	3,136	1,434	1,702	1,273,446	4,937	780	3,848	4,628	0.9
Total						5,702	4,265,372	**16,537**	1,710	8,436	10,146	0.6

Figure 4.5 Percentage of Low-Flow Toilets that Leak



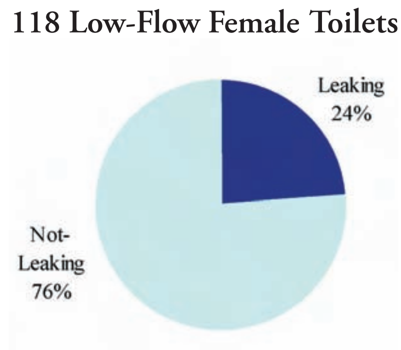


Figure 4.6 Annual Savings of Over $250,000 a Year from Restroom Water Efficiency

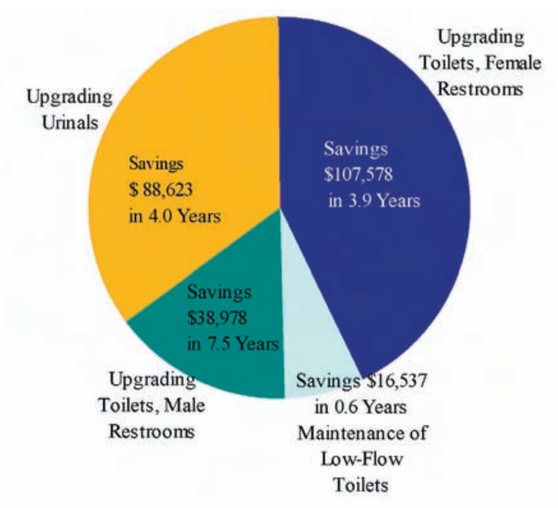


Table 4.5 Summary of Water and Monetary Savings Available from Improving Restroom Water Use Efficiency

	water savings CCF	water savigns gallons	Hardware and labor costs	$ annual savings	Payback period
Upgrading Toilets, Female Restrooms	37,096	27,747,708	415,100	107,578	3.9
Upgrading Toilets, Male Restrooms	13,441	10,053,518	292,600	38,978	7.5
Upgrading Urinals	30,560	22,858,524	354,200	88,623	4.0
Maintenance of Low Flow Toilets	5,702	4,265,096	10,146	16,536	0.6
Totals	81,096	60,659,750	1,061,900	251,714	**4.5**

toilet maintenance approximately once every 5 to 8 years, and replace older non-conserving toilets and urinals with low-flow toilets and waterless urinals, then it would save over $235,000 dollars and over 60.7 million gallons a year in water with a payback period of just over 4 years (Figure 5.6). This is enough water to supply the indoor water use of 3,377 people in water conserving homes (45.2 gallons/person/day, Vickers, 2002).

Chapter 5: The Residence Halls Water Audit

Residence Hall Water Consumption History

Residence Halls 1,2, 3 and 4 are adjacent to the main UC Berkeley campus. Annual water use in Residence Halls 1,2,3 and 4 has fluctuated from 1975-2003 (Figure 5.1). The fluctuation in water use is a result of a combination of behavior changes, technology upgrades, variation in summer population, removal of the dinning halls and maintenance issues. During the California drought of 1976-77, UC Berkeley Residence Hall students responded to the serious water shortage by reducing their water use through behavior changes such as taking shorter showers, turning off the faucet when brushing teeth, etc. During the 1970's drought, from 1975 to 1977, Unit 1 reduced its water use by 34%, and Units 2 and 3 reduced their water use by 29%. However, behavior changes are not permanent unless annual education continues, and the years following the late 70's drought show consumption quickly climbing back to pre-drought levels. During the 1987-1993-drought period, there was a slow decrease in water consumption that was also likely due to behavior changes.

In 1994 and 1996 Residence Halls 1 and 2 decreased their water use by 29% and 21% respectively as a direct result of upgrading to 1.6gpf toilets (Figure 5.2, 5.3). Unit one's 29% reduction in water use saved 4.4 million gallons of water a year (5,884 CCF) and $20,000 in reduced utility bills (water and wastewater charges of $2.37 and $1.03 per CCF, respectively*)*. Unit 2 upgrades to water efficient bathroom fixtures in 1996 resulted in reducing per capita water use by 7.5 gallons/student/semester compared to 1995 per capita water use (Figure 5.2). Since Unit 2 1996 renovations, Unit 2 water consumption has remained lower than Unit 1**.** The Unit 2 dining hall closed in the fall of 2002, and Unit 1 dining hall absorbed the extra students. This explains the decrease in Unit 2 water use and the increase in Unit 1 water use in 2002 (Berkeleyan, 2002**).** Unit 1 dining hall closed in 2003 when the New Crossroads dining hall opened in January 2003

Figure 5.1 Residence Hall 1,2,3 and 4 Annual Water Use

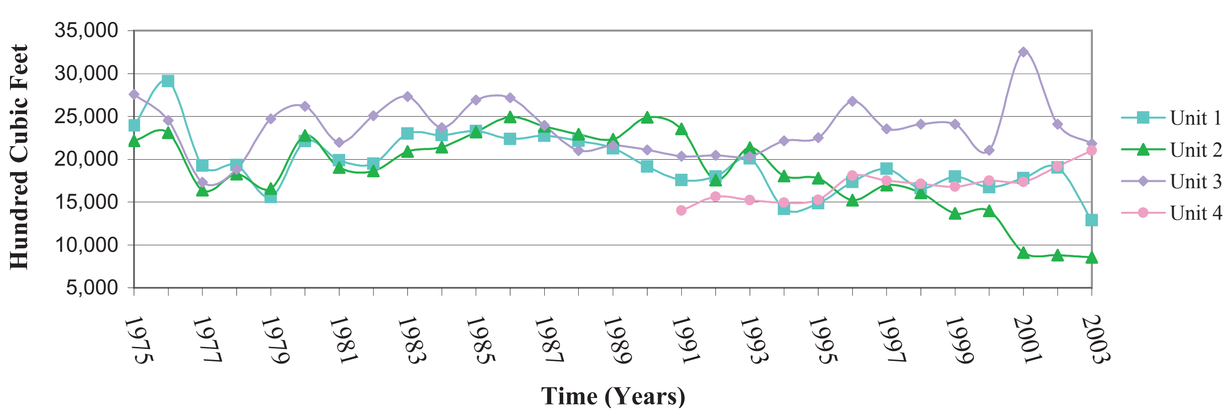
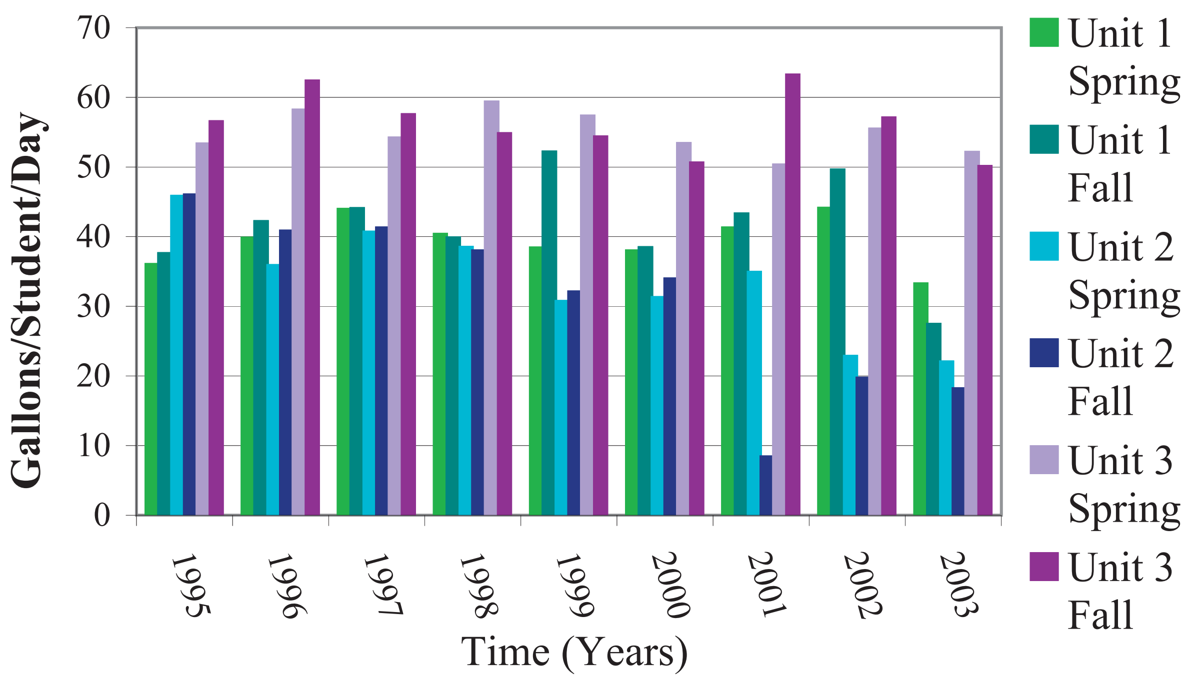


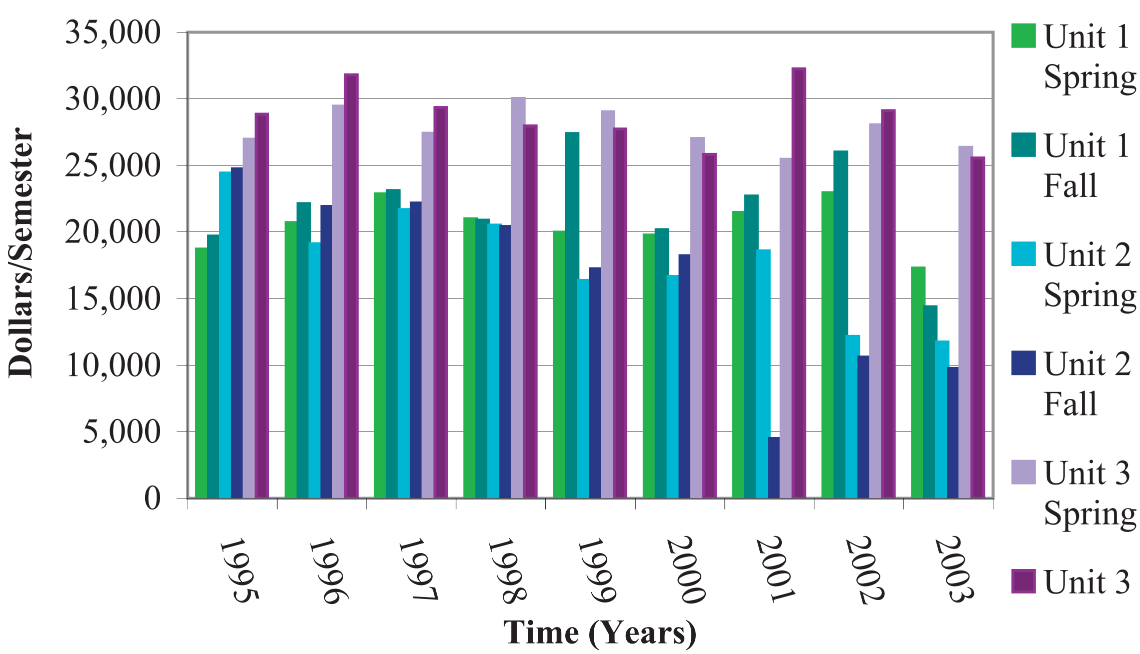
Figure 5.2 Residence Hall 1, 2 and 3 Water Consumption per Semester: 1995-2003



Spring Semester is Febuary-May

Fall Semester is September-December

Figure 5.3 Residence Hall 1, 2 and 3 Utilities Spending Per Semester: 1995-2003



Spring Semester is Febuary-May

Fall Semester is September-December

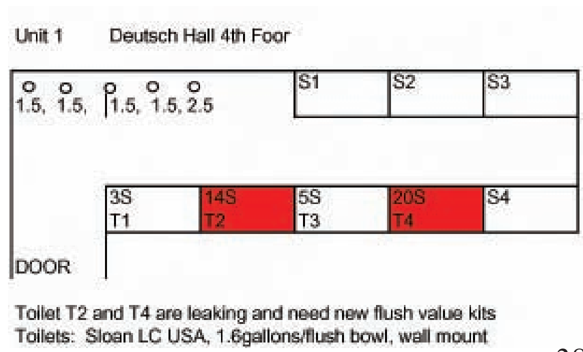
(Bob Jacobs, 2004). The drastic reduction in Unit 2 water use in the Fall of 2001 has not been explained by any water audit results or meeting with housing services. Therefore all direct comparisons between Unit 1 and 2 are only for the years 1995-2000 and 2003). Unit 3 water use is significantly greater than Unit 1 or 2 as it still has 4.5 gpf toilets.

Another factor significantly affecting the water consumption profiles of Unit 1 and 2 is the variation in summer occupancy levels. For example, Unit 2 had no occupancy during the summers of 2001-2003, and Unit 4 was closed during the summer of 2004. Due to the variation in number of students in the Residence Halls during the summertime, when comparing annual water use from year to year and residence halls to residence halls, only the Fall (February to May) and Spring (September-December) semester water consumption data was used. Analyzing semester water use date will give a more accurate picture of the per capita water consumption numbers for each Residence Hall.

Water Audit Methodology

Dan Muir, a water conservation expert with EBMUD, performed a complete restroom water audit for Residence Halls 1, 2 and 3, in conjunction with the author. Faculty managers for Unit 4 (Foothill, Bowles and Stern), and the Clark Kerr Campus (CKC) residence halls were interviewed, and a quick walkthrough water audit was performed. Faucet and shower flow rates were determined by reading the flow rate denoted directly on the fixtures, or by filling a flow bag in increments of five seconds and reading the flow rate from the bag. The flow rate bags were provided free from EBMUD. The EPAct mandates that the maximum allowable flow rate for showerheads be marked directly on the fixture (Vickers, 2002). All showers in the audited Residence Halls were 2.5 gpm and marked as such. Faucets flow rates ranged from 1.5 to 2.5gpm. Toilet brands, type, and flush volume were determined, if possible. If the toilets were marked as 1.6gpf then the flush duration times (determined as "seconds to flush") were counted. The seconds to flush was used to estimate if the toilets were leaking and determine actual flush volumes (non-leaking 1.6 gpf toilets should flush within 4-6 seconds). Detailed bathroom maps were drawn which included a fixture count and flow rates for the showers, toilets, faucets and urinals. The high water using toilets were identified in red on the detailed bathroom maps (Figure 5.4). The faucets flow rates were also included on each map. In addition, the flush-valve kit part numbers were recorded, when available. The Flush-valve part is what determines how much water each toilet uses per flush. The water audit data, as well as the annual and seasonal water use data provided by EBMUD, was used to evaluate the water conservation potential of the residence halls.

Figure 5.4 Water Audit Bathroom Maps



Water Audit Results

Units 1 and 2

Unit 1, at 2650 Durant Avenue, is comprised of four identical eight-story towers: Cheney, Deutsch, Freeborn, and Putnam Halls. Approximately 946 students live in the Unit 1 Residence Hall each year. Every floor has shared restrooms, with almost all floors containing coed bathrooms, but with a few single-sex floors. Unit 2 is very similar to Unit 1 in size, design, layout, and bathroom fixtures. Approximately 969 students live in the Unit 2 four eight-story towers named Griffen, Cunningham, Ehrman and Davidson Hall.

Units 1 and 2 have fairly similar facilities and, theoretically, following their upgrades in 1994 and 1996 respectively, should have very similar water use profiles per student for the Fall and Spring semesters. However, this is not the case. When comparing Unit 1 and 2, it is surprising to see that there is a substantial difference in annual water consumption and utility spending (Figure 5.2 and 5.3 respectively).

Although the student population has remained relatively constant, Unit 1 water consumption has steadily increased from 1994, when new toilets were installed, until 2003 when the dining hall was removed. Unit 1 water use has increased from 36 gallons/student/semester in 1994 to 47 gallons/student/semester in 2002. The water audit conducted in Fall 2004 determined that 49% of Unit 1 and 24% of Unit 2 toilets were flushing at greater then 1.6gpf (Table 5.1). In addition, the flush valve replacement kits used in Unit 1 are for a 3.5-gallon per flush part instead of a 1.6 gallon per flush part (part number A38A 3301038 rather then A41A 3301041). Whenever a faulty flush valve kit was replaced, the toilet was converted to a 3.5 gpf toilet. The incorrect flush valve kit is one reason for increased water consumption and percent of toilets flushing at 3.5 gpf or higher in Unit 1 compared to Unit 2. Unit 2 is unique in using 1.5 gpf urinal replacement kits for their toilets, seemingly without any problems, and saving 0.6 gpf.

Currently, there is no routine schedule for toilet maintenance. Only when a student reports a problem is it addressed. Annual maintenance, including a program to fix faulty flush valve kits and/or install the correct parts, would reduce utility spending of $6,131 in Unit 1 and $3,090 in Unit 2 per year (Table 5.1). Although the maintenance labor costs would be $3,245 for replacing 59 toilet flush valve kits in the first year, Unit 1 would still have a net savings of $3,108 after installation costs in year one. In the following years, the avoided cost would stay the same, but the maintenance requirements would decrease, as fewer flush valve kits would need to be replaced during a year. Unit 2 would save $1,495 after the installation costs of replacing 29 flush-valve kits in the fist year. Toilet maintenance in Unit 1 and 2 would have a payback period of six months (Table 5.1). In order to be conservative on the potential water and monetary savings, the calculations used the lower end estimate of 3.5 gpf per leaking toilet. However, according to EBMUD, the estimated flush volumes could be higher (Dan Muir, 2005), and therefore the potential savings could be greater than what is estimated here.

Residence Halls 1 and 2 have an assortment of 1.5, 2.0, 2.2 and 2.5 gallon per minutes (gpm) faucet aerators (Table 5.2 and 5.3). The potential savings from upgrading

Table 5.1 Annual Maintenance of the Toilets in Units 1 and 2 will save over $9,000 a year

	# of toilets/ unit	% of toilets that used > 1.6 gpf	# of students that used toilets >1.6 gpf	excess water use per year* CCF	excess utility spending/ year	Cost of 1st year maintenance **	savings 1st year	savings 2nd year	payback period years
Unit 1	120	49	464	1801	$6,125	3445	$2,680	$6,125	0.56
Unit 2	120	24	233	904	$3,073	1690	$1,383	$3,073	0.55

Assumptions:
* Water use is based on 5.1 uses/student/day (Vickers, 2002), Year = 300 days
** Maintenance cost is based on $15/kit, Labor = $50/hour, time is 1 hour per kit
Student population: Unit I, 946 students: Unit2 969 students

Table 5.2 Unit 1: $6,395 Dollars a Year Savings From Low-Flow Faucet Aerators

	Where We Are Now				Where WeCould Be	
Rated Flow Rate	2.2 gpm	2.0 gpm	1.5 gpm	total	1.5 gpm	0.5 gpm
Actual Flow rate*	1.4 gpm	1.2 gpm	1.0 gpm		1.0 gpm	0.5 gpm
# of faucets	24	23	79	120**		
% of student using each faucet type	19	18	63		100	100
total students using each faucet type	180	170	596	946	946	946
total gallon/day***	2,038	1,655	4,827	8,521	7663	3831.3
total CCF/year	817	664	1,936	3,417	3,073	1,537
$ costs/year****	2,779	2,257	6,583	$11,619	$10,449	$5,225
Unit 1 Potential savings/year*****					$1,170	**$6,395**

Table 5.3 Unit 2: $8,663 Dollars a Year Savings From Low-Flow Faucet Aerators

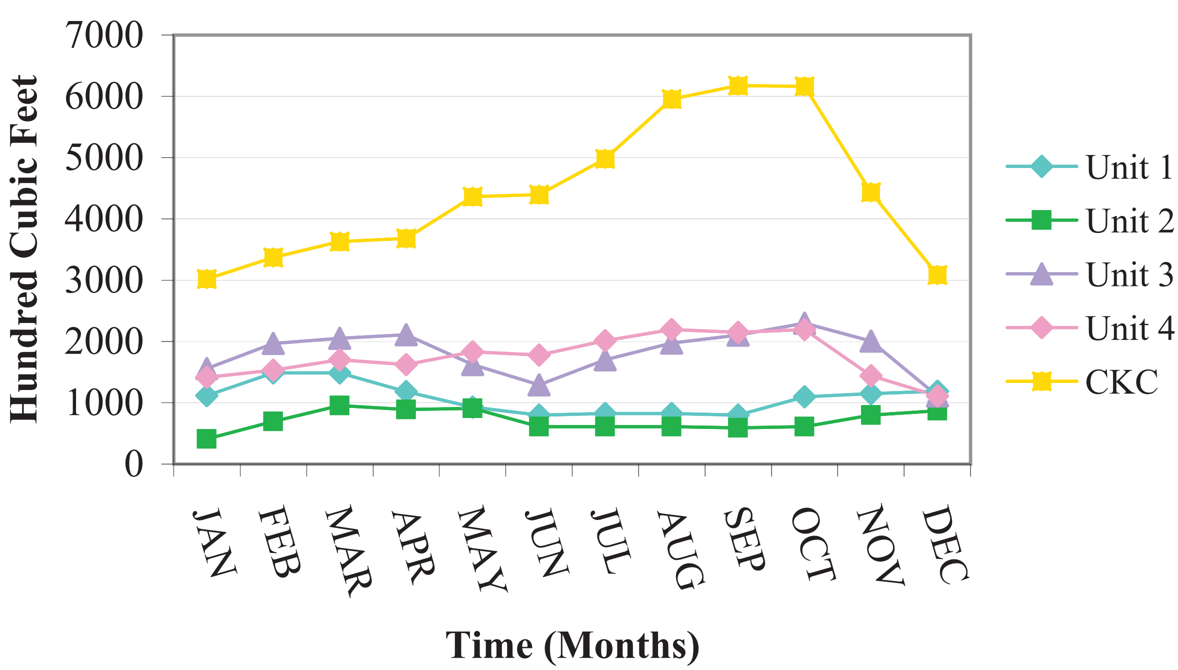
	Where We are Now				Where WeCould Be	
Rated Flow Rate	2.5 gpm	2.0 gpm	1.5 gpm	total	1.5 gpm	0.5 gpm
# of faucets	56	2	70	136**		
% of students using each faucet type	43.8	1.6	54.7		100.00	100
total students using each faucet type	424	15	530		969	969
total gallon/day***	5,838	147	4,292		7848.9	3924.45
total CCF/year	2,341	59	1,722		3,148	1,574
$ costs/year****	7,960	201	5,853		10,703	5,352
Unit 2 Potential savings/year*****					$3,311	**$8,663**

* Actual flow rate is lower than marked flow-rate
** total includes 17 unknown faucet flow rates
*** user rates based on industry standard of 8.1 minutes/person/day
****Water and wastewater costs are $2.37 and $1.03 respectively
***** Does not include additional savings from reduced energy costs
0.5 gpm aerators are free from EBMUD

the current aerators in Residence Halls 1 and 2 restrooms to 0.5 gpm is substantial. In student water audits, conducted during the Spring of 2003 in Professor Bill Berry's Earth and Planetary Science 80 lecture course at UC Berkeley, it was determined that students let the faucet run for approximately 10 minutes a day (Buckley, 2004). However, to provide conservative monetary savings estimates, all savings were calculated with industry standards of user rates of 8.1 minutes/person/day (Vickers, 2002). Water and monetary savings were calculated both for standard 1.5 gpm faucets and for more experimental 0.5gpm faucets. Actual flow rate is less than the rated flow, and actual flow rates were used in all calculations. EBMUD is giving away free faucet aerators that use 0.5 gpm. Six aerators were installed for a pilot test in Unit 2. If they are successful, retrofitting all the faucets there could save $6,395 and $8,663 dollars per year in utility bills for Unit 1 and Unit 2, respectively (Table 5.2 and 5.3). This savings does not include additional energy savings from the reduced amount of water needing to be heated. However, if the 0.5pgm faucets are not successful, an upgrade to 1.5 gpm faucets would still save Unit 1 and Unit 2 $1,171 and $3,311 per year respectively.

All the showers in the audited Residence Halls had 2.5 gpm showerheads. The 2.5-gpm showerheads are very sturdy, and while there are lower flow-rate showerheads available, they are not as vandalism proof, and are not recommended by EBMUD (Dan Muir, 2004). While it is not currently recommended to replace the showerheads, it is possible to use education to modify behavior that would reduce shower-times. The student audits of 2002 and 2003 identified that the average shower time is 15 minutes/student/day (Buckley, 2004). Even a small reduction in shower rate time has a large payoff both in terms of water and in energy savings.

Figure 5.5 Residence Halls 1,2,3,4 and CKC Monthly Water Use 2003



Irrigation water use is not metered separately in the Residence Halls that were audited. The residence halls (except CKC) show a marked reduction in water consumption during the summer months, when fewer residents are in the dorms (Figure 5.5). The reduced water consumption profile in the summer time is different than normal residential water use profiles, which exhibit an increase of water consumption in the summer months due to increased landscape irrigation. CKC has an extensive landscape to irrigate. Therefore, unlike the other Residence Halls which have a decrease in water use during the summer months due to reduced occupancy levels, CKC greatly increases its water use in the summertime.

Units 1, 2, and 3 have only minor irrigation needs. Before construction on the new Unit 2 Residence Hall began in

Table 5.4 Upgrading Unit 3 Toilets Could Save Over $16,000 a Year

# of toilets	Labor Cost $250/toilet	Hardware costs $150/ toilet	total costs	annual water savings CCF	$ annual savings	payback period Years w/ EBMUD credit	payback period w/out EBMUD credit	avoided costs after ten years
162	40,500	24,300	64,800	4,815	**$16,371**	1.75	3.96	**$163,710**

Assumptions
Hardware and labor cost per fixture are $250 + $150 / Toilet
920 students
Water and Wastewater costs are $2.37 and $1.03 respectively

Table 5.5 Unit 3: $7,113 a Year Savings From Installing Low-Flow Faucet Aerators

	Where We Are Now	Where WeCould Be	
Rated Flow Rate	2 gpm	1.5 gpm	0.5 gpm
Actual flow rate	1.2 gpm	1.0 gpm	
gallons/day	8,942	7,452	3,726
CCF/year	3,587	2,989	1,494
$ cost/year	12,194	10,162	5,081
Unit 3 Potential Savings		**$2,032**	**$7,113**

Assumptions
* Actual flow rate is lower than marked flow-rate
** total includes 17 unknown faucet flow rates
*** user rates based on industry standard of 8.1 minutes/person/day
****Water and wastewater costs are $2.37 and $1.03 respectively
***** Does not include additional savings from reduced energy costs
Students: 920, Faucets 160, 0.5 gpm aerators are free from EBMUD

2002, Unit 2 irrigated its landscape every night. Irrigation was discontinued during construction (Mr. St. Hill, 2004). After two years, the plantings were observed to have turned only slightly brown during the summer. Because of this outcome, irrigation could be done on a much more limited schedule in the Residence Halls.

Unit 3

Unit 3 is located at 2400 Durant Avenue and houses approximately 920 students in its four towers, Ida Sproul, Norton, Priestley, and Spens-Black Halls. In 1992 (or 1994), a fifth building, Cleary Hall, came on line. Clearly Hall has a separate water meter and is across the street form the traditional Unit 3 towers. In this analysis it will be considered separately from Unit 3. In 1988, major renovations took place in Unit 3. Low-flow 2.5 gpm showerheads were installed (Bailey, 2004). However, the toilets were not replaced. The flush-valve kits for the toilets in Unit 3 are 4.5 gpm.

Unit 3 uses approximately 19 gallons more water per student per day than Units 2 during the fall and spring semesters of 2000 (Figure 5.4). Unit 3 has it own dining hall, and therefore its per capita water use profile must be compared to the Unit 1 and 2 before the closing of their dining halls in 2003 and 2002 respectively. The primary reason for the increased water use and utility bills for Unit 3 Residence Hall is the result of having 4.5 gpf toilets vs. 1.6 gpf. One floor of each hall was carefully audited. Some toilets were identified as damaged and partially disconnected from the walls. In addition, at least one toilet was leaking from its handle and losing substantial amounts of water when flushed.

Unit 3 could save 5,457 hundred cubic feet of potable water a year and $16,371 dollars by upgrading to low-flow toilets (Table 5.4). In addition, UC Berkeley would qualify for a $36,114 credit on its utility bill from EBMUD, if they guaranteed to reduce their water consumption by 4,815 CCF , through their toilet upgrade incentive program (Muir, EBMUD). Given hardware and installation cost of $450/toilet ($72,900 output cost), and the EBMUD credit, Unit 3 would have a payback period of 1.75 years (Table 5.4).

The Unit 3 faucets had an average flow rate of 2.0 gpm. If all the faucets were replaced with 0.5 gpm faucets, Unit 3 would save approximately $15,000 dollars a year (Table 5.5). This does not include the additional savings from reduced energy cost. Replacing the faucets would save 4,483 CCF per year.

Unit 4

Unit 4 includes the Foothill, Bowles and Stern Halls. Foothill's toilets are 3.5 gpf tank toilets, although they use water conserving flush-valve kit parts to reduce each toilet's water use to 2.5 gpf. The showers are all 2.5 gpm. Bowles was built in 1929, and while having beautiful architecture it has a very old plumbing system. Currently it houses 192 male students. Stern Hall is also quite old and contains an old sewer system. It currently houses 267 female students. Both Bowles and Stern have high flow rate water use fixtures. Due to the age of the plumbing, careful examination should be done before replacing the toilets with low-flow fixtures. Some old plumbing that has very little grading requires re-grading of the pipes when moving to low flow toilets.

The Unit 4 building manager has complained about the increased rate of flapper deterioration due to the addition of chloramines used in all water supply by EBMUD potable water. There is a need to look into buying a new type of flapper with a deterioration rate that is unaffected by the presence of dissolved chloramines.

Unit 5

Unit 5 includes the Clark Kerr Campus (CKC) and Smyth-Fernwald Apartments, all of which are on the national register of historic buildings. CKC was originally built in 1867 as the location for the California School for the Deaf and the Blind. The existing buildings at this site were built between 1920 and 1950. UC Berkeley bought the property in 1982. The site is comprised of 50 acres with beautiful grounds that require extensive irrigation, 26 residential classrooms, and a variety of support buildings. Eight Hundred and forty students live on CKC during the academic year.

CKC campus has a very old physical infrastructure. The toilets, showerhead and faucets are quite old, and the toilets could use anywhere from 3.5 to 7 gpf. The master plan for the complete renovation of CKC will start in Spring 2005, with renovations expected to begin in 2006. However, this target date may be optimistic, as renovations have been planned for the last ten years, and have continuously been postponed.

CKC has an extensive landscape to irrigate but does not have a separate irrigation metering system and, therefore, it is impossible to accurately determine how much water is being used for irrigation. In addition, EMBUD cannot offer any financial rebates for improving irrigation water use efficiency, unless a separate irrigation meter is installed. EBMUD does have financial incentives programs to assist in the purchase of irrigation meters.

Residence Hall Conclusion and Next Steps

The water audits results for the Residence Hall I, 2 and 3 identified that UC Berkeley could potentially save $47,763 dollars a year through installing low-flow faucets, performing toilet maintenance and upgrading Unit 3 toilets (Figure 5.7). This corresponds to 14,047 CCF a year (28,789 gpd). This is enough water to supply 637 people's indoor water use in a water conserving home (45.2 gallons/person/day).

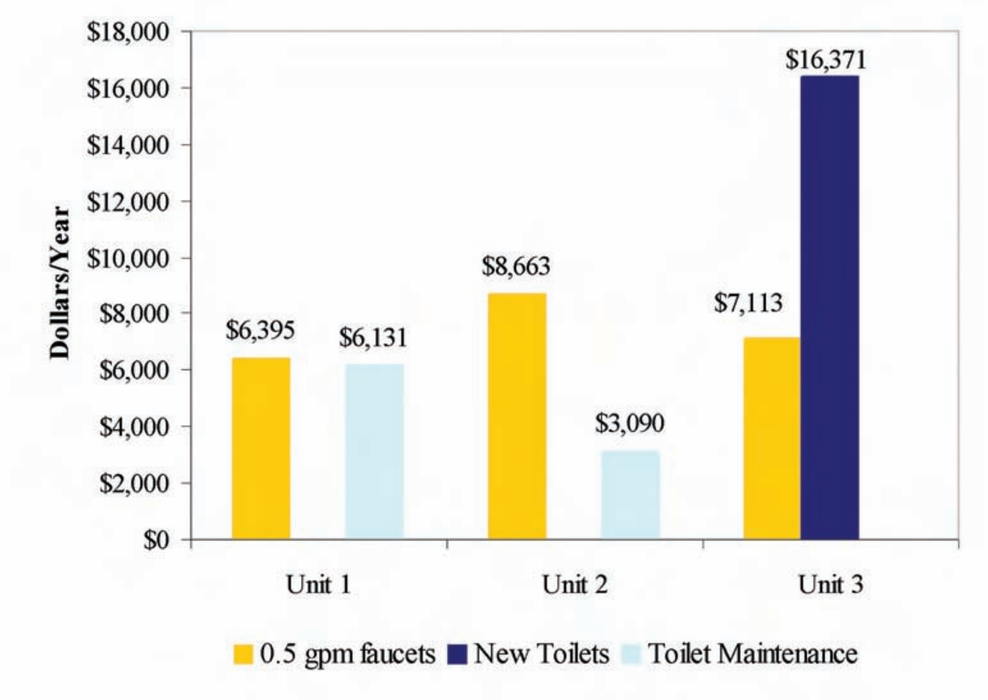
The water audits results indicate that there would be $22,170 a year in savings from installing 0.5 gpm low-flow faucet in Residence Halls 1, 2 and 3. EBMUD is currently providing the aerators free to its customers who agree to install them. As a result of the water audit, Housing Service has agreed to the low-flow aerators in Units 1, 2 and 3. The aerators have been delivered to housing maintenance, and they are waiting for the water strainers to be cleared before installation. The water strainers need to be cleared so that the buildup of dirt will not block the flow in the aerators. Next steps will be to evaluate the performance and the reduced water bill from the installation of the low-flow faucet aerators. EBMUD was able to install a water sub-meter on Duetsch Hall (one of the Unit 2 towers). It is hoped that someone will be able to read the meter for approximately three weeks, then install the aerators in Duetsch Hall and measure the corresponding water reduction. However, the sub-meter is not always able to work and is currently being tested for accuracy.

A detailed restroom water audit of Units 1 and 2 identified that 49% of the Unit 1 toilets and 24% of Unit 2 toilets were leaking. Regular maintenance could reduce Unit 1 and 2 water and wastewater bill by $6,125 and $3,073 dollars a year. In the summer time, Housing Services will be obtaining their own plumbers, and will no longer be paying the main campus a recharge rate for using the main campus plumbers. It is recommended that at that time Housing Service develop a toilet maintenance program.

Replacing Unit 3 4.5 gpf toilets with 1.6 gpf toilets would save $16,324 a year. In addition, EBMUD will provide a $36,114 rebate for upgrading the 162 toilets. Bob Jacobs, the director of Housing Services, signed a contract to begin the process of applying for the rebate prior to upgrading the toilets. However, he is retiring, and it will be up to his replacement to initiate the toilets replacement project. Unit 3 will be closed for renovations this summer, and this provides the perfect opportunity to upgrade Unit 3 restrooms.

It would be valuable to combine technology upgrades with education campaigns that would affect behavior. The technological upgrades such as the replacement of faucet aerators and flush-valve kits, combined with an education campaign to reduce shower times and turn off the bathroom faucet when brushing teeth and or shaving, would increase utility and water savings. Combining resource conservation education with lower utility bills serves the students both as a learning opportunity and through mitigation of rent increases due to rising costs of water and wastewater treatment. The infrastructure for student education is already in place with the Student Sustainability Coordinators program. Each residence hall has its own

Figure 5.6 $47,763 and 28,789 GPD a Year in Savings From: Low-Flow Faucet Aerators ($22,170), Units 1 and 2 Toilet Maintenace ($9,198) and New Toilets for Unit 3 ($16,371)



student sustainability coordinator, whose job includes providing education about issues relating to sustainability, such as recycling, energy consumption, purchasing choices, and water consumption behavior.

Education and signage could teach the students to report leaking faucets and showers, and toilet damage/malfunction. If successful, an education program would help identify excess water use from water using fixtures when they occur in stead of having to wait for annual inspections. Students in the residence halls do not directly pay their utility bills, but many of them care about their environment. Having a sign in the bathrooms adjacent to the faucets and in the showers that relates their water use to the Mokulmne River watershed and the availability of water for aquatic ecosystems, could be a daily reminder of why water conservation is important.

Another possible action that could be taken is to add “water wars” to the existing “energy wars” among the dormitories. Having prizes for the residence halls that are able to best decrease their water use would also encourage conservation behavior. Unit 1 and 2, whose infrastructure is almost the same, could directly compete against each other for total water consumed per student per day. For Units 3, 4, CKC, no direct comparisons can be made to each other; instead one could measure only a percent decrease.

While it is hoped that there will be a one-time fix in response to the audit results, it is important to note that if lasting water savings are to be realized, it is critical to institutionalize knowledge and increase student interest and support for any initiative. Student involvement is likely one of the best mechanisms for institutionalizing the practical applications of sustainability at UC Berkeley. The students have a tremendous amount of energy and enthusiasm. They learn by doing, and can help UC Berkeley achieve its goals of minimizing water consumption and wastewater production

Chapter 6: Case StudiesWater Conservation and Reuse with New Development and Major Renovations

Reducing New Building Water Use by 30% LEED WE Credit 3.1 and 3.2

The following case-studies are examples of buildings and laboratories that have achieved the LEED points for water efficiency (WE) credit 3.1 and 3.2 (20% and 30% reduction in water use, respectively) and WE credit 2.0 innovative wastewater technology. They demonstrate how new buildings can cost-effectively minimize water consumption and wastewater production. These case studies of buildings that have successfully reduced their water use by at least 30% provide concrete examples of how UC Berkeley new buildings can also reduce their water use 30% below standard buildings of comparable gross square feet and building occupancy level.

Buildings can reduce their water use by 30% over a conventional building through using currently available cost effective technology. The following actions, alone or in combination, can be sufficient to receive the LEED points for 20 and 30% reduction in water use: (1) low flow toilets (1 gpf), (2) Duel-flush toilets (0.8 and 1.6 gpf, depending on which button you push), (3) waterless urinals, (4) low-flow faucets (0.5 pgm) and automatic or push-rod (short duration) faucets.

Third Creek Elementary School

Third Creek Elementary School is located in Statesville NC, and opened in August of 2002. The school is a 92,000 sq. feet, one–story building, certified LEED Gold (39 points). The school qualified for both credit WE 3.1 and 3.2, water use reduction (20% and 30% reduction, respectively).

According to Rob Jackson, building supervisor, the 30% water use reductions was the result of the following factors. All toilets were 1-gallon/flush toilets. There was sufficient pressure (80 psi) to not yet have any problems with clogging. Waterless urinals were installed (Waterless No-FlushTM urinals, brand). In the two years since the school has opened they have had no maintenance problems, and have been so satisfied that they would like to put waterless urinals into all new school buildings. They also installed low-flow 0.5 pgm push-rod faucets. The faucets stay on for 3 to 5 seconds before the water turns off and the rod needs to be pushed in again to obtain more water.

Pennsylvania Department of Environment Protection's Cambria Office

The Pennsylvania Department of Environmental Protection Cambria office is a 36,000 sq. feet building completed in 2000. The two-story office building was certified LEED Gold (45 points). The school qualified for both credit WE 3.1 and 3.2, water use reduction.

According to Tammy Ford-Hanna, building facility manager, the 30% reduction below title 24 expected water use levels was achieved through the combined effect of waterless urinals, and push rod faucets which are on only when pressure is applied. There are many more men then women in the office and, therefore, the waterless urinals (Waterless No-FlushTM urinals, brand) had an even greater reduction in water use then an equally mixed gendered building. They have had no problems or complaints with the waterless urinals.

DPR-ABD Office Building DPR Construction, Inc.

DPR-ABD Office Building DPR Construction, Inc. in Sacramento, California was certified LEED Silver (37 points). The DPR office building qualified for WE credit 2.0, 3.1, and 3.2 innovative wastewater technology. The DPR office was able to reduce their wastewater production by 45% (Greener, 2004). This was achieved through the installation of waterless urinals (Waterless No-FlushTM urinals, brand). Dual flush Caroma toilets were installed. One button flushes only 0.8 gpf and the other flushes 1.6 gpf, depending on what is necessary. The estimated average flow rate for the toilets is between 1 to 1.2 gpf. Standard faucets were installed.

The Caroma Australian toilets have not had any clogging issues. However, the button that must be pushed can only be done with one finger, vs. the whole hand, and requires a bit of pressure. Some of the women have complained about the pressure necessary to flush, and the difficulty to press the button with fingernails. DPR has talked to the manufacture and they will be coming out with a new model that allows one to use the whole hand to activate the flush mechanism. Another complaint has been that because the toilets are tank toilets, it takes a few minutes to refill after being flushed, and when the toilets are in high occupancy usage, users can get frustrated and keep on flushing (which only compounds the problem). In addition, since the toilets were not made in the United States, the issue of whether the toilets were ADA complaint had to be negotiated. The dual-flush toilets are about $100 above a traditional toilet costs.

Permission to install the waterless urinals was quite a challenge. California state code currently does not accept nor prohibit waterless urinals. Sacramento city code also did not explicitly accept nor prohibit waterless urinals. It took many hours of negotiation to receive permission to install the first waterless urinals in Sacramento in the DPR office building. Legislature needs to be proposed in California that would allow waterless urinals to be compliant with state codes and preempt any local code that does not allow waterless urinals.

Waterless Urinals

Not all waterless urinals are the same in performance and maintenance costs. Based on extensive interviews with facility managers and plumbers at UC Santa Barbara, Cal State University Northridge, Cal State Hayward, UC Los Angeles and the City of Santa Monica, the following issues were identified. The most important issues to consider is not the cost of purchasing the urinals, but the cost of the maintaining the urinals, and the ease of fixing problems when and if they occur.

One important consideration is the costs of the cartridges. The two major brands being used at many of the UC/CSU schools, Sloan/Falcon and Waterless, have significantly different costs for the cartridges, $35 vs. $7, respectively. The Waterless brand urinal sells a seal which can be added to extend the life of the cartridge, whereas with the Sloan/Falcon unit, the whole cartridge needs to be replaced. Therefore, the Waterless brand cartridges are not only much less expensive, they also have a tendency to last longer.

The other major issue to consider is the ease of fixing problems when they occur. The Sloan/Falcon urinals only have a ¾ inch connection to the drain, and therefore it is not possible to pull the cartridge out and fit a snake down to fix any clogging problems. The plumber has to pull the Sloan/Falcon urinal off the wall to fix any problems. The Waterless urinals are much easier to unclog because they have a 2-inch connection, which allows the cartridges to be pulled out and a snake to be fit into the pipe.

In addition, all those interviewed stressed the importance of training janitorial staff both before the urinals are installed and again a month or two after installation. This is because the janitorial staff will make or break the user acceptance of the waterfree urinals. If the cartridges are changed when needed, no odor problems occur. However, if the janitors are not trained to recognize when the cartridges need to be replaced, the urinals will smell and not be accepted by the users.

Laboratories Water Conservation

Laboratories are the most water intensive buildings on the UC Berkeley campus and are estimated to use an order of magnitude more water per gross square feet (LRDP, 2005). In addition, UC Berkeley is planning to build 700,000 gsf of new campus laboratory space by 2020 UC. The following examples are successful strategies that other laboratories have used to reduce their water. They provide concrete examples of strategies for UC Berkeley to pursue with their new laboratories to meet their goal of minimizing water use and wastewater disposal.

Kansas City Science and Technology Center

The Kansas City Science and technology center captures rainwater. The captured reclaimed water is then used for toilet flushing, make-up water for the cooling tower, and outside irrigation. Pipes are connected to the roof and to a 1,500-gallon settlement tank. After the sediments settle, the rainwater is pumped into a 10,000-gallon storage tank outside the building.

A sump-pump pumps the water to the toilets, the cooling towers, and to the outside irrigation system. The rooftop rainwater recovery system is estimated, based on LEED calculations, to reduce domestic water use by 50% and save 735,000 gallons a year. The rainwater harvesting system reduces site runoff by 40%.

Emory University, Atlanta Georgia
Whitehead Biomedical Research Building at Emory University

The building captures and stores 70,000 gallons of rainwater. The captured rainwater decreases storm water runoff and allows the runoff to be used for used for outside irrigation. The building has a condensate recovery system that pumps the condensate from the air-conditioning system to the cooling towers to be used as make-up water. The condensate recovery system saves approximately 2.5 million gallons a year of water.

The Whitehead biomedical research building houses very expensive mice.

(In fact, the 150,000 mice are worth approximately 150 million, which was more then the cost of the entire building.) Mice cages must be cleaned. However, a common problem in mice care is that tech workers develop extensive allergies to the mice after working with mice for some time. In order to decrease worker exposure to mice, the whitehead Biomedical building has robots clean the cages. One robot picks up the cage and dumps the bedding out. The cage is then washed multiple times. A second robot puts new bedding in the cage. The system is quite water efficient because used wash water is re-used on the next cage. For example, the finale wash water from cage one is used as the second to last wash water for cage 2.

Math and Science Center at Emory University

Emory University installed a closed-loop cooling system for the physics department equipment. The cooling water is re-circulated as make-up water for the chiller. This system saves approximately 2.8 million gallons a year. Although the payback period was more then seven years, the chief financial officer said that regardless of the payback period, it would be a travesty to waste that much water. The payback period was seven years only because water is so inexpensive in Atlanta, Georgia. As the price of water and waste disposal continue to rise, and the price for the water conserving systems decrease, the financial incentives for installing these systems will continue to increase. In general, Emory University strives to implement any green initiatives in their new developments that have payback periods of less than five years.

Water Efficiency LEED WE Credit 2.0: Innovative Wastewater Technology

It is also possible for each of UC Berkeley's new buildings to recycle and reuse it own graywater or blackwater. The renovations of CKC or the New Hass/Boalt building could provide a perfect opportunity to recycle and reuse the shower water for the extensive ground irrigation. Currently, the City of Berkeley plumbing codes are in the process of being redone to allow permitting of graywater (Hollbacher, 2004). Although UC Berkeley likes to, but is not required to, follow city code, the university is required to follow state code, which does allow for graywater recycling. Furthermore, past State Architect Sim VanDeer, a graduate from UC Berkeley would likely write a letter on behalf of UC Berkeley asking for permission to install a graywater system.

There are many grants available for such innovative onsite water recycling programs (see chapter 7). Funding would be essential as the initial installation cost, relative to the cost of water and wastewater disposal, are still not yet extremely cost-effective. However, as the cost of water and wastewater disposal increases, these systems will have much shorter payback periods. In addition, it could bring together the Staff, Faculty, and Students in a real work design and build project. Under the supervision of a hired consultant, a design team could be put together made up of students and faculty from the environmental engineering, landscape architecture, architecture, public health, and business departments. This could be an incredible opportunity to use the extensive knowledge base in the faculty and students of the University to make a truly beautiful, ecological and economic system that purifies and reuses graywater and wastewater systems. The following examples are of building that successfully recycle and reuse their own graywater and or blackwater.

The Solaire Apartment Building in Battery Park, New York

The Solaire is a 27-story, 357,000 square feet residential apartment building located in Battery Park, New York City. It was completed in 2003 and is certified LEED Gold (41 points). The apartment building recycles 100% of its wastewater on site, and it uses the recycled water for toilet flushing, make-up water for the cooling towers, and the extra 5,000 gallons a day is used to water the neighboring park landscape. The 25,000-gallon purified recycled water storage tank, as well as the water-recycling infrastructure (collection tank, anoxic chamber, aerobic chamber, filtration pumps, UV and Ozone treatment), is located in the basement. In addition, roof rainwater is collected, stored in 10,000 gallons container and reused to irrigate the gardens on the 1st, 17th and 27thg floor.

The Solaire wastewater recycling system is owned and operated by Applied Water Management (AWM). Applied Water Management owns, builds and maintains each system (Clerico, 2004). The systems are self-contained units, but as development increases, more units can be added. The monthly and annual maintenance costs decrease with additional units. The labor cost for the first system is relatively high, but decreases for each additional system installed in the same proximity. The economy of scale encourages the units to be used for a cluster of buildings vs. each individual building. The Solarie currently only has one unit, but more are expected as additional buildings are built. This was the first system to be used in an urban city in which the system was not installed due to the unavailability of a sewer system. Such systems have been used previously due to the unavailability of a sewer system. The Solarie is a test case for other buildings and development in New York City (Mr. Clerico, December 2004).

Total installation costs vary depending on the whether the space is part of the building, or whether an inexpensive adjacent utility building can be built. The price typically fluctuates between $15/gallon and $100/gallon (375,000-2.5 million for 25,000 gallons/day). The Solarie's current annual maintenance cost is approximately $75,000 a year and requires approximately 15 square feet for a 25,000-gallon a day system (Clerico, 2004). The total installation and maintenance cost is typically 1 cent/gallon. New York water is relatively inexpensive, approximately 0.4 cents per gallon (Clerico, 2004). However, a New York State Green Buildings Tax credit helped to make the system more economically viable. The Solaire building received $2.8 million over five years for the assortment of green building features. Their water-treatment system cost about $1 million dollars. They have not yet been able to calculate the payback period.

The systems are expensive to install but have a life span of 25-50 years. As the technology improves and the price of the membranes is reduced, at the same time as the price of water and wastewater charges increase; the economics of the system will become more feasible and profitable. As the City of New York acknowledged with its tax credits for the water-treatment system, it is in the municipality's best interest to hold water and wastewater production steady, even as the city grows, in order to avoid the additional expensive of building new wastewater treatment faculties. It is not quite yet in the developer's best interest, and the payback period remains greater than five years.

One of the best aspects of the applied wastewater management project, according to Mr. Clerico, is the acceptance of the tenants for using recycled water. The health department of New York, as well as other officials, thought that the high-end residents of the apartment building would be unhappy using recycled water. However, this is not the case. Most residents accepted the system without question, and some even speak with pride about the water recycling system.

NRDC Office Building in Santa Monica CA

The NRDC office building in Santa Monica, CA, was able to reduce its water use compared to conventional buildings by 50% (http://www.nrdc.org/media/pressrelease/031113.asp). The water use reduction was accomplished via a combination of water-efficient fixtures (dual-flush toilets, waterless urinals and high-efficiency dishwashers) and capture/use of stormwater, rainwater and graywater for toilet flushing and landscape irrigation. The water reuse system is an Equaris Infinity System, which uses a multi-stage filtration system with reverse osmosis and ozone disinfection. Purified water is produced at about ½ cent per gallon. The system maximizes the efficiency of its reverse osmosis filter. Typical filters reject about 3 gallons of water for every gallon produced, however, this system recycles the concentrate back into the system and rejects the water only when it exceeds a high threshold.

David L. Lawrence Convention Center in Pittsburgh, USA

The David L. Lawrence Convention Center in Pittsburgh, USA has a graywater system that recycles and saves 50% of the convention center's water. The graywater is used for toilet flushing and irrigation. The graywater is purified by an aerobic digester and submicron filtration systems followed by ultraviolet light. The graywater system is estimated to save 6.4 million gallons a year, enough water to supply 132 Pittsburgh households per year.

Adam Joseph Lewis Center for Environmental Studies, Oberlin College

At Oberlin College, the Adam Joseph Lewis Center for Environmental Studies was the result of an idea developed by students in a course at Oberlin College. The building brought together two influential members of the environmental and sustainability movement. The client was environmental educator David Orr, and the architect was William McDonough. Among other green features, the building has a living machine that treats wastewater to a tertiary standard. A living machine is a solar powered micro-based ecosystem that purifies wastewater. Its primary source of energy is from the sun, and it has a diverse assortment of bacteria, algae, bacteria, snails, fish and flowers that work together to break down and digest pollutants. The living machine not only purifies the building's wastewater but also educates students, faculty, staff, and visitors about natural wastewater treatment processes, and also provides research opportunities for the students.

Next Steps

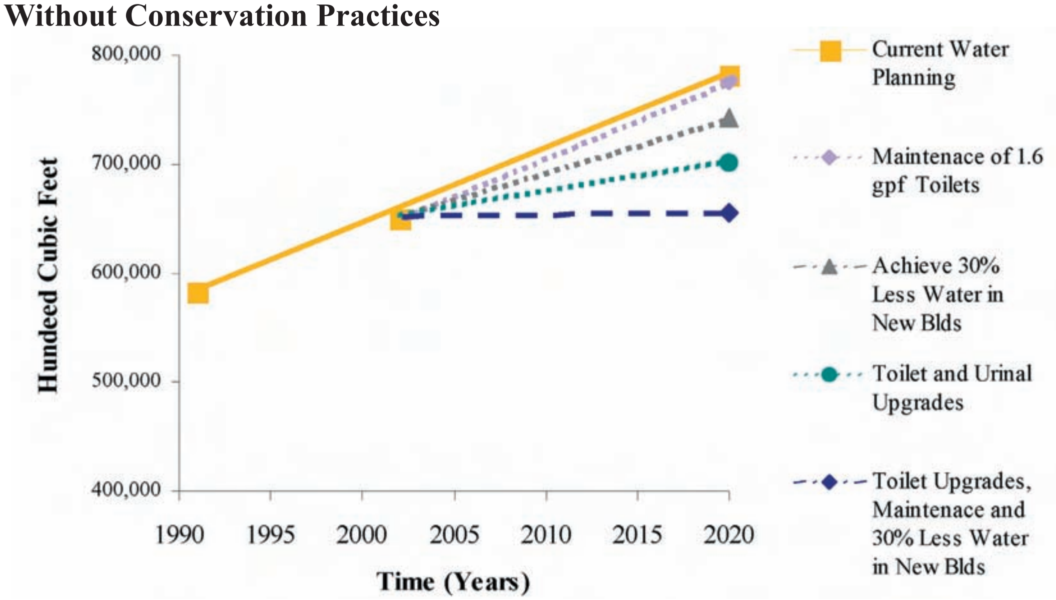
The case studies show examples of how other institutions were able to achieve 30% reduction in new buildings water use, recycle their own wastewater and reuse laboratory water. These case studies illustrate concrete examples of facilities that were able to achieve substantial water savings. These case studies can be a valuable resource as UC Berkeley looks to formulate a plan for how to meet its goals of minimizing water consumption and wastewater production. The facility managers, architects, planers, project managers, plumbers, janitors and others who worked in these case example buildings, can provide answers to question UC Berkeley might have on how to implement best management practices utilized by these other institutions.

Chapter 7: Conclusion

The University of California at Berkeley has taken the important step of forming a policy specifically calling for minimizing water consumption and wastewater production, but has not yet developed specific strategies for achieving these goals. This report provides cost-effective actions that UC Berkeley could take to achieve its goals of water conservation. The water audit conducted of main campus restrooms has shown the potential for UC Berkeley to reduce its water consumption and wastewater production by 13% (60.7 gallons a year) through improving restroom water use efficiency, through actions such as replacing older toilets and urinals, and conducting annual maintenance of restroom water using fixtures. These actions would result in over $235,000 dollars in reduced utility spending, with a payback period of 4.2 years. The subset of the residence halls audited show a potential to save 28,789 gallons a day and over $47,000 dollars a year from toilet maintenance and low-flow toilet replacements, with a payback period of only 3.4 years. This report also showed the steps UC Berkeley would need to take to build new buildings that use 30% less water than a "conventional" building of the same size, function and occupancy level. If UC Berkeley chooses to improve its restroom water use efficiency as well as reduce new building water use by 30% on the main campus, it will save $366,000 a year in water and wastewater charges, based on the planned development through the year 2020, and maintain its current water use levels even as it expands and grows. This would provide enough indoor water use for 4,000 residents in the Bay Area.

The following recommendations are concrete steps UC Berkeley could take to cost-effectively achieve its goals of minimizing water consumption and wastewater production.

Figure 7.1 UC Berkeley Main Campus Potential Water Consumption in 2020: With and Without Conservation Practices



Next Steps

Two concurrent events provide a perfect opportunity for improving restroom water use efficiency. The first is that the Residence Halls, which currently pay UC Berkeley for the use of their plumbers, will be hiring their own plumbers this fall. Therefore, there will be at least one full-time plumber, who is currently working at Albany Village, who will be without work and without a department to charge his time to. This plumber will have the time to improve restroom water use efficiency, and could be supported on the savings from reduced utility bills. Secondly, the new ADA-compliant bathroom program is the campus' first program to systematically look at the bathrooms on campus. This provides the opportunity to cost-effectively integrate restroom water use efficiency in with the ADA-compliant program.

Develop a program for replacing older non-conserving toilets and urinals:
UC Berkeley currently has had no systematic plan or policy to identify and upgrade older non-conserving water use fixtures such as toilets and urinals. They are currently upgraded only when they break and no longer function. This report shows the significant water savings and cost-effectiveness of replacing the older non-conserving toilets and urinals (see chapter 4 for specific numbers and payback periods).

Develop a toilet maintenance program:
UC Berkeley currently has no toilet maintenance program. However, many toilets can leak and waste substantial amounts of water without the problem being visible to the user and/or a problem being reported. There is an opportunity to save substantial amounts of money with payback periods of under a year from instituting a toilet maintenance program (see chapter 4 for specific numbers and payback periods).

Dedicate a plumber for improving restroom water efficiencies:
When the residence halls obtain their own plumber in summer 2005, evaluate dedicating the available plumber to improving restroom efficiency. The resulting savings would more than compensate for the plumber salary and still provide additional savings to the University.

Incorporate a toilet and urinals replacement program with the new ADA compliant bathroom program:
The new ADA-compliant program is upgrading the main floor bathrooms in buildings with major auditoriums to be handicap accessible. At the same time that the handicap accessible toilet conversion is being done, UC Berkeley should consider upgrading the whole bathroom with water efficient fixtures, as well as consider upgrading the additional bathrooms in the entire building. If these two programs are combined, additional funding would be available to meet the goals of making all bathrooms handicap accessible and of reducing UC Berkeley water use and utility spending. The university should make sure to apply for rebates from EBMUD when upgrading restrooms for the ADA compliant bathroom program.

Partner with EBMUD:
The EBMUD water conservation department is available to help UC Berkeley meet its water conservation goals. They have water conservation experts who will conduct free water audits to identify cost-effective mechanisms for UC Berkley to reduce its

water use. A partnership with EBMUD will provide help to conduct comprehensive water audits, as well as receive rebates for implementing water conservation measures. The lack of utilization of the free resources available from EBMUD is one of the greatest unutilized opportunities available to UC Berkeley.

Achieve 30% reduction in water use for new Buildings:
Any steps that UC Berkeley can take to design and construct new buildings with reduced operation and maintenance costs will provide a long-term benefit to the University over the 50-100 year lifetime of the building. Many buildings achieve 30% water use reduction from installing waterless urinals and automatic low-flow faucets (see chapter for 6 for many case examples of how a 30% reduction in new buildings water use can be achieved).

Test waterless urinals in the next new building or bathroom renovation project:
UC Berkeley should conduct its own test using the two or three prominent waterless urinal brands (Waterless and Sloan/Falcon, as well as possibly a cartridge-free brand of urinal), and compare their performances with conventional urinals. Have the plumbing and janitorial staff evaluate the performance of the urinals.

Add specifications for waterless urinals to UC Berkeley construction and design standards:
Have the janitors, plumbers and project managers test out and decide on the best performing waterless urinals for the UC Berkeley campus. Add the specs for waterless urinals to our construction and design standards and mandate the use of waterless urinals as a part of any new building project.

Laboratory Specific Recommendations:

Conduct a water audit of the six buildings that consume 21% of the water used by the main campus:
Six labs (VLSB, LSA, Latimer, Koshland, Cory, and McCone) use 21% of the water for the main campus. A water audit should be conducted to identify the potential to reduce these buildings' water consumption, such as eliminating once-through cooling water (such as in Cory Hall), and optimizing multiple-pass cooling systems.

The life-cycle analyses of reduced operations cost should be included in the overall decision of cost-benefit for laboratory renovation:
It has been said that donors will never give money for maintenance; however, they might give money for sustainability, resource conservation, and green design. The funding pitch should be for resource conservation, and such funds can legitimately be used to fund the renovations that result in resource conservation such as elimination of once-through cooling in older campus laboratories.

Achieve Labs21 credit 4.1 metering of process water:
UC Berkeley needs to meter process water to know (1) which process is the most water intensive (2) if water conservation measures were successful.

New laboratories should be built with flexibility to allow easy hook-up of new equipment to the cooling towers:
Although new labs are water-efficient, new equipment is commonly installed with once-through cooling. Due to the changing nature of science research, departments often get new equipment. Sometimes it is easier and less expensive for departments to hook up their new equipment to an industrial water line than to fill out a service order and pay for the equipment to be hooked up to the cooling tower. Because the departments do not pay their own water bill, there is no financial incentive for departments to make sure to hook up new equipment to the cooling tower.

Water Metering and Education of Campus Water Users

Providing building occupants with monthly water use data:
Currently, no feedback on building water use is provided to the building occupants. Departments and building users currently do not see their water bill nor pay for it. The first step to resource conservation is providing consumers with the knowledge of their resource consumption levels. Over the last year, an experiment was started to show occupants in three buildings their energy uses on a monthly basis. Simply showing the building occupants their energy use resulted in behavioral changes that lowered their energy consumption by 10%. The six laboratories that constitute the major water users on campus provide an ideal opportunity to see the results of behavior modification that could be realized from providing them their water use information. It would be beneficial to include water use information in the overall energy use information program. If the program is already in the place, the additional work will be minimal to include water consumption values along with the energy consumption values, and the potential savings could be significant.

Provide real-time water use data to buildings, as well as staff resources to analyze the data in order to quickly detect leaks when they occur:
Physical Plant is working on adding real-time building water meters to the process automation monitoring and control system (SCADA). This will eventually allow real-time-water data to be tracked. Currently, there is not enough staff to verify all the monthly water readings. Therefore, in order for the real-time water meter information to be useful to decrease water use, funds must be made available to dedicate personnel to analyze the real-time water data.

Add the real time water data and real-time water savings to a publically accessible web page:
Currently, monthly building water use is available from a web page that can only be accessed from an on-campus computer. The information does not currently come up in searches on the UC Berkeley website nor is the availability of the information publicized at all. Allow access to building water use data from off-campus computers, make sure the information comes up in searches, and verify the monthly readings for accuracy.

Post signage:
Post water conservation stickers that explain the importance of conserving water and

relate water use to environmental protection in the dorms and laboratories. Target signage in the residence halls to reduce shower time and to turn off faucets when brushing one's teeth. For residence halls, consider sponsoring "Residence Hall Water Wars", giving prizes to the units that have the greatest percentage decrease in water use. In the laboratories, show monthly water use data and comparisons to other comparable laboratories to give water users data on whether they are conducting good practices or not. Include signs or stickers in the bathroom with contact information to report broken/leaking toilets, urinals, and faucets.

Develop Campus Water Conservation Goals, With Supporting Policy and Practices

Although implementing UC Berkeley water use efficiency programs is cost effective, cost effectiveness is not always enough sufficient for the actions to be implemented Achieving water conservation will require a sustained on-going commitment that water conservation is an important goal to achieve, similar to the green building policy that calls for a 10% reduction in energy use. A sustained effort to reduce UC Berkley water use will require both a top-down and grassroots commitment from UC Berkeley staff, faculty and students.

Ensure that those who do the work receive some of the benefit

In order to implement programs to achieve these goals, incentives must be placed to ensure that those who pay the costs for implementation will also receive some of the budgetary benefit. One substantial challenge to implementing and sustaining water use efficiency is the disconnect between the people who perform the labor (such as fixing leaking toilets), the people who pay for the parts, and the people and organizations which benefit from reduced water and wastewater bills. For example, a comprehensive toilet maintenance and toilet replacement program would require many hours of the UC Berkeley plumbers' time and but the benefit would be a reduction in the utility bill paid by a separate division. The water conservation program should be set to provide some benefit for those who do the work, such as billable time, budget reimbursement/offset, or some other tangible benefit.

Make sure to allocate a change in budget when water conservation measure decrease spending for one unit but increase spending in another:

When UC Berkeley installs waterless urinals, whose budget will pay for the cartridges? Does it come out of the utility budget, plumbing budget, or janitorial budget? These are important issues when considering installing waterless urinals. If, for example, the cleaning crew who change the cartridges are responsible for buying the cartridges but do not get an increase in their budget to accommodate this expense, this creates problems with getting buy-in for maintenance of the urinals, and could thereby potentially cause the waterless urinals to be unsuccessful for reasons that have nothing to do with the technical functionability of the new technology.

Reinvest some of the money saved into continued resource savings activities:

In order to sustain UC Berkeley resource conservation efforts, a percentage of the reduced utility spending should be allocate to a revolving fund to finance continual resource efficiency upgrades. Creating a revolving fund will continue to finance conservation measures which in turn will continue to lower UC Berkeley utility spending.

Outside Funding Options:

Apply for Rebates from EBMUD:
EBMUD offers utility rebates to bring low flow (1.6 gpm) toilet replacement programs for flushometer toilets to within a two-year payback period, as well as offering $25 per toilet for replacing high water use tank toilets. UC Berkeley is not currently taking advantage of these programs. For example, Foothill residence hall has replaced a number of their 3.5 gpf tank toilets without requesting a rebate from EBMUD. In addition, when the bathrooms in the main campus have been upgraded in conjunction with major renovations, there has been no effort to receive a credit from EBMUD. EBMUD also offers rebates for irrigation meters and building meters. As UC Berkeley moves to real-time building water metering, it should approach EBMUD for help with funding.

Another opportunity with EBMUD is a potential new pilot program that may be available in 2005. The program is called "pay as you go" (**Leann Gustafson, 2004).** As this report went to press, this plan was being requested in the EBMUD budget. Even if it is not approved, a partnership with UC Berkeley before EBMUD's next budget cycle could guarantee funding for this project. In this pilot program, EBMUD pays for the initial hardware cost of installing water efficient fixtures. The residence, industry, or institution then pays their regular monthly utility bills or slightly higher bill until the hardware costs have been completely paid back, at which time their utility bill is reduced to reflect their current water use. This program is a win-win for all parties. The customer, UC Berkeley, obtains the initial cash for upgrading to water efficient fixtures, uses the cost savings from reduced water usage to help provide the money for the monthly payback to EBMUD, and then realizes the on-going savings on utility bills after the payback period.

Partner with the California Urban Water Conservation Council (CUCWCC):
Other avenues and partnerships for UC Berkeley to receive funds for improving water efficiency could be between UC Berkeley, EBMUD and the California Urban Water Conservation Council (CUCWCC). The CUWCC is a consensus-based partnership of water suppliers, public advocacy organizations, and other interested groups who are concerned with the water supply and conservation of natural resources in California. Those members who have signed a memorandum of understanding (MOU) have agreed to practice water conservation best managements practices that are economically and technically feasible and which are not environmentally or socially unacceptable. EBMUD is a partner. Currently no school has signed on as a member.

The potential benefits for UC Berkeley as a member of the CUWCC include the following: (1) The organization helps provide implementation practices that would fulfill UC Berkeley's goal of minimizing water consumption and wastewater production, (2) CUWCC can provide financial and technical resources that would facilitate meeting these goals, (3) a very important requirement of all programs recommended by the council is that they are cost effective and, therefore, joining the council would not hurt UCB financially, (4) UC Berkeley would be the first school to sign the MOU and doing so would continue UC Berkeley practices of forethought and leadership.

Apply for California State Proposition 50 funds and other grants:

There are many grants available for water conservation and protection. UC Berkeley should consider hiring a grant writer to apply for the numerous resource conservation grant funds currently available. One such funding opportunity is the California State Proposition 50 funds. The California Department of Water Resources administers this agricultural and urban water use efficiency grant program. There are a few opportunities for UC Berkeley to receive some of the $30 million dollars available. One example would be to have a team of engineers, landscape architecture, business and public health faculty and staff design the proposed EMBUD package water recycling system. The current location for this system was chosen due to the perception that it would be an "ugly" system and therefore should be located next to the cogeneration plant in the industrial section of campus. However, it does not have to be unattractive, and with proper funding the system could be designed to be a visually attractive ecological water treatment and recycling system that could be a centerpiece for the university (see chapter 6 for some examples of beautiful and ecological water recycling systems).

Conclusion:

As the population of UC Berkeley and California continues to grow, and water shortages in California and the world become more severe, UC Berkeley, as a domestic and international leader, could strengthen its long history of forethought, leadership and innovation through demonstrating that it is feasible to implement a sustainable water plan. UC Berkeley's demonstration of institutional water use efficiency would result in lower water consumption and wastewater production, reduce utility spending and stretch the limited water resources available in California. This report has shown the specific opportunities available for UC Berkeley to become an international leader in sustainable water planning. These opportunities, if pursued, would fulfill UC Berkeley's mission to deliver programs of instruction, research and public service of exceptional quality to the State of California through its own practices and therefore demonstrate to its students how to conserve and protect our precious water resources.

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