Water Conservation, Reuse and Recycling Master Plan

Final

STANFORD UNIVERSITY
October 2003

Prepared by
Maddaus Water Management
and
Stanford University

County of Santa Clara

Environmental Resources Agency
Planning Office

County Government Center, East Wing, 7th Floor
70 West Hedding Street
San Jose, California 95110-1705
(408) 299-5770 FAX (408) 288-9198
www.sccplanning.org

September 9, 2003

Mr. Tom Zigterman
Ms. Marty Laporte
327 Bonair Siding
Stanford, CA 94305-7272

Dear Tom and Marty:

Thank you for all your work in revising and completing the Stanford University Water Conservation, Reuse, and Recycling Plan. Planning staff appreciates your July submittal of the creek diversion baseline information requested by our office. Staff also commends Stanford for the ongoing implementation of plan elements, such as the Water-Wise Garden at Ryan Park.

Continued compliance with this GUP condition will be evaluated during subsequent annual reports. Implementation of the plan will be the basis for continued compliance with the GUP condition. Updated status of the plan will be part of the annual reporting process for Stanford.

The County Planning Office staff has communicated clarifications to you regarding future exploration of recycled water usage and annual reporting requirements for this plan. This office has determined that, with the clarifications provided to you by staff, the Water Conservation and Recycling Plan satisfies the mitigation requirements of the General Use Permit, Condition P.4, and the Mitigation Monitoring and Reporting Program (MMRP) Measure PS-1C. This letter will serve as verification for your office that, as of August 31, 2003, Stanford was in compliance with these mitigation requirements. Thank you again for your work on this project.

Best regards,

Ann Draper, Planning Director

cc: Tim Heffington
Gary Rudholm
Charles Carter
Catherine Palter

Foreword from the County of Santa Clara Planning Office: The Stanford University Water Conservation, Reuse and Recycling Master Plan

Background

Stanford University was required to submit this plan to the County of Santa Clara Planning Office in December 2001. The purpose of this plan is to demonstrate that Stanford can feasibly mitigate the impact from increase in water consumption associated with Stanford's land use and development activity, as identified in the December 2000 Stanford Community Plan/General use Permit (GUP)/Environmental Impact Report (EIR). The EIR established an environmental mitigation monitoring and reporting program (MMRP). The MMRP was adopted by the Santa Clara County Board of Supervisors in December 2000. The mitigation measures identified in the MMRP must be implemented by Stanford and are monitored by the County.

Submittal of this plan was a specific mitigation requirement identified in the December 2000 MMRP and GUP. Detailed background for this requirement is contained within those documents. Those documents are available on the County Planning Office web site (see web address at end of this foreword). Excerpts from both of those documents are provided at the end of this foreword.

The Process

Stanford's draft plan was submitted in December 2001. The County provided opportunities for other jurisdictions and agencies to review and comment on the draft document. After internal review and consideration of comments received, the County provided consolidated feedback to Stanford. The Santa Clara Valley Water District was a partner to the County in providing thorough review and comment to Stanford University. The revised document was then submitted, reviewed, and approved by the County Planning Director.

For further information regarding the Stanford University Community Plan, General use Permit, and Environmental Impact Report, contact the County Planning Office or visit the County web site (contact information provided at the end of this foreword).

Future Use and Reporting on the Plan

The specific language of the mitigation program (PS-1C: Water Conservation and Recycling) is contained within this foreword. In addition to the MMRP, the General Use Permit (GUP) is the permit under which specific conditions of approval for Stanford future development and land use activity are specified. Some of these conditions are specific for selected projects. Others, such as Condition P.4 require submittal of more generalized program/policy documents. These other plans and documents provide more detail regarding general measures outlined in the MMRP and GUP.

Essentially, this water conservation plan is intended to demonstrate how Stanford will conduct aggressive water conservation and recycling to keep demand below its present allocation. To comply with the requirements of the MMRP and the GUP condition, Stanford must implement water conservation measures and stay within the 3.033 mgd average daily allocation from SFPUC, apply for an increase in its water allocation, or seek other sources of water.

Ultimately, Stanford will need to reduce its projected demand from the Hetch Hetchy supply by six percent, or receive approval from the San Francisco Water Department to exceed the current allocation of 3.033 million gallons per day. Stanford is precluded from increasing withdrawals from Stanford creeks to achieve its water conservation goal. Stanford will submit water consumption information and summarize how elements of this conservation plan are being implemented on an annual basis, and that information will be presented in the County's Annual Report on Stanford University Compliance with the GUP and Mitigation Monitoring and Reporting Program.

County Planning Office Project Management:
Ann Draper: Planning Director
Gary Rudholm: Senior Planner, Post-Approval Monitoring
Tim Heffington: Associate Planner, Project Manager: Stanford University Environmental Mitigation Monitoring and Reporting Program

Santa Clara Valley Water District Review
William Springer, Community Projects Review Unit
Karen Morvay, Water Conservation Specialist

Draft Document Provided for Review and Comment to:
Santa Clara County Planning Office
City Of Palo Alto Department of Community Services
Town of Portola Valley
City of Menlo Park
City of Woodside

CONTACT INFORMATION
For further information, regarding this document or other Stanford University Community Plan and General Use Permit policy issues, contact the County Planning Office by phone or visit our web site.

PHONE: (408) 299-5784.

WEB SITE: www.sccplanning.org

End of County Planning Office Foreword

GUP Excerpt, Condition P.4

4. Within twelve months of General Use Permit approval, Stanford shall prepare and submit to the County Planning Office for review and approval a Water Conservation and Recycling Master Plan, which will identify measures for reducing potable water use on campus. Measures included in the plan may be required as conditions of approval for proposed building projects and/or through the annual General Use Permit monitoring process. The overall goal of the plan shall be to ensure that Stanford does not exceed its allocation of 3.033 million gallons per day (mgd). Increased water withdrawals from creeks shall not be used to meet this goal. The plan shall address the following items:

Mechanisms for use of recycled water for turf and landscaping irrigation, toilet flushing, and other appropriate activities;

a. Measures to reduce domestic water use in existing buildings;

b. Continued and new water conservation measures for new and remodeled buildings; and

c. Methods to reduce use of water for irrigation.

MMRP Excerpt

PS-1C: Water Conservation and Recycling

(a) Stanford shall embark on an aggressive program of water conservation and water recycling. The conservation program shall include measures to reduce domestic water use (e.g., retrofit existing residences with low-flow toilets and showerheads) and to reduce use of water for irrigation (e.g., require use of drought-tolerant landscaping). The recycling program shall include consideration of recycled water or gray water use for toilet flushing in new buildings. Stanford will continue to implement water conservation measures for proposed new buildings to minimize future water use. Stanford should consider the use of recycled water for turf irrigation for the golf course, athletic fields, and other landscaped areas.

To implement these recommendations, Stanford shall prepare and submit to the County Planning Office a Water Conservation and Recycling Master Plan, which will lay out the proposed measures for reducing potable water use on campus. The goal of the plan shall be to ensure that Stanford does not exceed its allocation of 3.033 mgd. The Plan shall be prepared following the adoption of the CP and approval of the GUP. Increased water withdrawals from Stanford creeks shall not be used to meet this goal. A ten percent reduction in average daily water use would keep water consumption well within Stanford's existing allocation of 3.0333 mgd, while a six percent reduction (0.18 mgd), would meet the current allocation. A ten percent reduction in average daily water use is feasible with implementation of the program described above.

(b) If conservation and recycling does not achieve at least a six percent reduction in potable water demand from Hetch Hetchy, the University would have to apply for an increase in the allocation of water from the San Francisco Water Department, and receive approval prior to exceeding the existing allocation. Alternatively, Stanford could reduce its water consumption or seek other sources of water.

Impacts Mitigated: Increase in water consumption.
Lead Agency: Stanford University [Santa Clara County]
Implementing Agency: Stanford University
Timing: Start: GUP Approval/individual project design/review
Complete: Ongoing

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1.0 EXECUTIVE SUMMARY

1.1 Purpose

This Water Conservation, Reuse and Recycling Master Plan has been prepared to comply with Condition of Approval P4 and Mitigation Measure PS-1C of Stanford University's 2000 General Use Permit (2000 GUP). The condition specifically states the following:

Within twelve months of General Use Permit approval, Stanford shall prepare and submit to the County Planning Office for review and approval a Water Conservation, Reuse and Recycling Master Plan, which will identify measures for reducing potable water use on campus. Measures included in the plan may be required as conditions of approval for proposed building projects and/or through the annual General Use Permit monitoring process. The overall goal of the plan shall be to ensure that Stanford does not exceed its allocation of 3.033 million gallons per day (mgd).

This plan has been developed to demonstrate that Stanford can develop the academic and support buildings and housing units allowed under the 2000 GUP and remain within the current water allocation. This Master Plan provides a menu of potential water conservation measures for implementation. However, it is also possible that Stanford will identify other water conservation measures or reduce its customer base, or increase its supply in the next 10 years. Such measures may be substituted for measures in this plan providing that the water conservation measures comply with this GUP. The mechanism for monitoring compliance with Condition of Approval P4 and Mitigation Measure PS-1C will be the annual comparison of actual water consumption to the current water allocation. This will be reported to the County in the GUP Annual Report along with a description of conservation measures implemented by Stanford each year.

1.2 Overview of Stanford's Water Supply

The Stanford Facilities Operations Water Shop operates the domestic water system that provides potable water to the Stanford campus. The Stanford domestic water system meets all state and federal water quality requirements. The main source of water to the campus is the City and County of San Francisco through the San Francisco Public Utilities Commission (SFPUC; See Appendix A, listing SFPUC (Hetch-Hetchy and well sources of domestic water supply). The majority of the domestic system has been installed since the early 1960s, but parts of the system date from the early 1930s. Backup potable water supply is provided by three wells on Stanford property.

The Stanford Water Shop also operates a non-potable (lake) water system on the Stanford campus. The lake water supply (non-potable) is used for irrigation and backup fire protection. Since about 1985 there has been a program to maintain and expand the lake water system to irrigate areas with the non-potable water instead of the domestic water. The lake water system includes Searsville Lake and Felt Lake. Lake Lagunita is not part of the lake system.

1.3 Stanford's Water Use Compared to Other BAWUA Agencies

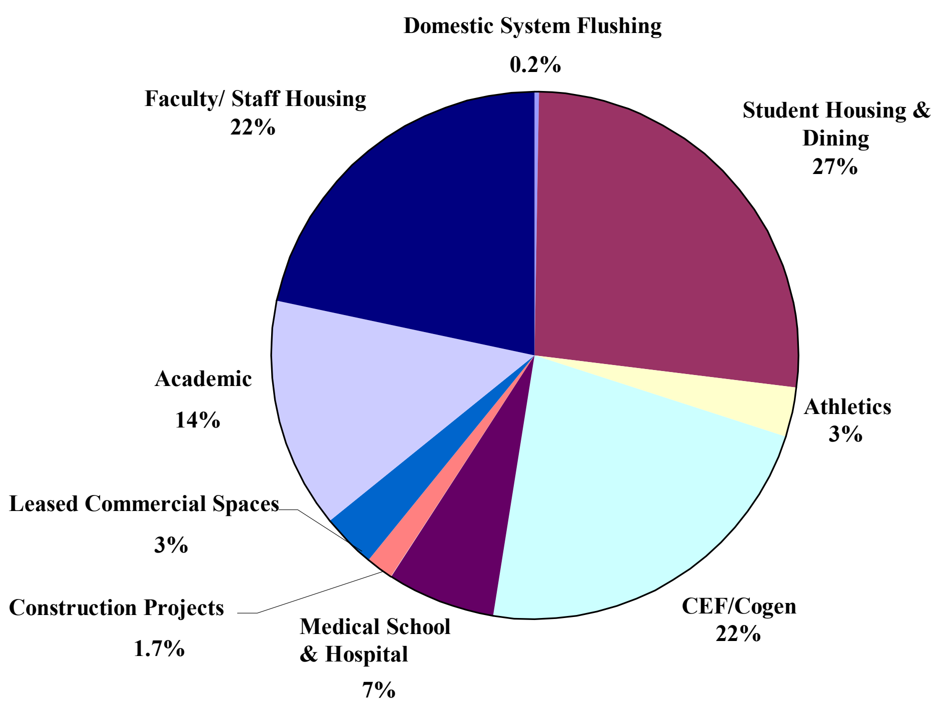
Of the 184 mgd allocated to the Bay Area Water Users Association (BAWUA) agencies, Stanford University's allocation is 3.033 mgd and for 1999-2000 its average daily consumption was 2.7 mgd. Stanford's average daily domestic water consumption represents only 1.5 percent of the total BAWUA supply from SFPUC. Using BAWUA's data that identifies SFPUC purchases among BAWUA agencies, Stanford ranks 19th in consumption volume - among the lowest consumers. Stanford University already has implemented an aggressive water conservation program. For 1999-2000, Stanford's total domestic and non-potable gross per capita consumption was 147 gallons per capita per day (gpcd). Stanford's gpcd is low compared with neighboring cities (e.g., City of Menlo Park is at 366 gpcpd and City of Palo Alto at 227 gpcpd, BAWUA Annual Survey, December 2000; See Appendix B, Exhibit 15 from BAWUA Annual Survey Report, December 2000).

1.4 Review of Stanford's Water Demands

The 12-month moving average shows an average daily supply production of approximately 2.7 mgd. Metered consumption data were analyzed for specific categories of use. Monthly metering data were used from 1996 through 2000. From the five years of data, the 12-month moving average was calculated using twelve months of monthly data moving through time (i.e., each data point on the trend line represents the average of the previous 12 months of meter readings). The moving average data are used to determine consumption trends for the five years. Figure ES-1 presents an annual average domestic water system demand profile for the key categories of water use on campus. Note that student housing, faculty/staff housing and the Central Energy Facility (CEF/Cogen) are the three largest categories of use. The CEF/Cogen facility is described in Section 4.

The largest demands and the primary end uses of domestic water are toilet flushing and irrigation, which constitute over 30% of water use on campus. As a result, the internal use for toilet flushing and external use for irrigation are two key focus areas for conservation, reuse and recycling (See Section 4 for detailed discussion).

Figure ES-1. Average Annual Demand By Category for Domestic Water System



1.5 Baseline Water Use Projection

In order to determine the need for and level of meaningful water conservation, it is necessary to establish a baseline water use projection. First, historic campus development and water use were identified (See Appendix C – Data from 5 years of metered domestic water consumption), and then campus expansion plans under the 2000 GUP were reviewed with the Stanford University Architect/Planning Office, to determine potential increases in population and gross square footage. This information was used to project the growth in future water demand. The baseline water projection, assuming a certain development rate and without conservation, is provided in Figure ES-2. Absent implementation of this Master Plan, the projection could rise from the average daily demand in 2000 of 2.7 mgd to as much as 3.6 mgd in 2010 at the anticipated end of the 2000 GUP program. Therefore, the goal of the conservation/recycling Master Plan is to reduce the demand by approximately 16 percent or 0.57 mgd to keep the demand below 3.033 mgd.

Stanford's Master Plan is based on conservatively high estimates of future water use in order to best position Stanford for achieving the goal in the long term. The estimated water consumption projections in the GUP EIR were based on per capita use (BAWUA, 1999) and water consumed (per square foot) for existing campus academic and landscaped spaces. The projected water consumption estimates in this Master Plan are based on significantly more detailed review of projected increases in square footage for specific types of academic spaces, population, landscaped areas, and housing unit. The water use estimates are higher than those presented in the GUP EIR because, for planning purposes, it is better to estimate water use on the high side so that conservation measures will be designed to address the highest potential use.

1.6 Water Conservation, Reuse and Recycling Master Plan

Water conservation, reuse and recycling measures were evaluated based on analysis of water use trends from the metered water data and also during site visits and interviews with key Stanford personnel at representative or high volume water using facilities on campus. The 14 conservation measures listed in Table ES-1 were deemed applicable to Stanford University and further analyzed for cost effectiveness. Benefits accrue from lower water purchase costs, lower wastewater discharge costs, and deferred capital projects. The cost of water saved is the present value of the annual Master Plan implementation costs over 30 years, divided by the volume of water saved over 30 years (Table ES-2).

Nine of 14 conservation measures were individually cost effective with a utility benefit cost ratio above 1.0 (Table ES-1). At this point, this menu of measures appears to provide the most cost effective and reasonable means for Stanford to achieve the goal of staying within its current allocation. Over time, different measures may become feasible, or more cost effective, and may be substituted for some of these measures.

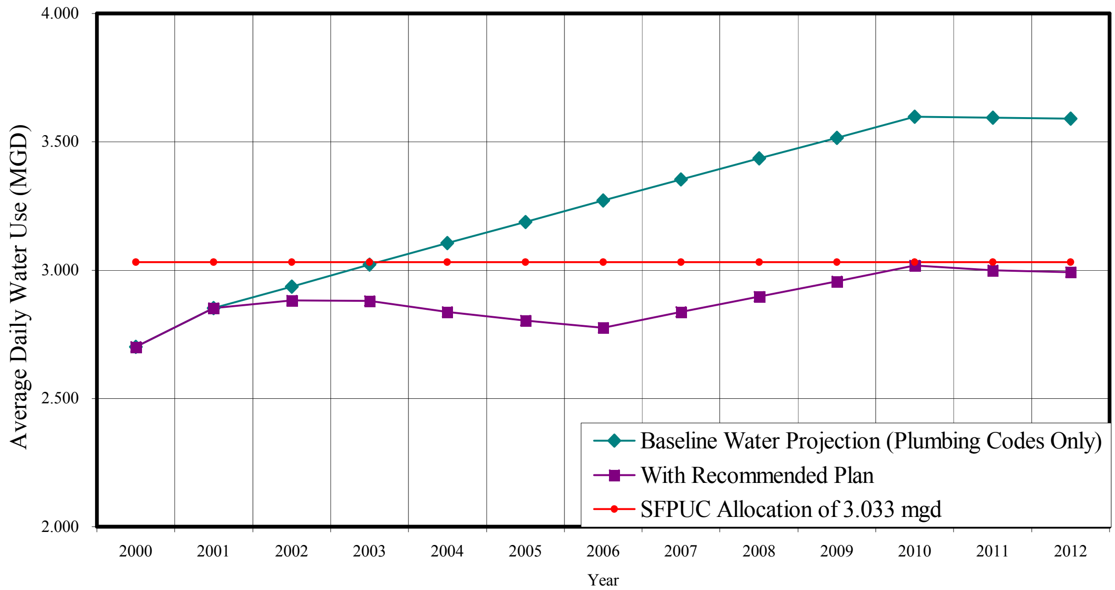
Table ES-1. Estimated Results of Individual Measures

No.	Measure	Evaluation Criteria		
		Average Water Savings, mgd*	Utility Benefit-Cost Ratio	Cost of Savings per million gallons, $
1.	Ultra Low Flush Toilet Replacement	0.084	1.09	1,451
2.	Showerhead Retrofit	0.007	2.77	581
3.	Urinal Replacement	0.023	1.54	1,026
4.	High-Efficiency Washer Replacement**	0.010	19.14	492
5.	Public Outreach Programs	0.026	1.02	3,180
6.	CEF Blow down Reuse	0.060	1.04	1,000
7.	Faculty/Staff Housing Water Audits	0.037	3.46	733
8.	Landscape Water Management	0.010	1.38	480
9.	Selective Landscape Retrofit	***	***	***
10.	New Water Efficient Landscape	0.022	0.27	3,230
11.	New Landscape on Lake Water	0.086	6.72	132
12.	ET Controllers on New Faculty/Staff Housing	0.124	0.96	321
13.	Selected Academic Areas on Lake Water	0.013	5.86	163
14.	Football Practice on Lake Water	0.011	12.31	78

* Caution: savings cannot be added without handling measure overlap water savings averaged over 30 years. Actual savings in 2010 may be higher. (See Appendix D);
** This measure's benefit-cost ratio included a rebate of $200 per washing machine.
*** To be determined, the annual report will list specific projects completed during the reporting year and associated estimated water savings .

The overall water savings from conservation measures in the Water Conservation, Reuse and Recycling Master Plan are combined with the no-cost benefits of the National Plumbing Efficiency Standards. The plumbing standards result in natural conservation that occurs due to eventual replacement of the existing plumbing fixtures with more water-efficient models. Plumbing fixtures installed in all new and renovated buildings will meet the National Plumbing Efficiency Standards. The Master Plan compared to the baseline projection without conservation but including plumbing code benefits is presented in Figure ES-2. This graph illustrates that water demand will remain below 3.033 mgd even after the 2000 GUP build out is completed. Demand will actually decrease because of continued conservation (Appendix D contains a summary explaining the demand forecasting methodology).

Figure ES-2. Projected Water Demand With And Without Water Conservation Master Plan



The Master Plan has an overall projected water savings of 0.58 mgd in 2010. The estimated present value cost is $5.14 million, and estimated present value of the benefits is $5.48 million for a benefit/cost ratio of 1.06 (Appendix D includes detailed discussion of benefit/cost ratio). The overall results from the cost-effectiveness evaluation of the conservation, reuse and recycling Master Plan are presented in Table ES-2.

Table ES-2. Estimated Savings and Costs of Water Conservation, Reuse and Recycling Master Plan

Savings/Costs	Master Plan
Water savings in 2005, mgd	0.38
Water savings in 2010, mgd	0.52
Total Cost 2002-2005, million $	2.75
Total Cost 2006-2010, million $	1.78
Present Value of Costs, million $**	4.90
Present Value of Benefits, million $*	7.59
Cost of Water Saved $/million gallons**	965
Benefit/Cost Ratio	1.55

*Based on current cost of SFPUC water of $1,176 per million gallons.
**Present Value is based on 30-year actual costs and benefits.

1.7 Overview of Master Plan

The Master Plan contains the best package of conservation measures for Stanford (Table ES-3). Maddaus Water Management, with more than 25 years of professional experience and working with water conservation programs throughout the world, has found that, typically, water conservation programs save about 0.5 to 1.0 percent of total water consumption per year for each year of the program. The Master Plan will save 1.6 percent of the domestic water per year and is considered very aggressive. Included in the Master Plan is a landscape retrofit measure, which includes selective re-landscaping with water-efficient landscapes instead of inefficient turf areas. These areas are to be determined by the Stanford University Architect/Planning Office and Grounds Department and could include non-use areas such as exterior portions of Escondido Village. Further details on the programs are contained in Section 6.0.

1.7.1. Additional Recommendations for New Buildings and Renovations – Recommended Plans Review Process

Besides conservation measures and the existing Stanford internal process to review plans for new buildings, the Master Plan includes additional recommendations. In addition, future Stanford plan reviews would focus on interior and exterior water use with additional specific criteria. The interior plumbing and equipment design review that Stanford undertakes would include review of efficiency of water consumption based on available technology. For example, to prevent disposal of steam condensate with poor quality (and use of additional domestic water), review of design of steam systems in buildings should include building heat load analysis and appropriate heating equipment sizing. Heat exchanger trapping and condensate return piping should be designed to prevent heat exchanger failures and steam condensate contamination.

1.7.2. Landscape Water Management for Recommended Best Management Practices

Although most landscape water use is on the lake system, landscape water use on the domestic system still amounts to almost 0.6 mgd or over 22 percent of current use. The Santa Clara County "Guidelines for Architecture and Site Approval" include landscape guidelines to encourage the use of drought tolerant, native plants. All Stanford applications for Architecture and Site Approval (ASA) include a landscape plan that identifies plantings consistent with these guidelines. Based on our evaluation the following strategy for increasing water efficiency is recommended.

1. Practice landscape water management on all large turf sites.
2. New and renovated landscaped areas should use only the lake water system for irrigation (unless prohibitively expensive).
3. Amend Stanford University Facilities Design Standards (FDS) to provide current details, specifications and plant lists, to ensure water efficient landscapes are installed.
4. Implement Stanford University Landscape Design Guidelines, March 1989 for all new and re-landscaped areas. Review all landscape and irrigation plans from the standpoint of achieving landscape water use efficiency.
5. Implement reuse of Central Energy Facility (CEF) cooling tower and Heat Recovery Steam Generator (HRSG) blow down water for landscape irrigation; investigate the feasibility of a connection to the lake water system.
6. Selectively retrofit landscape areas with low water use plant materials and efficient irrigation systems. Replace existing irrigation controllers with a link to the Maxicom system or similar wherever practical.
7. Investigate the application of new irrigation technology for the Stanford campus.

The use of lake water in-lieu of potable domestic water for irrigation demands will not cause Stanford to exceed its historic demands on its lake water system. The demand identified in the Master Plan is within the range of Stanford's historic diversions under its existing water rights, and is therefore consistent with

Condition of Approval P4 in Stanford's General Use Permit. No additional creek diversions or water rights are required to meet this demand.

1.8 Implementation and Staffing the Master Plan

Implementation of the Master Plan will be led and managed by the Utilities Division. Implementation of the specific programs will be the responsibility of individual departments, as shown in Table ES-3. Implementation of the Master Plan will involve staffing, funding and other resources. The Utilities Division will manage the Water Conservation, Reuse and Recycling Master Plan. In-house staff can carry out some of the work; other work can be done by contract.

Table ES-3 – Master Plan Measures and Implementation Responsibilities

No.	Measure	Brief Description	Responsible Departments
1.	Ultra Low Flush Toilet Replacement	Replace 90 percent of inefficient toilets with 1.6 gallon/flush models in all campus facilities.	Student Housing, Zones (Academic), Athletics, Medical School
2.	Showerhead Retrofit	Replace 90 percent of inefficient showerheads with low flow models in all campus facilities.	Student Housing, Athletics
3.	Urinal Replacement	Continue with current urinal replacement plans but hold-off on the remaining until 0.5 gal/flush units or valves are on the market and use these to attain a 90 percent replacement rate.	Student Housing, Zones (Academic), Athletics, Medical School
4.	High-Efficiency Washer Replacement	Replace existing washing machines in student housing with efficient (such as front loading) models. Retain pay-per-use machine types.	Student Housing
5.	Public Outreach Programs	Implement a multi-faceted public education program directed at departments, students, and employees stressing the need to conserve water. Highlight programs and rebates available.	Utilities
6.	CEF Blow Down Water Reuse	Prepare preliminary engineering and pilot testing of cooling tower and boiler blow down water for irrigation. Determine best way to integrate this source with the lake system and use to irrigate new and existing areas.	CEF, Utilities, Grounds
7.	Faculty/Staff Housing Water Audits	Offer indoor/outdoor water audits to not less than 30 percent of the faculty-staff housing on a repeating five-year cycle. Focus on reduction of irrigation, toilet and washer use.	Utilities/Contractor
8.	Landscape Water Management	Provide water budgets and tracking of performance on a monthly basis for large irrigated sites. Conduct large turf audits periodically.	Grounds, Utilities
9.	Selective Landscape Retrofit	Retrofit turf areas known or shown to be inefficient with low water use plant landscapes where feasible and cost-effective.	Planning, Grounds
10.	New Water Efficient Landscape	Amend and require use of Stanford's Landscape Design Guidelines and FDS to ensure predominant use of water efficient plant types is used. Develop and adhere to water budgets. Conduct water efficiency reviews of plans.	Planning, Grounds
11.	New Landscape on Lake Water	Put all new landscapes on the lake water system.	Utilities, Capital Planning Management
12.	ET Controllers on new Faculty/Staff Housing	Install evapotranspiration (ET) Controllers on all irrigated landscaped areas associated with new Faculty/Staff Housing units	Utilities, Grounds
13.	Selected Academic Areas on Lake Water	Switch irrigation of five specifically identified landscapes from the domestic to lake system.	Utilities, Grounds
14.	Football Practice Field on Lake	Extend the lake system to irrigate the football practice field.	Utilities, Athletics

2.0 INTRODUCTION

2.1 Goals and Objectives for Water Conservation, Reuse and Recycling Master Plan

This Water Conservation, Reuse and Recycling Master Plan (Master Plan) has been prepared to comply with Condition of Approval P4 and Mitigation Measure PS-1C of Stanford University's 2000 General Use Permit (2000 GUP). Condition of Approval P4 states:

> *Within twelve months of General Use Permit approval, Stanford shall prepare and submit to the County Planning Office for review and approval a Water Conservation, Reuse and Recycling Master Plan, which will identify measures for reducing potable water use on campus. Measures included in the plan may be required as conditions of approval for proposed building projects and/or through the annual General Use Permit monitoring process. The overall goal of the plan shall be to ensure that Stanford does not exceed its allocation of 3.033 million gallons per day (mgd). Increased water withdrawals from creeks shall not be used to meet this goal. The plan shall address the following items:*
>
> a. *Mechanisms for use of recycled water for turf and landscaping irrigation, toilet flushing, and other appropriate activities;*
> b. *Measures to reduce domestic water use in existing buildings;*
> c. *Continued and new water conservation measures for new and remodeled buildings; and*
> d. *Methods to reduce use of water for irrigation.*

The environmental analysis in the Stanford University Draft Community Plan and General Use Permit Application Environmental Impact Report (Stanford EIR December 18, 2000) for public services and utilities estimated the water demand of the development proposed in the 2000 GUP; See Appendix B, Exhibit 15 from BAWUA Annual Survey Report, December 2000). The resulting demand, added to current consumption, was greater than the current water allocation (3.033 million gallons per day) from San Francisco Public Utilities Commission (SFPUC). This was identified as a significant impact, which was mitigated to a less than significant level after implementation of Mitigation Measure PS-1C. Mitigation Measure PS-1C requires preparation of a Master Plan to show that Stanford can reduce water consumption to remain under the current water allocation. The EIR estimated that a 6 percent reduction would be needed by the time GUP-related development was completed if Stanford were to stay within its current allocation. The EIR found such a reduction to be feasible. (Note: the mitigation measure also states that if conservation and recycling does not achieve at least a 6 percent reduction in demand from SFPUC, Stanford will need to apply for an increase in the allocation of water from the SFPUC, and receive approval prior to exceeding the existing allotment.) This became Condition of Approval P5.

The estimated water consumption projections in the GUP EIR were based on per capita use (BAWUA, 1999) and water consumed (per square foot) for existing campus academic and landscaped spaces. The projected water consumption estimates in this plan are more conservative and based on significantly more detailed review of projected increases based on square footage and housing units. This more detailed review resulted in higher estimate of potential water demand than previously estimated in the 2000 GUP EIR.

The 2000 GUP does not have an expiration date, but the EIR assumed that the allowed development would occur within 10 years. This Water Conservation, Reuse and Recycling Master Plan also assumes that academic and housing developments will occur at a constant rate until it is completed in 10 years. Although the actual development rate may not be consistent, the conclusions about water demand and conservation at final build out are valid independent of when build out actually occurs. It should be noted that the estimated water demand in this report should be considered a conservative maximum. Actual water demand would be less if, for example, faculty/staff housing units were constructed at the lower end of the density range.

This very conservative approach has been developed to demonstrate that Stanford can develop the academic and support buildings and housing units allowed under the 2000 GUP and remain under the current water allocation. It is foreseen that a menu of water conservation measures will be implemented. However, it is also possible that Stanford will identify other water conservation measures or reduce its customer base, or increase its supply in the next 10 years instead of implementing measures in this plan in order to remain under the current allotment. The mechanism for monitoring compliance with Condition of Approval P4 and Mitigation Measure PS-1C will be the annual comparison of actual water consumption to the current water allocation. This will be reported to the County in the GUP Annual Report along with conservation measures that were implemented during the reporting period, estimated water savings, and a map showing locations of projects.

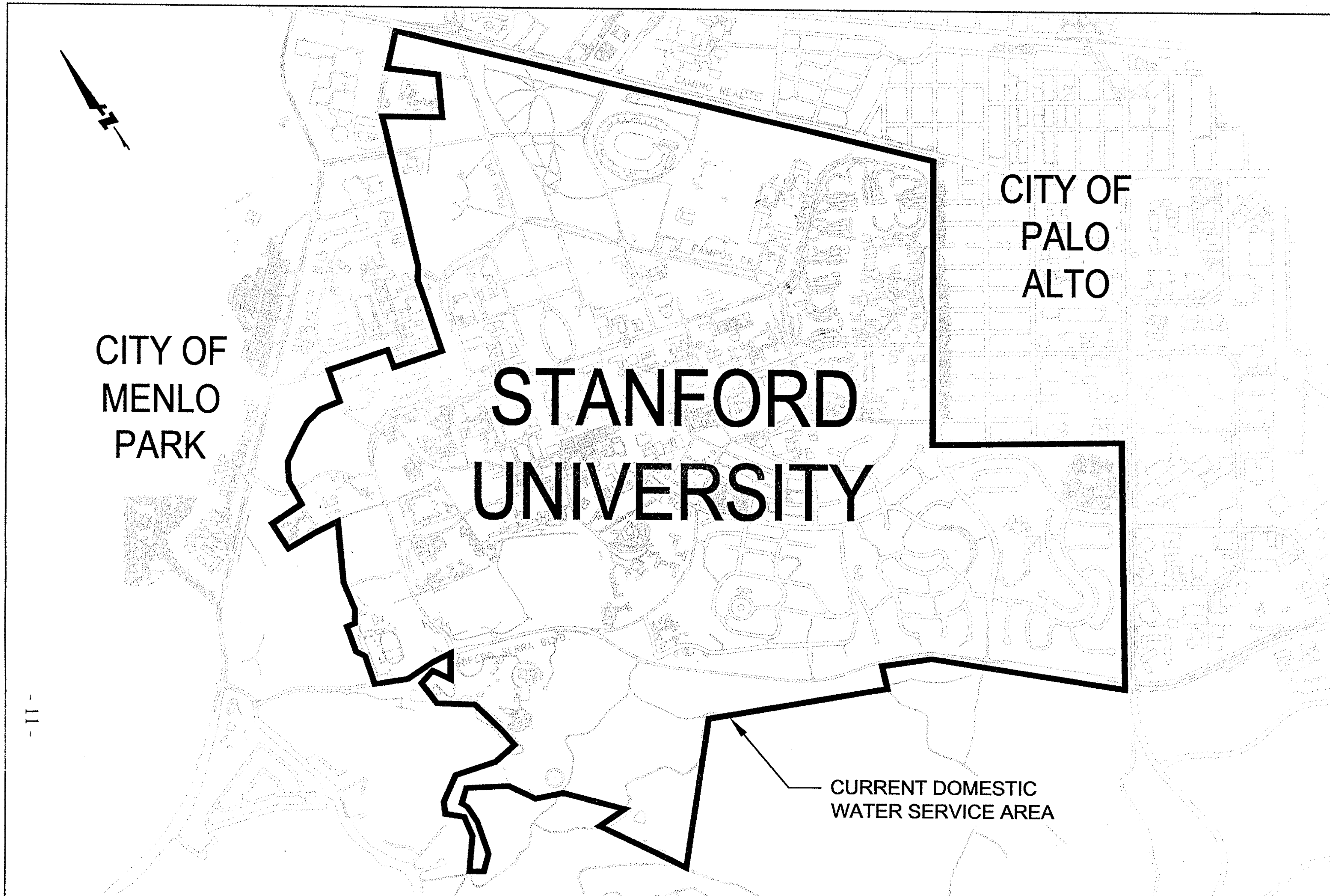
2.2 Description of Stanford's Domestic Water System

Stanford's domestic water system delivers potable water to the Stanford campus. The Stanford domestic water system meets all state and federal requirements. The main source of water to the campus is from the City and County of San Francisco through the (SFPUC). The majority of the domestic water from SFPUC is from the Hetch Hetchy Reservoir, located in the Sierra Nevada Mountains. The SFPUC water comes to Stanford through two turnouts in the foothills between Junipero Serra Blvd. and Highway 280 and one turnout off El Camino Real. Stanford has three active wells that can deliver 1,500 gallons per minute to either the domestic or non-potable system. There are three pressure zones on campus, all of which are supplied from the SFPUC system. The domestic water is stored in two domestic water reservoirs (See Appendix A for schematic diagram showing sources and uses of domestic water). Foothill Reservoir 1 serves the upper elevation areas above 150 feet, in pressure Zone 1, and Foothill Reservoir 2 serves the main academic area of the campus in pressure Zone 2. Pressure Zone 3, the El Camino Real connection serves the Escondido Village Graduate Student Housing area.

As shown in the Domestic Water Service Area Map (Figure 2-1), the domestic supply system delivers water throughout the campus via 145 miles of water mains to customers through over 1,600 water meters. Water pipe sizes range from one-inch to 24-inch diameter. The majority of the domestic system has been installed since the early 1960s, but parts of the system date from the early 1930s.

The domestic water distribution system is sampled on a continuing basis to verify that the water meets all state and federal requirements. All domestic water is fluoridated. This is done at each turnout by injecting a sodium fluoride solution into the water main. Water is then sampled, tested and the results recorded daily. Monthly reports are submitted to the State of California Department of Health Services.

The Stanford Facilities Operations, Utilities Division, Water Shop maintains the domestic water distribution system and has a pro-active annual flushing and maintenance program to prevent water quality problems and leakage from old piping. In the fall of 2003, SFPUC will be changing the disinfection process for the domestic water system from chlorine to chloramines. The change in disinfectant chemicals is being implemented by SFPUC to comply with new U.S. EPA disinfectant byproduct regulations. It is anticipated that water systems with chloraminated water will require additional domestic water flushing to maintain water quality.



STANFORD UNIVERSITY Facilities, Information & Technology 327 Bonair Siding Stanford, CA. 94305-7270	Figure 2-1. DOMESTIC WATER SERVICE AREA			
	Scale: 1"= 1800'	1 OF 1	By: LSM	Date: 05/09/02

The Stanford University Utilities Division meters campus water consumption and tracks the annual water consumption using the Utility Metering Database.

2.3 Availability of Domestic Water from San Francisco Public Utilities Commission and Other Water Sources

SFPUC's Domestic Water System

Stanford University is one of 29 water utilities that purchase water wholesale from the City and County of San Francisco through the SFPUC. The 29 water utilities are members of the Bay Area Water Users Association (BAWUA) and each water utility has a contract and associated water supply allocation with the City and County of San Francisco. The total supply assurance from SFPUC to BAWUA agencies is 184 mgd, although during most years additional water is available.

Stanford's Lake Water System (Non-potable Water)

The Stanford Water Shop also operates a separate water system that provides non-potable (lake) water to the campus. The lake water does not meet domestic water quality standards (without treatment) and is used for irrigation and backup fire protection. The lake water system includes Searsville Lake and Felt Lake. Lake Lagunita is not part of the lake system.

Reclaimed Water Availability

One potential alternative source of non-potable water is reclaimed wastewater from the City of Palo Alto Regional Water Quality Control Plant (RWQCP). The RWQCP prepared a Draft Environmental Impact Report (DEIR, August 1994) for the RWQCP Wastewater Reclamation Program. At that time, the RWQCP proposed the Wastewater Reclamation Program to facilitate increased use of reclaimed water and replace certain types of potable water use, such as irrigation. Another objective was to reduce the volume of the RWQCP's discharge of treated wastewater to San Francisco Bay. The reclaimed wastewater was to be used for landscape irrigation at city parks, freeway medians, and other large irrigated areas within the RWQCP's service area and the City of Menlo Park.

With the exception of the Foothill Main Project, the DEIR included information at a program level of detail. The Foothill Main Project included more detailed information about the development of a pipeline to the Santa Cruz Mountain foothills and the construction of a storage reservoir in the foothills southwest of Stanford University. At the time the DEIR was completed, the RWQCP had not entered into any formal agreements with the potential water users identified in the DEIR.

According to Santa Clara Valley Water District (SCVWD) staff (pers. commun. Bob Kenton,), although the SCVWD presently has no partnership agreement on specific recycled water programs with Palo Alto, the SCVWD may likely be a partner in the future on specific recycled water programs and may have significant financial incentives in place to promote the use of recycled water. According to the SCVWD, efforts are continuously being made to secure funding from the federal government for recycled water programs, and interest free loan may be available from the State of California's revolving fund loan program. Therefore, Stanford should assume that the full cost may not necessarily be paid by Stanford; but rather identify the marginal cost of other options in order to identify a reasonable cost for Stanford's share.

The DEIR did not specifically address costs of the project to customers. However, Palo Alto's estimated cost of recycled water is currently about $ 0 to 1,200 per acre-foot. Information from the Palo Alto Regional Water Quality Control Plant (RWQCP) Engineer, indicates that it is likely that the cost of recycled water would be about 50 percent of the price of domestic water (Daisy Stark, pers. commun. 4/24/02). This estimated cost did not include the customer's costs for design, installation, and maintenance of distribution system infrastructure, such as blending tanks, and distribution lines throughout Stanford University. In addition, costs to comply with regulatory requirements for recycled wastewater, such as training, labeling, sampling, documenting, and reporting were not evaluated. The reclaimed wastewater quality was reviewed for various non-potable uses. Stanford would continue to consider the use of recycled water in the future, especially if the water quality and cost-effectiveness improve. Stanford will also stay informed and participate in discussions about the availability of recycled water. The evaluation indicated that total dissolved solids (TDS) concentration was at 1000 mg/l (compared with cooling tower blow-down at 300-500mg/l), sodium concentration at 240 mg/l, and chloride at 400 mg/l (e.g., irrigation guideline listed in the RWQCP EIR , Table 3-2, is < 300mg/l,). Recent data from the RWQCP indicates that chloride levels are at about 300 mg/l. Local recycling of CEF/Cogen blowdown water was considered more effective because of its local availability and high quality.

For these reasons, a recycled water system supplied by Palo Alto is not recommended at this time. However, Stanford will continue to consider the use of recycled water in the future, especially if the water quality and cost-effectiveness improve.

Stanford's Water Use Compared to Other BAWUA Agencies

Of the average daily 184 mgd allocated to the BAWUA agencies, for 1999-2000, Stanford University's average daily consumption was 2.7 mgd. This average daily domestic water consumption by Stanford represents only 1.5 percent of the total BAWUA supply assurance from SFPUC. Using BAWUA's data that identifies SFPUC purchases among BAWUA agencies, Stanford ranks 19th in consumption volume, among the lowest consumers (Appendix B, Exhibit 15 from BAWUA Annual Survey Report, December 2000).

Stanford University already has an aggressive water conservation plan. For the past ten years, Stanford University has been converting domestic water irrigation systems to lake water irrigation for athletic fields and campus grounds. Additionally, Stanford uses drought tolerant plants in landscaping and has invested resources to install new irrigation systems that use evapotranspiration (ET) technology to indicate irrigation settings based on soil moisture and climate (Appendix E). Since the last drought, Stanford has also retrofitted 5-gallon toilets and high flow showerheads to low flow fixtures. For 1999-2000, Stanford's total domestic and non-potable gross per capita consumption was 147 gallons per capita per day (gpcpd), compared with neighboring cities (e.g., City of Menlo Park at 366 gpcpd and City of Palo Alto at 227 gpcpd, BAWUA Annual Survey, December 2000, (Appendix B, Exhibit 15 from BAWUA Annual Survey Report, December 2000).

3.0 DESCRIPTION OF STANFORD'S CURRENT CONSERVATION PROGRAMS

3.1 Water Conservation Efforts Undertaken To-Date

Various water conservation measures have been implemented at Stanford University for some time. Once-through cooling systems, where domestic water, which is less than 60 ^{o}F, is used once only (then discharged to sanitary sewer) to cool equipment is not permitted according to the Utilities Division Water Conservation Policy that was developed in 1998. A Stanford Facility Design Standard (FDS), applicable to both building retrofit and new buildings, provides guidelines for replacing once-through cooling systems with closed-loop process-cooling loops using campus chilled water or mechanical refrigeration/cooling.

Over the years, the Stanford Utilities Division has been converting campus irrigation from domestic SFPUC water to lake and ground water. Examples of projects where campus landscape irrigation was changed from domestic to lake water include the soccer fields, campus grounds areas such as The Oval and Lomita Mall, and landscaping around student housing in Toyon and Wilbur Hall areas. However, even if campus irrigation uses only lake and ground water, Stanford expects that water conservation will be integrated into design of new construction, planned renovation and retrofit projects owing to limited water availability. Many existing landscape areas have been retrofitted with Maxicom ET Controllers (Appendix E).

Recently, Stanford retrofitted some older student housing and academic buildings with low-flow bathroom fixtures. In FY 2001, the Student Housing Department worked with the Utilities Division and the Santa Clara Valley Water District Water Conservation Program and retrofitted more than 700 5-gallon-per-flush (gpf) toilets with 1.6-gpf ones. The Santa Clara Valley Water District (SCVWD) Water Conservation Program currently provides rebates for Water Efficient Technologies (WET), including high efficiency washing machines, high efficiency nozzle sprayers for cafeteria dishwashers, and reclamation and reuse of rinse waters. In 2001, Stanford received rebate funding from the SCVWD for toilet retrofit projects, where older 3.5- and 5- gpf toilets were retrofitted with 1.6-gpf ones. Stanford plans to participate in the WET program if it is still available when qualifying projects are started.

The goal of Stanford's Water Conservation Program is to promote efficient use of water by designing structures with equipment that uses water sparingly and by educating water users about the need to conserve water. The Utilities Division uses the Utility Metering Database to analyze important trends in campus water consumption. Utilities will work with Planning and other campus departments to develop options for improving efficiency in water use and to ensure that the best quality domestic water is conserved and continues to be available for academic and research use.

3.2 Current Industry Standards & Stanford Guidelines Related to Water Use for New Development

3.2.1. Interior Water Use

Current National Plumbing Efficiency Standards have requirements established in 1992, which reduce the water use of interior fixtures including:

- Toilets at 1.6 gpf
- Urinals at 1.0 gpf
- Showerheads at 2.5 gallons per minute (gpm)
- Faucets at 2.2 gpm

These requirements are regulated by the Energy Policy Act of 1992: Section 123: Energy Conservation Requirements for Plumbing Products. The SCVWD recommends that where fixtures with lower flow are available and are appropriate for the user, bathroom faucets could use 1.5 gpm and kitchen faucets could use 2.2 gpm. When new plumbing fixtures are installed in new or renovated buildings they are required to meet or exceed the current National Plumbing Efficiency Standards.

3.2.2. Exterior Water Use

Stanford will adhere to the principles and practices outlined in the Stanford University Landscape Design Guidelines, March 1989. New landscapes continue to be designed according to guidelines and criteria that emphasize water efficient plant material and efficient irrigation. The Stanford University Landscape Design Guidelines emphasize native landscaping.

Specific measures within the Stanford University Landscape Design Guidelines include:

1. Confine irrigated lands to areas of greatest human use. (p. 57)
2. Where irrigation is required, apply the latest, most successful water conserving technologies. (p. 57)
3. When appropriate, site new buildings so that foundation and buffer planting is drought tolerant and rural in character. ("As the University has grown, the contrast of a sophisticated built environment sitting next to open fields of oak trees and tall brown grass has remained central to the Stanford ambiance", p. 41)
4. Keep more water-intensive landscapes confined to courtyards, entry courts, or active recreation fields. (p. 41)
5. Choose drought tolerant species that do not require heavy application of energy intensive fertilizers, pesticides or herbicides, and water. (p. 67)

Current practices will continue to incorporate large areas of native and/or drought tolerant plants. Soils will continue to be treated prior to planting and exposed soil will be mulched. Stanford will continue to expand the coverage of the Maxicom or similar irrigation controller system, which is tied to a campus weather station for efficient water application. Current landscape maintenance practices include monitoring and reducing and/or eliminating water applications after the initial establishment of the plants.

3.3 Plans Review Process for New Buildings and Renovations

The current internal Stanford review process for plans includes review of the proposed design for both interior and exterior water use. Stanford Facilities engineers review the interior plumbing and equipment design. For example, once-through cooling systems are not allowed.

The plans are reviewed by Stanford staff from Utilities, Planning and Grounds Departments for exterior water use including review of landscape planting and irrigation design for type of plants and irrigation system components. The University's design guidelines for water conservation are listed above in Section 3.2.2.

4.0 HISTORICAL WATER USE AND PROJECTIONS OF FUTURE USE

4.1 Analysis of Historical Water Use

In order to accurately account for water conservation benefits from water conservation program savings, it is necessary to establish a baseline water use from historical data. The evaluation of historical water supply production for Stanford involved the analysis of available metering data between 1995 and 2000. Data show that the 12-month moving average from 1995 to 2000 for the domestic system is increasing slightly and was at approximately 2.7 mgd for fiscal year 1999-2000, the base year for the 2000 GUP. This report focuses specifically on water conservation for the domestic water supply system. The historical water use was further broken down into a water system profile to establish water demands by nine individual categories. The nine categories of water use analyzed are listed as follows:

- Student Housing & Dining
- Faculty/Staff Housing
- Academic
- Athletics
- Central Energy Facility (CEF/Cogen)
- Medical School
- Leased Commercial Spaces
- Construction Projects
- Domestic System Flushing

The categories were chosen to analyze domestic water use and consumption based on monthly-metered data from the Stanford Utilities Metering Database. The categories used represent specific types of water uses and are similar to those reported annually to BAWUA (BAWUA 2000). Analysis of the domestic water consumption trends included evaluation of monthly meter data for five years (1995 - 2000). A short description of the water use categories follows.

Student Housing and Dining. This category includes the undergraduate and graduate Student Housing and Dining Services. Included are dorms, fraternities and sororities, dining halls and kitchens, common use landscaped areas, and coin-operated laundry facilities.

Faculty/Staff Housing. This category includes approximately 900 single-family and multiple-family housing where approximately 2,500 university faculty and staff live. Included are common use landscaped areas, landscaped lands associated with homes, and internal and external house water use.

Academic. This category includes all the academic buildings, except the School of Medicine, and central campus landscaped areas. Included are laboratory, teaching, and administrative buildings, as well as libraries and the museum.

Medical School. This category includes all the buildings used by the School of Medicine that are located on campus in unincorporated Santa Clara County. Included are laboratory and administrative buildings and landscaped areas.

Athletics Department. This category includes all the athletic buildings, facilities, and playing fields. Included are swimming pools, gyms, administrative buildings, football practice field, football stadium, golf course (with minor interior use, irrigation is on the lake system), and common use landscaped areas.

Central Energy Facility/Cogen. The Central Energy Facility (CEF) produces electricity, chilled water, and steam for the campus and chilled water and steam for Stanford Hospital. Domestic water is used as the source supply for chilled water and steam make-up. There is also minor use of domestic water for bathrooms. The cogeneration (Cogen) facility is a power plant owned and operated by Cardinal Cogen, a subsidiary of General Electric. Commissioned in 1987, the plant consists of a natural gas powered turbine driving a 39.2 megawatt (MW) generator, waste Heat Recovery Steam Generator (HRSG), and a steam powered turbine driving a 10.7-MW generator. Waste heat from the gas turbine combustion process is used by the HRSG to generate high pressure steam, which is in turn used in the steam turbine to generate additional electricity. This is called a combined cycle process. Stanford uses about half the power generated by the Cogen plant, the balance is sold to PG&E.

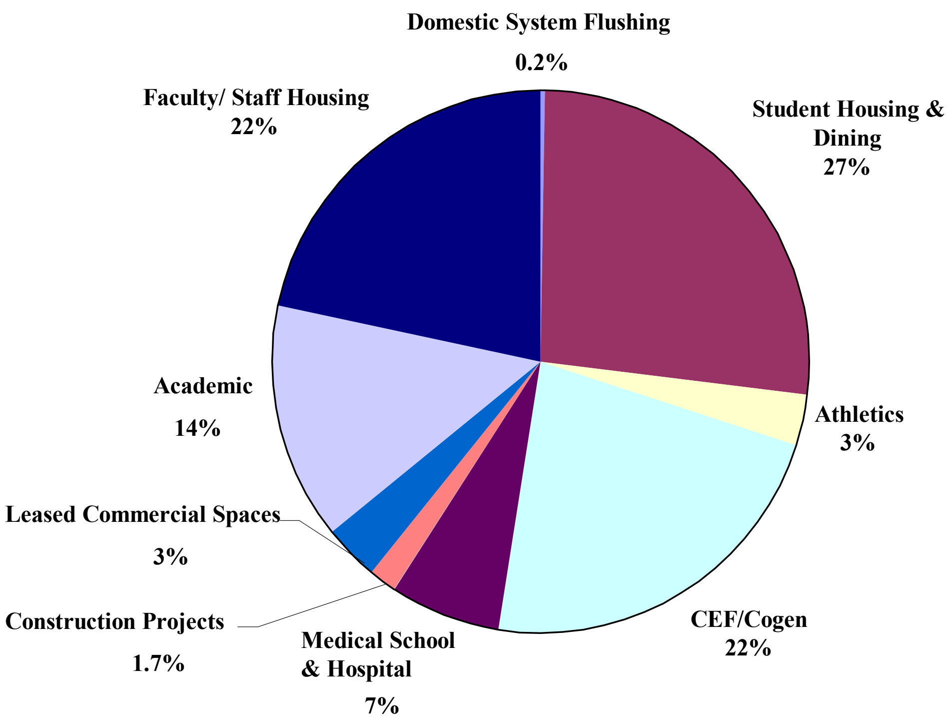
Leased Commercial Spaces. This category includes: the U.S. Post Office, Stanford Bookstore, various cafes and eateries, two Palo Alto schools (Escondido, Nixon), and Tresidder Union. Some minor landscaping is associated with these facilities.

Construction Projects. Buildings under construction or renovation are metered separately. The separate metering of construction projects began in 1998.

Domestic System Flushing. The Stanford Water Shop performs domestic water system flushing. Flushing is a routine maintenance practice for domestic water systems because it is necessary for maintaining water quality. Flushing is metered separately.

The respective percent of total annual average domestic water demand based on 5 years of metered data for each category is illustrated in Figure 4-1. This does not include unaccounted for water. Unaccounted-

Figure 4-1. Average Annual Demand By Category for Domestic Water System



for water is approximately 6.6 percent. Stanford's domestic system is very efficient compared to the industry goal of less than 10 percent unaccounted-for water as determined reasonable by the American Water Works Association (AWWA, 1996).

The following Table 4-1 represents the relative indoor and outdoor use patterns for the eight primary categories of use.

Table 4-1. Internal and External Domestic Water Use by Category

Category	Internal Water Use (percent)	External Water Use (percent)
1. Student Housing	70	30
2. Faculty/Staff Housing	40	60
3. Academic	80	20
4. Athletics	45	55
5. Construction Projects	0	100
6. Leased Commercial Spaces	50	50
7. Medical School	75	25
8. CEF	100	0

4.2 Major End Uses of Domestic Water

In addition to the historical water use by category presented in the above section, it is necessary to further review the data to determine major end uses of water and additional opportunities for water savings.

Where water savings are possible, water conservation measures target the appropriate major end uses. There are some end uses of water that are similar across nearly all categories. Two of these major end uses of domestic water are: (1) toilets; and (2) landscape irrigation, which are presented in Table 4-2 and Table 4-3 below.

Water use for toilet flushing is based on calibrating a fixture model to the various categories of water use. Estimates were made about the number of persons using the facilities in each category, and the number of times per day they do so.

Table 4-2. Domestic Water Use for Toilets by Category

Category	Average Water Use (gpd)	Percent of Total Daily Toilet Flushing
1. Student Housing	109,620	39.4
2. Faculty/Staff Housing	55,476	19.9
3. Academic	62,080	22.3
4. Athletics	8,511	3.1
5. Construction Projects	none	none
6. Leased Commercial Spaces	9,557	3.4
7. Medical School	33,100	11.9
8. CEF	negligible	negligible
Total	**278,344**	**100.0**

For indoor water use the total amount of water used for flushing toilets is 278,344 gallons per day, totaling about 10 percent of the total domestic water use on campus. Table 4-2 shows that the majority of the water use for toilets is in two housing categories: student and faculty/staff housing.

Table 4-3. Domestic Water Use for Landscape Irrigation

Category	Average Water Use (gpd)	Percent of Total Landscape Use
1. Student Housing	164,430	27.7
2. Faculty/Staff Housing	266,310	44.9
3. Academic	59,946	10.0
4. Athletics	31,624	5.3
5. Construction Projects	5,043	0.8
6. Leased Commercial Spaces	32,153	5.4
7. Medical School	35,306	5.9
8. CEF	negligible	negligible
Total	**594,812**	**100.0**

Irrigation water use, shown in Table 4-3, was based from review of the seasonal pattern of water billing data and assuming that nearly all of outdoor or seasonal use was for landscape irrigation. Irrigation is a significant use of domestic water, at about 22 percent of overall domestic use. Table 4-3 shows that over 70 percent of the irrigation using domestic water occurs in the housing areas, particularly in faculty/staff housing.

The two leading end uses of water: toilet flushing and landscape irrigation represent over 30 percent of the domestic water used on campus. Therefore, these two end uses are specifically targeted by conservation measures, in addition to evaluation of other end uses in Section 5.0.

Additional analysis was performed on historical irrigation water use patterns to assess the efficiency of water application rates in order to determine water conservation potential. The estimate for irrigation efficiency uses climate-adjusted water application rates for particular plant types and actual metered data for a specific area of a specific plant type to assess application rates. For example, Table 4-4 presents the water application rate for selected landscaped areas compared to the weather-adjusted water application rate theoretically required, based on the plant type. As a reference, the application rate is compared to water needs for cool season grass (local reference evapotranspiration value, ETo) as an upper bound (assuming 100 percent of ETo) and warm season grass irrigation needs (assuming 60 percent of ETo) on the lower bound to estimate irrigation efficiency for healthy plant growth. Local evapotranspiration data (ET) is measured hourly at a California Irrigation Management Information System weather station in San Jose. Evapotranspiration values for different plant types are defined in many irrigation publications (e.g., "Landscape Water Management for Water Savings", Municipal Water District of Orange County, 1998).

All application rates for the golf course and athletic fields, which have a full-time staff attending to playing surfaces quality, were relatively efficient compared to warm season grass application rates. Landscapes around academic buildings and student housing have been found to have higher application rates possibly resulting from one or a combination of any of these three factors: high water use plant types, old inefficient irrigation systems, or irrigation timers needing adjusting. The landscaped areas around academic and student housing areas are targeted for conservation measures as described in Section 5.0.

Table 4-4. Water Irrigation Application Rates for Selected Areas of Stanford Campus

Area	Water Source	Water Use, gpd (1)	Acreage			Application Rate (Inches water per year)
			Turf (2)	Shrubs (2)	Total	
Golf Course	Lake	250,000	110	---	110	30
Academic	Dom	60,000	6.3	6.4	12.7	62
Student Housing	Dom	164,400	40	2.6	42.6	52
Football Practice	Dom	15,800	5.4	---	5.4	38
Athletics on Lake	Lake	97,300	39.7	---	39.7	33
Totals	-	**490,200**	**201.4**	**9**	**210.4**	
(3) Reference Cool Season Grass						*64*
(4) Reference Warm Season Grass						*38*

Dom = Domestic Water Supply Source
gpd = gallons per day
(1) Estimated from seasonal variance in metered data from Stanford Utilities Metering Database
(2) Calculated from Landscapes at Stanford, map provided by Stanford Utilities (August 2001)
(3) Based on 100% of Eto (see text above)
(4) Based on 60% of Eto (see text above)

4.3 Campus Expansion Plans

The approved 2000 GUP campus expansion plans were used to develop the future water use projections. Data were provided and reviewed by the Stanford University Architect/Planning Office prior to initiation of modeling efforts and the development of the baseline water use projection discussed in the following section. Projections shown in Table 4-5 assume a 10-year build out of the 2000 GUP.

Table 4-5. Campus Expansion as Approved in 2000 GUP and Used for Future Water Use Projections

CATEGORY	PROJECTIONS										
	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Gross Academic Square Footage	8,342,334	8,813,353	9,016,853	9,220,353	9,423,853	9,627,353	9,830,853	10,034,353	10,237,853	10,441,353	10,644,853
Student Housing Beds	9,354	10,039	10,239	10,439	10,639	10,839	11,039	11,239	11,439	11,639	11,839
Faculty/Staff Housing	882	984	1,086	1,168	1,290	1,392	1,494	1,596	1,698	1,799	1,900
Med School Occupants	4,082	4,194	4,306	4,418	4,530	4,462	4,754	4,866	4,978	5,090	5,201
Total Population	19,666	19,774	19,882	19,990	20,098	20,206	20,314	20,422	20,530	20,638	20,748

Notes:

1) FY 2000-2100 growth under 2000 GUP: 2,035,000 academic square footage, 668 faculty/staff housing units and 350 post-doc housing units, 2201 total increase in faculty, staff and students. Medical school population increase totals 1,119. General campus population increase totals 1,082.
2) All future academic building, housing units and population growth is distributed evenly across the FY 2000-2010 planning horizon with two exceptions: 1) The addition of 485 student beds constructed under 1989 GUP is included in 2000-2001 academic year; and 2) A balance of 267,519 sq. ft. of academic building constructed.
3) Academic GSF does not include student housing GSF (3,684,377 up to and including build out under 1989 GUP).
4) Faculty/Staff units exclude the 108 units served water by the City of Palo Alto.

4.4 Baseline Water Use Projections by Category through 2010 GUP Build out

Historical water use and campus expansion plans under the approved 2000 GUP were evaluated to develop a baseline water use projection for the Stanford University campus, assuming that additional water conservation measures were not implemented. The baseline water use projection is based on growth projections described in Table 4.5 and the analysis of 5 years of metered data for each of the eight categories described in Section 3.0.

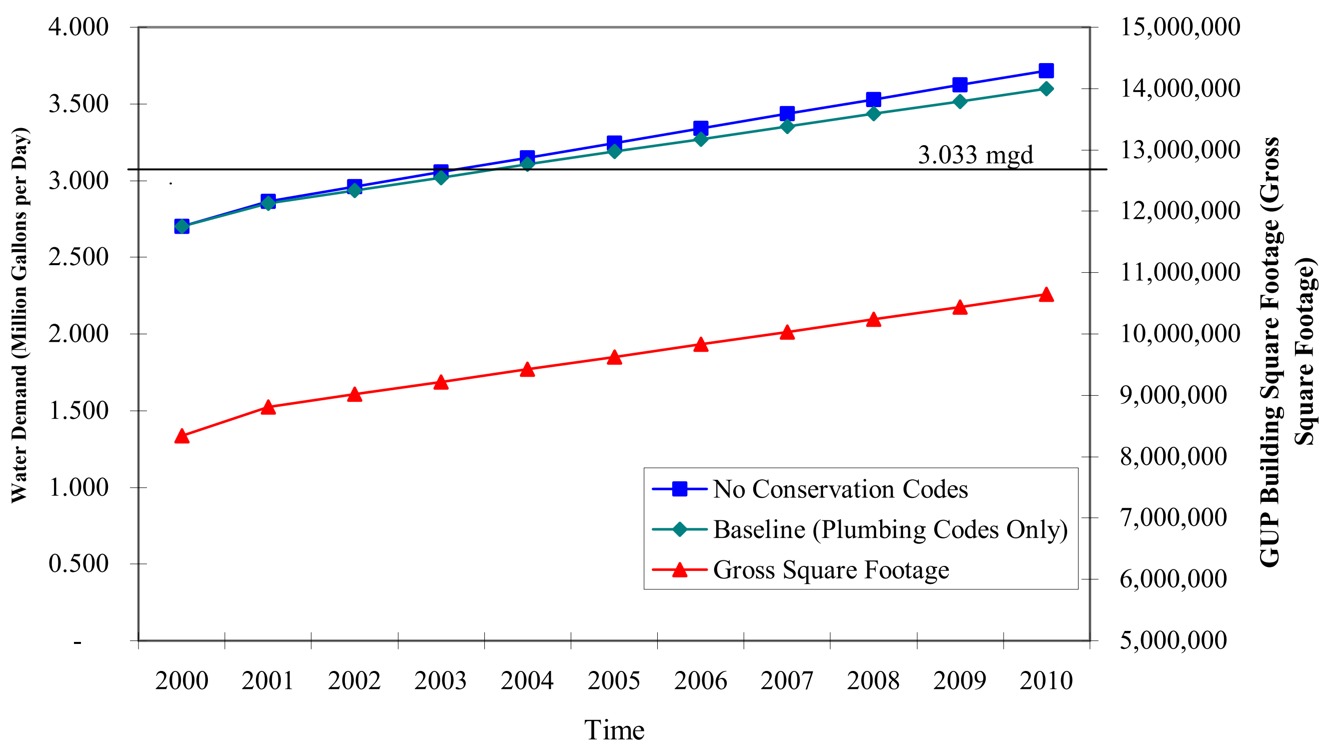
In developing the baseline water projection, each water use category was assumed to increase in proportion to one of the projections listed in Table 4-5. Specifically, the following relationships were assumed:

- Student Housing & Dining water demand increases with the number of new student beds
- Faculty/Staff Housing water demand increases with the number of new faculty staff housing units
- Academic water demand increases with academic square footage
- Athletics water demand increases with the campus population
- Central Energy Facility (CEF) water demand increases with academic square footage
- Medical School water demand increases with medical school occupants
- Construction Projects water demand increases with academic square footage
- Leased Commercial Spaces water demand increases with total campus population

This projection also takes into account current practices in water conservation such as the Landscape Design Guidelines and benefits of the expected natural replacement of plumbing fixtures to meet the National Plumbing Efficiency Standards that have been in place for almost 10 years (Appendix F). The future benefit of the Plumbing Efficiency Standards is especially significant and is also indicated as "baseline, (plumbing codes only)" and "No conservation codes" in Figure 4-2. The no conservation case shows that the water use would be higher if these plumbing standards were not in place.

Without water conservation (using conservatively high assumptions), the current average daily water use at 2.7 mgd, is projected to equal as much as 3.6 mgd by the end of the 2010 GUP build out. Therefore, it is clear that a water conservation, reuse and recycling program is needed to reduce campus-wide water use to stay within the 3.033 mgd daily allocation. Section 5.0 includes an evaluation of the water conservation measures potentially applicable for Stanford University and the resulting potential for water savings with associated costs of the conservation measures.

Figure 4-2. Projected Baseline Water Use Without Conservation and With Water Savings Benefits from Plumbing Codes Compared to Campus Growth



5.0 WATER CONSERVATION, REUSE, AND RECYCLING MEASURES

Water conservation, reuse and recycling should be based on the need for and benefit from saving water. The need to conserve water at Stanford, as in many communities throughout California and the world, is because of limited water supply. The cost savings from water conservation, reuse and recycling are primarily derived from reduced domestic purchases, reduced wastewater discharge costs and from the deferred need to acquire new water supplies.

5.1 Assessing Water Conservation, Reuse and Recycling Potential

Selection of water conservation, reuse and recycling measures that are applicable to Stanford is based on a review of projected water demands and growth on campus as discussed above in Section 4.0. The cost effectiveness of alternative conservation measures is evaluated in the following Sections.

5.1.1. Review of Water Metering Data

Analysis of water metering data indicated certain trends and areas where internal and /or external water use is relatively high (Table 4-1). High internal water use (especially for toilets, Table 4-2) is present in Student Housing, Academic areas and the Medical School, so for these categories conservation measures will focus on fixed end uses such as toilet flushing. Categories with high external uses were faculty/staff housing, athletics, and leased commercial spaces, so for these categories conservation measures will primarily focus on irrigation and landscape-related issues.

5.1.2. Site Visits

Maddaus Water Management performed site visits and interviews with Stanford staff knowledgeable about facility water use. Potential water conservation measures were discussed with Stanford staff. The following buildings were visited (with water use category listed in parenthesis):

- CIS (Academic)
- Gilbert Building (Academic)
- Beckman Building (Medical School)
- Central Energy Facility (CEF)
- Athletic Buildings and Fields (Athletic)
- Golf Course (Athletic) on Lake system
- Escondido, Stern, Toyon and Raines Buildings (Student Housing)

5.2 Spectrum of Measures for Water Conservation, Reuse, and Recycling Potential

Maddaus Water Management evaluated a comprehensive spectrum of water conservation measures in close collaboration with Stanford University utilities managers and individuals who will manage and implement the water conservation program (e.g., student housing representatives). Measures evaluated and included in this plan were determined to be appropriate for Stanford University.

In the assessment of conservation potential, consideration was given to a comprehensive list of conservation measures used by numerous utilities throughout California. Currently, over 165 utilities, including the Santa Clara Valley Water District and the San Francisco Public Utilities Commission, determine cost-effective conservation measures to implement in their service areas based on the Memorandum of Understanding (MOU) Regarding Urban Water Conservation in California. The 14

California Best Management Practices listed in the MOU are overseen by the California Urban Water Conservation Council and are presented in Table 5-1. Many of these measures are also used by utilities throughout California as part of the urban water supply planning process governed by the California Urban Water Management Planning Act, last amended in 1995. Some of these may be applicable for Stanford (CUWCC, 2001). The measures were considered when this Master Plan was developed, however only some are applicable to Stanford University's unique system and water use patterns. Site visits were used to refine the list of potential measures.

Table 5-1. Example of Water Conservation Best Management Practices

California Urban Water Conservation Council
As amended March 2001
(Completion Requirements in Italics)

1. **Water Survey Programs for Single-Family and Multi-Family Residential Customers** *(Survey 15 percent of residential customers within 10 years)*
2. **Residential Plumbing Retrofit** *(Retrofit 75 percent of residential housing constructed prior to 1992 with low-flow showerheads, toilet displacement devices, toilet flappers and aerators)*
3. **System Water Audits, Leak Detection and Repair** *(Audit the water distribution system regularly and repair any identified leaks)*
4. **Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections** *(Install meters in 100 percent of existing unmetered accounts within 10 years; bill by volume of water use; assess feasibility of installing dedicated landscape meters)*
5. **Large Landscape Conservation Programs and Incentives** *(Prepare water budgets for 90 percent of all commercial and industrial accounts with dedicated meters; provide irrigation surveys to 15 percent of mixed-metered customers)*
6. **High-Efficiency Washing Machine Rebate Programs** *(Provide cost-effective customer incentives, such as rebates, to encourage purchase of these machines that use 40 percent less water per load)*
7. **Public Information Programs** *(Provide active public information programs in water agencies to promote and educate customers about water conservation)*
8. **School Education Programs** *(Provide active school education programs to educate students about water conservation and efficient water uses)*
9. **Conservation Programs for Commercial, Industrial, and Institutional Accounts** *(Provide a water survey of 10 percent of these customers within 10 years and identify retrofitting options; reduce water use by an amount equal to 10 percent of the baseline use within 10 years)*
10. **Wholesale Agency Assistance Programs** *(Provide financial incentives to water agencies and cities to encourage implementation of water conservation programs)*
11. **Conservation Pricing** *(Eliminate non-conserving pricing policies and adopt pricing structure such as uniform rates or inclining block rates, incentives to customers to reduce average or peak use, and surcharges to encourage conservation)*
12. **Conservation Coordinator** *(Designate a water agency staff member to have the responsibility to manage the water conservation programs)*
13. **Water Waste Prohibition** *(Adopt water waste ordinances to prohibit gutter flooding, single-pass cooling systems in new connections, nonrecirculating systems in all new car wash and commercial laundry systems, and nonrecycling decorative water fountains)*
14. **Residential Ultra-Low-Flush Toilet Replacement Programs** *(Replace older toilets for residential customers at a rate equal to that of an ordinance requiring retrofit upon resale)*

The SCVWD Water Conservation Program currently provides rebates for Water Efficient Technologies (WET), including high efficiency washing machines, high efficiency nozzle sprayers for cafeteria dishwashers, and reclamation and reuse of rinse waters in x-ray machines. Stanford will review the potential retrofit projects and opportunities for rebates available from the SCVWD WET program and work with the SCVWD staff to obtain rebate funding.

The potential applicability of the above and additional conservation measures such as greywater were reviewed according to the following criteria:

- **Technology/Market maturity.** Is the technology commercially available and supported by the necessary service industry?
- **Applicability.** Is the technology applicable to the climate, building stock, or equipment that are typical at Stanford University?
- **Customer acceptance/equity.** Are customers willing to implement the measure? Is it fair?
- **Secondary impacts.** Does the measure affect environmental health or safety, or raise political problems?
- **Better measure available.** If there is more than one measure that addresses a specific inefficiency of water use, is one measure equivalent in function and clearly more cost-effective than other(s)?

This screening removed the measures that were inappropriate for further consideration. For example, greywater usage requires specified treatment, storage, and specific types of irrigation to be used for landscape irrigation. This alternative incurs significant environmental health and safety risks and requirements and also would be cost prohibitive, thus the measure was eliminated from further evaluation.

5.3 Evaluation of Potential Water Conservation, Reuse or Recycling Measures

After reviewing a comprehensive list of measures using the criteria above, the following 14 water conservation measures are considered appropriate for Stanford University (Table 5-2). They are evaluated for water savings potential and cost-effectiveness in the Sections below. The plumbing fixture replacements (showerheads, toilets, urinals, faucets) in Student Housing, Athletics, and Academic areas are selected based on quality, ease of maintenance, customer acceptance, and durability. The estimated costs for fixture replacements include scheduling the work with student residents. Additionally, working hour restrictions, incidental repairs, key control and security, contract requirements for insurance and bonding also impact the cost. The SCVWD has experienced lower costs for fixture replacements in municipal retrofit programs. The SCVWD has provided samples of showerheads and faucets, which are currently being tested and could reduce the cost of these fixture replacements.

Table 5-2. Potential Water Conservation Measures

No.	Measure
1.	Ultra Low Flush Toilet Replacement
2.	Showerhead Retrofit
3.	Urinal Replacement
4.	High-Efficiency Washer Replacement
5.	Public Outreach Programs
6.	CEF Blow down Reuse
7.	Faculty/Staff Housing Water Audits
8.	Landscape Water Management
9.	Selective Landscape Retrofit
10.	New Water Efficient Landscape
11.	New Landscape on Lake Water
12.	ET Controllers on New Faculty/Staff Housing Units
13.	Selected Academic Areas on Lake Water
14.	Football Practice on Lake Water

5.3.1. ULF Toilet Replacement

Recommend Stanford continue to implement a toilet replacement program, replacing high water-use toilets with ultra low-flush (ULF) toilets. ULF toilets reduce toilet-flushing water to about 1.6 gallons per flush (gpf). This is a significant water savings from an average of 5-7 gpf for regular (pre-1980) toilets, and 3.5 gpf for post-1980 toilets.

This program could be applicable to all existing housing and academic and commercial buildings and athletic facilities. It would have an overall goal, such as, replacing 90 percent of existing toilets within a specified time (e.g., three years).

Recommend Stanford develop an incentive strategy for the various customer groups. Toilets could be installed as part of remodeling projects or as separate projects.

The cost of the program would include the cost of the toilet and installation by a contractor. Costs would vary from $300 for a gravity flush toilet to $550 to a flush-o-meter-type toilet. Once toilets are replaced, the customer's toilet water end use should decline about 50 percent (Residential End Uses of Water, AWWARF, 1999).

5.3.2. Showerhead Retrofit

Recommend Stanford identify buildings constructed before 1992 that have not been retrofitted. Stanford would develop an incentive strategy to install low-flow showerheads in buildings with high flow fixtures. Installation could continue until at least 90 percent of all buildings are so equipped. Showerheads cost about $25 each, including installation, and save about 21 percent of shower water use.

5.3.3. Urinal Replacement

Recommend Stanford identify buildings constructed before 1992 that have not been retrofitted. Stanford would develop an incentive strategy for departments to retrofit old, inefficient urinals. The current standard for urinal flush volume is 1.0-gallon per flush. It appears that the standard may soon change and 0.5-gallon per flush urinals will be available. For existing urinals that are of the wash down type (no pool of water in the fixture) it is possible to just change the valve and leave the fixture in place. This would conserve water and save the cost of installing a new urinal. Waterless urinals are also available, but they require special maintenance and soon will only save an extra 0.5-gallon per flush. The program could continue until at least 90 percent of all buildings are so equipped with 0.5-gal per flush units. Urinals could cost $650 each (installed). Valves cost about $200 installed. An average cost of $400 per urinal is assumed. Water savings would be about 75 percent of urinal water use (change from 2 gallons/flush to 0.5 gallon/flush).

5.3.4. High-Efficiency Appliance Promotion Programs

Recommend Stanford replace existing coin-operated washing machines in Student Housing with new efficient (front-loading, horizontal axis technology) coin-operated models. This could reduce the current wash volume from 31.5 gallons per load to 20 gallons per load with new machines , saving 35 percent of the water used for washing clothes. Studies presented by the Consortium for Energy efficiency (CEE) indicate that high-efficiency commercial washers save up to 50 percent of energy costs and use about 30 percent less water. The CEE states that data from a study of a senior citizens community showed that water savings ranged from 10.5 gallons/cycle (28 percent) to 22.5 gallons per cycle (59 percent) over the baseline washer (Appendix F, CEE, 2000-02). The Student Housing Department is currently investigating the feasibility of a large-scale replacement of clothes washers. It may be possible for Stanford to take advantage of the washer rebate offer from the Santa Clara Valley Water District and Pacific Gas & Electric (where gas water heating and/or dryers are used). Currently the combined rebates could provide up to $175 per machine.

The total cost of new washers is anticipated to approach $1200. For the purposes of a water savings and cost effectiveness evaluation, an incremental Stanford rebate cost of upgrading to efficient models is assumed at $200 per machine. This would be the assumed amount of a rebate to the Student Housing Department.

In addition, other privately owned washing machines could be upgraded if owners changed the machines and participate in the SCVWD rebate offer directly.

5.3.5. Public Outreach

Public information and outreach serve as the “glue” to tie all the other measures together. It would not only call attention to and publicize specific conservation measures but also promote water conservation awareness among Stanford Utility customers, students, and faculty and employees. Most importantly, it would convey to the Stanford community the importance and significance of water conservation. Water conservation awareness could include poster contests, T-shirt design contests, presentations and tours with hands-on demonstrations, and radio advertisements. Additionally, customer bill inserts could include printed educational material, such as information showing use in gallons per day for the last billing period compared to the same period the previous year.

The following steps could be used to design new public information programs:

- Develop water conservation specific theme and logo.
- Identify key target groups.
- Select members for a water conservation committee.
- Identify communication paths, resource materials, and volunteers.
- Design and implement specific campaigns.
- Ensure effective coordination and implementation.

It is assumed that the public outreach program could save 3 percent of targeted end uses. Assumed cost is $50,000 per year.

5.3.6. CEF Blow Down Water Reuse

Blow down of cooling tower water is necessary to maintain an acceptable mineral concentration balance in the recirculating cooling water. Stanford is fortunate to have low mineral concentration SFPUC water to use in its cooling towers. The CEF cooling towers run very efficiently with about 10 cycles of concentration, which means that the process allows the cooling tower water to recycle until it is 10 times its initial concentration before it is discharged to the sanitary sewer. In many other locations in the San Francisco Bay Area cooling towers only run at 3 to 6 cycles. Due to Stanford's existing very efficient and aggressive management to prevent corrosion by the cooling tower water, there is little room for additional water conservation through operational changes. The current blow down of cooling tower water is about 50,000 gallons per day (gpd). The blow down water was tested and the mineral concentration is less than 300 mg/l TDS. On the basis of TDS, the blow down is acceptable for other uses, such as landscape irrigation or toilet and urinal flushing in new buildings. In addition to cooling tower source the blow down from the Heat Recovery Steam Generator at the CEF is also a significant source of reuse water (13,000 gpd) and also of good quality (although not specifically tested in this project). Thus an estimated 63,000 gpd is available on average, but this varies during the year depending upon the steam and cooling load on the plant. For example, cooling tower blow down increases in the summer when more water is needed for irrigation. The amount of blow down water will increase in the future as the load on the plant increases due to new buildings coming on-line.

The CEF is centrally located but the blow down would require storage, piping and pumping to reuse sites. It may be possible to simply tie the blow down into the lake water system. Alternatively, a separate piping system may be required. Specific projects to distribute and reuse the water would need to be developed. At this preliminary planning level it is assumed that the blow down could be reused at a capital cost of $500,000 and an operating cost of $10,000 per year. For the purposes of this evaluation it is assumed that the reuse water can be tied directly into the lake system and used for existing landscape needs. Based on a comparison of reuse supply and domestic irrigation demands, about 25 percent of the area currently irrigated with domestic water will also need to be converted over to the lake system to make full use of this water source. The cost estimate above is for the tie-in and the conversion and extension of the lake system. Treatment of the blow down water will be needed to remove anti-corrosion additives. The cost of treatment has not been estimated.

5.3.7. Faculty/Staff Housing Water Audits

Stanford would offer an indoor and outdoor water survey to not less than 30 percent of metered existing faculty/staff single-family and multiple-family customers.

Specific activities for each indoor survey would include:

- Check for leaks including toilets, faucets, and meter check

- Check flow rates for showerheads and faucets, and offer to replace or recommend replacement with low flow models as appropriate
- Check toilet flow rates, recommend installation of displacement device or direct customer to Ultra Low Flush Toilet (ULFT) replacement program, as appropriate; replace leaking toilet flapper, as necessary

The outdoor survey would consist of the following:

- Check irrigation system and timers
- Review or develop customer irrigation schedule in minutes of watering time per week for spring, summer, and fall.
- Provide a rain shut-off device (optional)
- Measure currently landscaped area (optional)
- Measure total irrigable area (optional)

Customer will be provided with survey evaluation results and water savings recommendations and given an information packet. Stanford will track surveys offered, surveys completed, survey results, and survey costs. Surveys cost about $50 per home (when using student labor) and will save about 5 percent of indoor use and 10 percent of outdoor use. Audits have about a five-year life and so must be repeated every five years to maintain savings.

5.3.8. Landscape Water Management

Stanford would undertake projects to increase water use efficiency at existing landscapes in student housing, academic, athletics, and faculty/staff housing. Although this report focuses on domestic use, this measure is equally applicable to irrigation water on the domestic and lake systems.

For accounts with Dedicated Irrigation Meters:

- Identify irrigation only accounts and provide them with a landscape water budget based on published plant water needs for turf grass or shrubs as appropriate.
- Provide notices with each water bill that shows the relationship between actual use and the water budget
- For larger accounts, such as selected athletic fields and other large landscapes, provide graphical comparison of monthly water use and water budgets

For accounts with Mixed-Use Meters:

- Develop a strategy to market landscape water use surveys and other techniques to accounts with significant seasonal water use that includes, where cost-effective:

  1. Landscape water use analysis and audits
  2. Voluntary water use budgets
  3. Installation of dedicated landscape meters
  4. Training in landscape and irrigation system maintenance
  5. Financial incentives such as rebates for efficient irrigation systems
  6. Follow-up water use analysis/surveys

General:

- Install climate-appropriate water-efficient landscaping at new facilities
- Provide customer notices at the beginning and end of the irrigation season advising them to check and adjust irrigation systems and timers

The cost of providing this service is assumed to be $1,000 per acre for a large turf area (figured on turf area per water meter basis). Over a five-year period, the top 25 percent of accounts on the domestic system with significant irrigation would be covered. The program is assumed to have a five-year life so surveys must be repeated periodically to maintain savings. Accounts that are treated would save about 10 percent of irrigation use. The cost of this service, $1,000 per acre, is applied every five years.

5.3.9. Selective Landscape Retrofit

Existing accounts with significant turf (used for decorative purposes only) would be relandscaped with water efficient plant material. Such projects would also involve replacing sprinkler turf irrigation systems with systems appropriate for shrubs and ground covers. Narrow strips of turf would be replaced because of the difficulty of irrigating efficiently. The retrofit would apply to selective landscape in academic areas, housing and public areas where the turf is not required for playing fields, student recreation or departmental use. Low water use plant material can generally be irrigated with about 30 percent less water than required by turf. The cost of relandscaping is on the order of $100,000 per acre, depending on soil preparation, specific plant material selected (which is usually more expensive than turf), and need for irrigation system retrofit.

Actual sites for retrofitting are to be determined. Future work would involve creating a list of those areas where retrofitting is appropriate and could save water. Retrofitting would likely be done in conjunction with building construction and renovation.

5.3.10. New Water Efficient Landscape

Stanford has been including water conservation measures in its landscape for the past 25 years. Current practices that will continue to incorporate large areas of native and/or drought tolerant plants and/or mulch into the improved areas, treating soils prior to planting, mulching all exposed soil, and installing the Maxicom or similar controller system that is tied to a weather station for efficient irrigation.

New landscapes would continue to be designed according to guidelines and criteria that emphasizes water efficient plant material, efficiently irrigated. The Stanford University Landscape Design Guidelines emphasize native landscaping. For this measure Stanford will adhere to the principles and practices outlined in the Stanford University Landscape Design Guidelines, March 1989.

Landscape maintenance practices include monitoring and reducing and/or eliminating water applications after the initial establishment of the plants. Additionally, areas not currently on the Maxicom system could be retrofit. The addition of the Maxicom controller or equivalent could be expensive relative to the size of a landscape project, adding an additional $5,000 to $10,000 per project.

5.3.11. New Landscape on Lake Water

New landscapes would be irrigated with lake water, rather than a mix of lake water and domestic water, as is the present practice. Outdoor use for new academic square footage, student housing, athletics, and commercial building landscaping would see no additional outdoor use on the domestic system. This would be a change in policy. The additional cost of this measure is assumed to range from $1,000 to $10,000 per account, depending upon the current distance of the new accounts from the current lake system. Since the landscape would be as originally planned, only the water connection would be altered. The water savings of this measure may be limited by the capacity of the lake system to take on new irrigated areas. Because of this uncertainty, long-term plans should rely on conservation measures to reduce the new irrigation demand, such as water efficient landscaping and reuse of cooling tower blow down.

5.3.12. ET Based Irrigation Controllers for New Faculty/Staff Housing Units

Stanford will install Evapotranspiration (ET) Controllers on newly constructed faculty-staff housing areas. These controllers place the responsibility for adjusting watering times to compensate for changing weather on the management company that provides the controllers. It is assumed that the controllers can be installed for approximately $300 each and maintained with a monthly fee (charged by the service provider) of approximately $4.00. Pilot tests have indicated that potential irrigation water savings are on the order of 15 to 25 percent. (Irvine Ranch Water District, 2001) Savings of 15 percent of irrigation use for new single-family homes and 20 percent of irrigation use for new multiple-family units.

5.3.13. Selected Academic and Medical School Landscaped Areas on Lake Water

The following five areas, currently irrigated with domestic water, could be switched over to the Lake System.

1. Law School
2. Kresge Auditorium
3. Brown Building
4. Alumni Center
5. Center for Clinical Sciences Research (CCSR) (Medical School)

Total turf area is 3-4 acres. The average water savings would be about 14,000 gallons per day (pending review of actual meter data). A water audit could be conducted for some of these areas to verify water savings. Cost for this conversion is assumed to be $5,000 per account, or $25,000 total.

5.3.14. Football Practice Field on Lake Water

The football practice field encompasses 5.4 acres of turf, irrigated with domestic water. Current use averages 15,800 gallons/day. The Lake system is located nearby and the retrofit to supply this area with Lake water would be relatively simple, and assumed to cost about $10,000.

6.0 CONSERVATION, REUSE AND RECYCLING MASTER PLAN EVALUATION

The measures described above were evaluated using a benefit-cost methodology to assess their value for implementation. A summary of the cost effectiveness analysis and results are provided below.

6.1 Water Savings and Costs of Measures

In order to combine measures into a cohesive program that Stanford could implement, evaluation of certain data is useful to include in the analysis of water savings, costs, costs per million gallons of water saved and benefit-cost ratio. Costs for implementing individual measures are derived from the best available industry knowledge and experience similar conservation programs.

The benefit-cost ratio and the cost of water saved in $/million gallons are presented in Table 6-1 based on the results of the measure evaluation. Our evaluation model, called the Decision Support System (DSS, See Appendix D), uses a 30-year analysis period for present value calculations. Savings are averaged over a 30-year period and can be different in selected years. In later years the water savings from the conservation measures will be higher than the values listed since all measures start at zero savings and ramp up to full effect after three to ten years. Water savings are presented for the whole program as a package of measures. However, Table 6-1 provides a rough estimate of the conservation potential of each individual measure.

Table 6-1. Results of Evaluation of Individual Measures

No.	Measure	Evaluation Criteria		
		Average Water Savings, mgd*	Utility Benefit-Cost Ratio	Cost of Savings per million gallons, $
1.	Ultra Low Flush Toilet Replacement	0.084	1.09	1,451
2.	Showerhead Retrofit	0.007	2.77	581
3.	Urinal Replacement	0.023	1.54	1,026
4.	High-Efficiency Washer Replacement**	0.010	19.14	492
5.	Public Outreach Programs	0.026	1.02	3,180
6.	CEF Blow down Reuse	0.060	1.04	1,000
7.	Faculty/Staff Housing Water Audits	0.037	3.46	733
8.	Landscape Water Management	0.010	1.38	480
9.	Selective Landscape Retrofit	***	***	***
10.	New Water Efficient Landscape	0.022	0.27	3,230
11.	New Landscape on Lake Water	0.086	6.72	132
12.	ET Controllers on New Faculty/Staff Housing	0.124	0.96	321
13.	Selected Academic Areas on Lake Water	0.013	5.86	163
14.	Football Practice on Lake Water	0.011	12.31	78

* Caution: savings cannot be added without handling measure overlap water savings averaged over 30 years. Actual savings in 2010 may be higher. (See Appendix D);

** This measure's benefit-cost ratio includes a rebate of $200 per washing machine.

*** To be determined, the annual report will list specific projects completed during the reporting year and associated estimated water savings.

6.2 Benefits of Saving Water

It is not certain where Stanford might acquire new water supplies in the future in the absence of water conservation. In our evaluation, the benefits are based on deferring the cost of a new well for Stanford and savings from reduced sewer flows. Specifically the benefits are based on the following assumptions:

- Cost of SFPUC water ($1,176 per million gallons currently)
- Cost of new well $1,000,000
- Operating cost of new well $150/million gallons pumped (energy and chemicals)
- Pump tax from Santa Clara Valley Water District at $330 per acre-foot pumped
- Maximum capacity of new well 500 gpm (0.72 mgd)
- Operating capacity of average 0.45 mgd
- Addition of new well is assumed if and when average day domestic demand reaches 3.25 mgd (which will occur about 2006 w/o additional conservation). This could be eliminated if additional conservation keeps domestic average daily use below 3.033 mgd.
- Cost of wastewater discharge to Palo Alto regional facility at $1000 per million gallons

The above benefits apply to reduction in indoor and outdoor use. Programs that reduce both will have benefits, however outdoor use reduction programs that reduce peak day water use will have the most impact on the timing of constructing a new well. Water supply capital projects are designed to meet peak day capacity needs, and the next increment of supply is constructed as the existing capacity approaches peak day demands.

Other benefits from the program include energy savings from the following measures: Showerhead Retrofit; High Efficiency Washers; and Faculty Staff Housing Water Audits. These benefits accrue to the water user (customer) and factor into their decision to participate in voluntary programs.

6.3 Cost-Effectiveness Analysis

Only a complete program consisting of individual conservation measures that has a benefit-cost ratio of more than 1.0 is considered cost effective (Appendix D). As a point of reference for the cost of water savings per million gallons, SFPUC water currently costs $1,176 per million gallons. Any cost of water saved that is less than this is cheaper than buying the water from SFPUC. As presented in Table 6-1, 10 out of 14 individual measures have a benefit-cost ratio over 1.0.

In order to achieve the goal of maintaining domestic water use within the 3.033 mgd allocation, all measures listed in Table 5-2 were needed for the Master Plan.

6.4 Evaluation of Master Plan

The program of measures described above was evaluated to determine combined water savings, costs and benefits. Results are shown in Table 6-3 and include water savings, cost by year for implementation, benefits, and benefit-cost ratio for the program. Note that the program is cost-effective, with a benefit/cost ratio over 1.0. The Master Plan would eliminate the need for a new well.

Figure 6-1 shows the projected water demand without conservation and then with the Master Plan. The baseline, or no additional conservation is labeled “Baseline (Plumbing Codes Only).” It should be used for comparison purposes only because the plumbing and appliance codes are already in place and providing “free” conservation over time as older fixtures and appliances are replaced with new more efficient models that meet today's standards. Conservation savings are measured against this baseline. Furthermore, after the GUP 2000 build out is completed, the conservation measures will keep Stanford within the 3.033 mgd allocation.

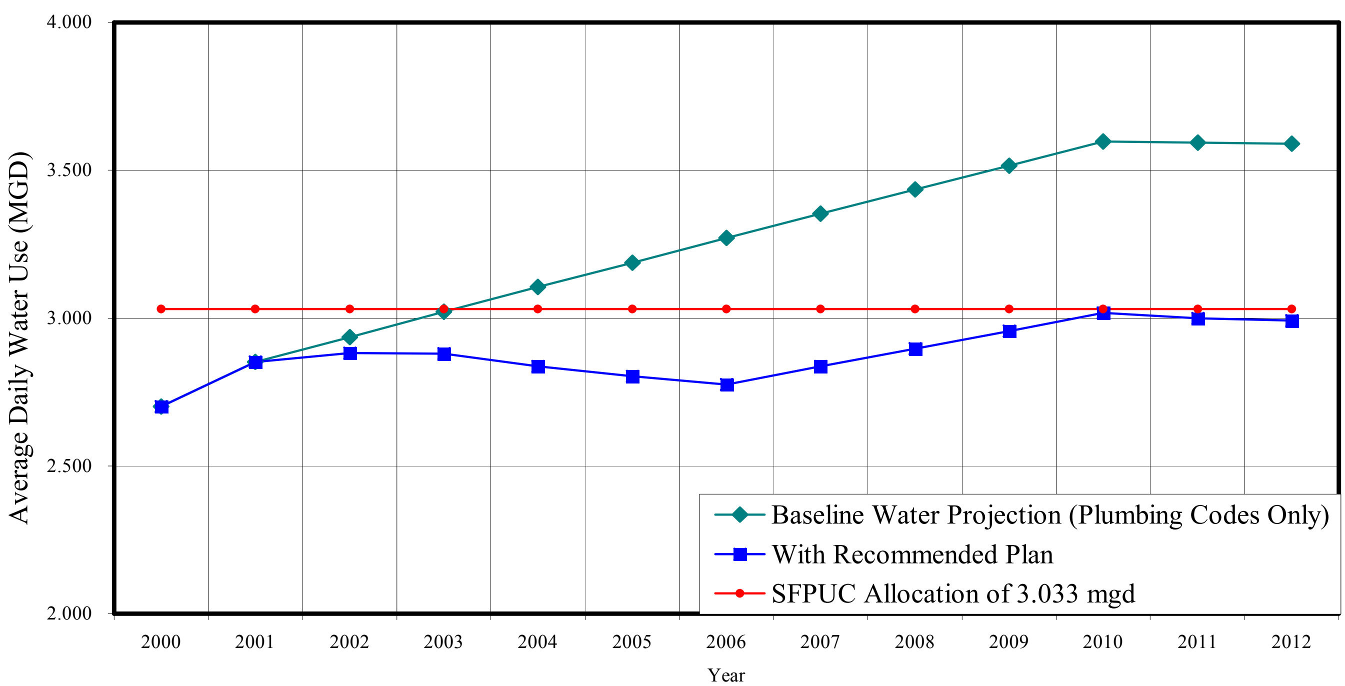
Table 6-2 shows the water savings and costs and benefits for the Master Plan. Note that total costs shown for the two five year-periods is coincidently close to but not the same as the 30-year present value of the costs. The benefits are based on the current costs of SFPUC water and the list described in section 6.1.

Table 6-2. Estimated Savings and Costs of Water Conservation, Reuse and Recycling Master Plan

Savings/Costs	Master Plan
Water savings in 2005, mgd	0.38
Water savings in 2010, mgd	0.52
Total Cost 2002-2005, million $	2.75
Total Cost 2006-2010, million $	1.78
Present Value of Costs, million $**	4.90
Present Value of Benefits, million $*	7.59
Cost of Water Saved $/million gallons**	965
Benefit/Cost Ratio	1.55

*Based on current cost of SFPUC water of $1,176 per million gallons.
**Present Value is based on 30-year actual costs and benefits.

Figure 6-1. Projected Water Demand with and without Water Conservation Master Plan



7.0 RECOMMENDED WATER CONSERVATION, REUSE AND RECYCLING MASTER PLAN

7.1 Recommended Master Plan Measures

Based on the evaluation in Section 6.0, the Master Plan was found to be the best plan for Stanford. The Master Plan measures are briefly described in Table 7-1. Note, measures are not listed in priority order.

Table 7-1. Master Plan Measures

No.	Measures	Brief Description
1.	Ultra Low Flush Toilet Replacement	Replace 90 percent of inefficient toilets with 1.6 gallon/flush models in all campus facilities.
2.	Showerhead Retrofit	Replace 90 percent of inefficient showerheads with low flow models in all campus facilities.
3.	Urinal Replacement	Continue with current urinal replacement plans but delay on the remaining until 0.5 gal/flush units or valves are on the market and use these to attain a 90 percent replacement rate.
4.	High-Efficiency Washer Replacement	Replace existing washing machines in student housing with efficient (such as front loading) models. Retain pay-per-use machine types.
5.	Public Outreach Programs	Implement a multi-faceted public education program directed at departments, students, and employees stressing the need to conserve water. Highlight programs and rebates available.
6.	CEF Blow down Reuse	Prepare preliminary engineering and pilot testing of cooling tower and boiler blow down water for irrigation. Determine best way to integrate this source with the lake system and use to irrigate new and existing areas.
7.	Faculty/Staff Housing Water Audits	Offer indoor/outdoor water audits to not less than 30 percent of the faculty-staff housing on a repeating five-year cycle. Focus on reduction of irrigation, toilet and washer use.
8.	Landscape Water Management	Provide water budgets and tracking of performance on a monthly basis for large irrigated sites. Conduct large turf audits periodically.
9.	Selective Landscape Retrofit	Retrofit turf areas and irrigation systems known or shown to be inefficient with low water use plant landscapes where feasible and cost-effective.
10.	New Water Efficient Landscape	Amend and require use of Stanford's Landscape Design Guidelines and FDS to ensure predominant use of water-efficient plant types is used. Develop and adhere to water budgets. Conduct water efficiency reviews of plans.
11.	New Landscape on Lake Water	Put all new landscapes on the lake water system.
12.	ET Controllers for New Faculty/Staff Housing	Install Evapotranspiration (ET) based controllers on all irrigated landscapes in new Faculty/Staff housing areas.
13.	Selected Academic Areas on Lake Water	Switch irrigation of five specifically identified landscapes from the domestic to lake system.
14.	Football Practice on Lake	Extend the lake system to irrigate the football practice field.

7.2 Additional Recommendations for New Buildings and Renovations – Recommended Plans Review Process

Besides conservation measures and the existing Stanford internal process to review plans for new buildings, the Master Plan includes additional recommendations. In addition, future Stanford plan reviews would focus on interior and exterior water use with additional specific criteria. The interior plumbing and equipment design review that Stanford undertakes would include review of efficiency of water consumption based on available technology. For example, to prevent disposal of steam condensate with poor quality (and use of additional domestic water), review of design of steam systems in buildings should include building heat load analysis and appropriate heating equipment sizing. Heat exchanger trapping and condensate return piping should be designed to prevent heat exchanger failures and steam condensate contamination.

7.3 Landscape Water Management for Recommended Best Management Practices

Although most landscape water use is on the lake system, landscape water use on the domestic system still amounts to almost an average of 0.6 mgd or over 22 percent of current use. Water conservation is also planned for the Lake System to ensure supply will be available. The proposed CEF reuse project will help in the supply area but there is still a need for improved campus wide landscape water management. Based on our evaluation the following strategy for increasing water efficiency is recommended.

1. Practice Landscape Water Management on all large turf sites (suggested cut-off is 0.5 to 1.0 acres per site). The Santa Clara Valley Water District has offered two water audits. These should be arranged by the Utilities Department and coordinated by the Grounds Department that is responsible for implementation of audit findings. Irrigation systems found to have low sprinkler uniformity should be scheduled for renovation. Suggested irrigation watering times resulting from the water audits should be programmed into the Maxicom system by the Grounds Department.
2. New and renovated landscaped areas should use only the lake water system for irrigation (unless prohibitively expensive). Separate meters will be placed on all large landscapes. Tie irrigation of all large sites into Maxicom system, including installation of flow sensors. Provide appropriate water budgets for each site.
3. Amend Stanford University Landscape Design Guidelines, March 1989, or Facilities Design Standards (FDS) to ensure water efficient landscapes are installed. Suggested amendments include:
    a. Provide a list of recommended drought tolerant plant materials including low water use turf, ground covers, shrubs and trees. There are a number of good books specific to the Bay Area such as “Water Conserving Plants and Landscapes for the Bay Area” by East Bay Municipal Utility District (1990).
    b. Require that irrigation plans and irrigation plans show a water budget for the project and a suggested baseline irrigation schedule.
    c. Provide criteria as to when and how to tie new landscaped areas into the Maxicom irrigation controller and include flow sensors.
    d. Review landscape plan for water efficiency.
4. Implement Stanford University Landscape Design Guidelines, March 1989, and FDS Guidelines for all new and relandscaped areas. Review all landscape and irrigation plans from the standpoint of achieving landscape water use efficiency. Adopt a goal of a water budget of three feet of applied water per year (not on individual projects, but overall). Do an annual water use review of all newly and recently planted areas to verify appropriate watering.

5. Create new supply for lake water system through implementation of reuse of CEF cooling tower and Heat Recovery Steam Generator blow down. Prior to tying these streams into the lake system do thorough chemical testing and if necessary, irrigation of test plots to verify the water is not harmful to plants.
6. Selectively retrofit landscape areas to save water. Criteria for retrofit projects could include:
   a. Eliminate narrow strips of turf (less than eight feet wide) by replacement with other drought tolerant plantings.
   b. Eliminate slopping turf that serves no purpose other than ornamental
   c. Replace high water use plants with low water use plants, except in flowerbeds and courtyards
   d. Connect irrigation systems to the Maxicom system where feasible and cost-effective (from a water savings standpoint)
7. Investigate the application of new irrigation technology to the Stanford Campus. The first new technology to investigate is installing ET Controllers on existing faculty/staff housing areas. Existing faculty/staff housing consumes almost half of the irrigation water on the domestic system (10 percent of total domestic use). The number of required controllers for Stanford faculty staff housing is not known. These controllers would replace existing controllers and shift the responsibility of adjusting watering times to compensate for changing weather to the management company that provides the controllers. Pilot testing a few brands of ET Controllers in the existing faculty/staff housing area is recommended to find the most advantageous and easy to implement. It is appropriate that a consistent brand is selected. Installation on new housing units is included in the Water Conservation, Reuse and Recycling Master Plan

7.4 Implementing and Staffing the Master Plan

Implementation of the Master Plan will involve staffing, funding and other resources. The Utilities Division will manage the Water Conservation, Reuse and Recycling Master Plan. Implementation of the specific programs will be in collaboration with individual departments, as shown in Table 7-2. In-house staff can carry out some of the work; other work can be done by contract.

In order to effectively manage this program Stanford Utilities Division will need to allocate resources to manage the Water Conservation Master Plan. Duties would include:

- Coordinate, communicate implementation of all measures/programs
- Develop budget and track expenses and progress
- Develop and carry-out the Public Outreach Program
- Interface with other outside groups such as the Santa Clara Valley Water District, SFPUC and the BAWUA
- Participate in the activities of the California Urban Water Conservation Council, as appropriate
- Investigate and potentially pilot-test new technology
- Provide timely information to departments on their water use, develop water budgets, and compare water budgets to actual use for large landscape users.

Table 7-2. Responsible Departments for Implementation of Measures

No.	Measure	Responsible Departments
1.	Ultra Low Flush Toilet Replacement	Student Housing, , Zones (Academic), Athletics, Medical School
2.	Showerhead Retrofit	Student Housing, Athletics
3.	Urinal Replacement	Student Housing, Zones (Academic), Athletics, Medical School
4.	High-Efficiency Washer Replacement	Student Housing
5.	Public Outreach Programs	Utilities
6.	CEF Blow down Reuse	CEF, Utilities, Grounds
7.	Faculty/Staff Housing Water Audits	Utilities/Contractor
8.	Landscape Water Management	Grounds, Utilities
9.	Selective Landscape Retrofit	Planning, Grounds
10.	New Water Efficient Landscape	Planning, Grounds
11.	New Landscape on Lake Water	Utilities, Capital Planning Management (CPM)
12.	ET Controllers	Utilities, Grounds
13.	Selected Academic Areas on Lake Water	Utilities, Grounds
14.	Football Practice on Lake Water	Utilities, Athletics

Note: Zones, Utilities, and Grounds are departments within the Stanford University Facility Operations Department.

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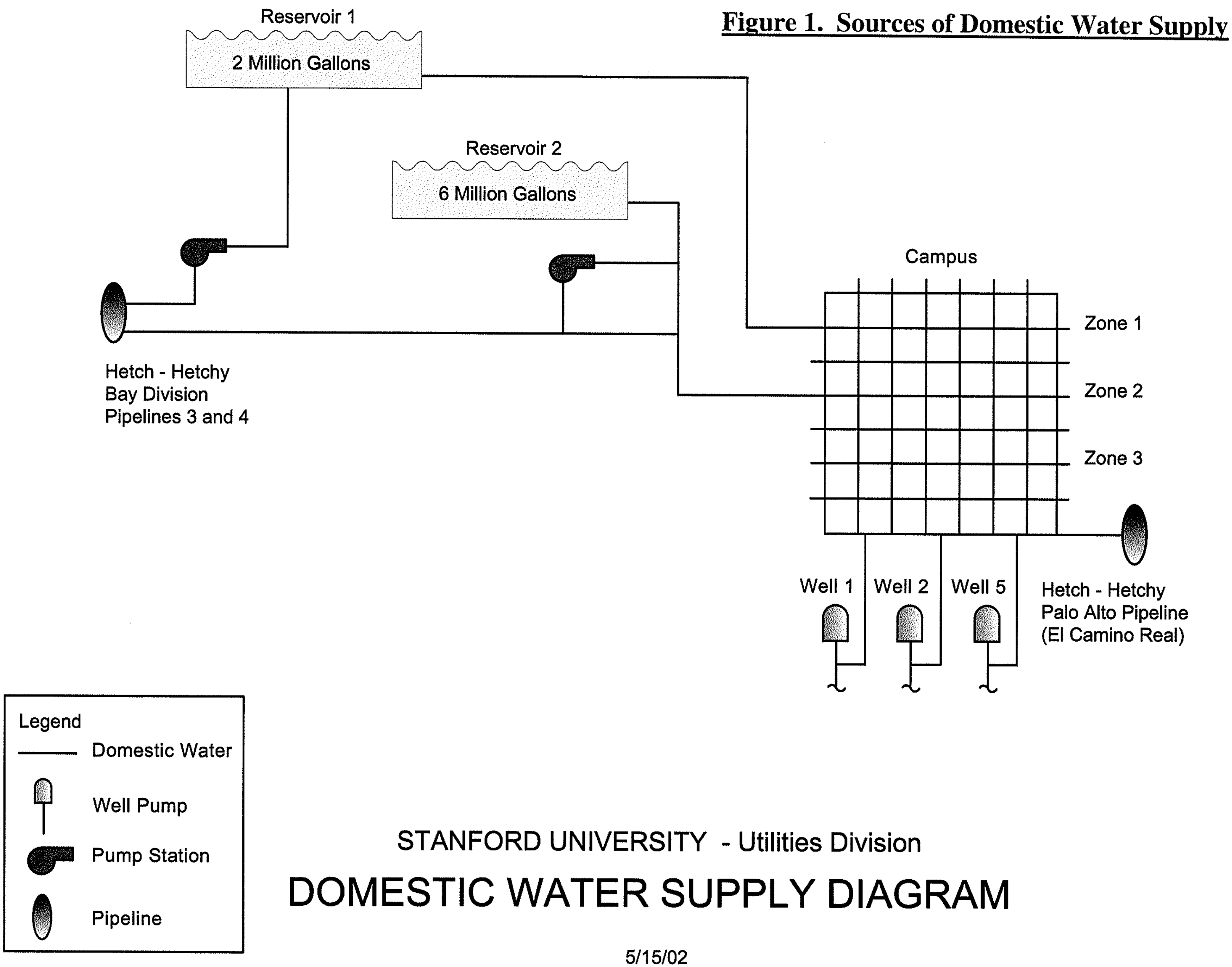
LIST OF APPENDICES

Appendix A

Figure 1. Sources of Domestic Water Supply



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Appendix B

Exhibit 15, BAWUA Annual Survey Report, 2000

Gross Per Capita Consumption Among BAWUA Members
FY 1999-00

Agency	Service Area Population	Total Consumption* (ccf)	Gross Per Capita Consumption (GPCPD**)
Guadalupe Valley County WD	10,800	130,412	24.7
East Palo Alto WD	27,300	996,890	74.8
City of Daly City	104,571	4,138,917	81.1
North Coast WD	39,667	1,690,405	87.3
Los Trancos Water District	1,230	59,273	98.8
Westborough WD	9,990	504,272	103.4
City of San Bruno	41,750	2,148,394	105.5
Skyline County WD	1,631	84,702	106.4
Brisbane Water Department	4,063	227,801	114.9
Coastside County WD	17,990	1,060,573	120.8
City of Millbrae	21,394	1,268,771	121.5
CWS - Mid Peninsula	120,820	8,231,977	139.6
Mid Peninsula (Belmont WD)	25,500	1,744,963	140.2
City of Redwood City	83,000	5,784,279	142.8
City of Hayward	128,000	9,133,496	146.2
Stanford University	24,700	1,772,457	147.1
Alameda County WD	318,250	24,654,808	158.8
Cordilleras	40	3,105	159.1
CWS - South San Francisco	54,060	4,218,788	159.9
City of Burlingame	30,000	2,383,663	162.8
Estero Municipal ID	34,252	2,765,373	165.5
City of Mountain View	76,025	6,274,818	169.1
City of Sunnyvale	131,200	11,276,687	176.1
City of Milpitas	65,000	5,831,829	183.9
CWS - Bear Gulch	65,830	6,150,566	191.5
City of Palo Alto	61,200	6,779,838	227.0
City of Santa Clara	102,500	12,317,089	246.3
Town of Hillsborough	11,760	1,720,719	299.9
Purissima Hills WD	5,800	1,033,036	365.0
City of Menlo Park	10,200	1,819,883	365.6
City of San Jose (North)	7,000	2,469,789	723.1
Totals	**1,635,523**	**128,677,573**	**161.2 (Average GPCPD)**

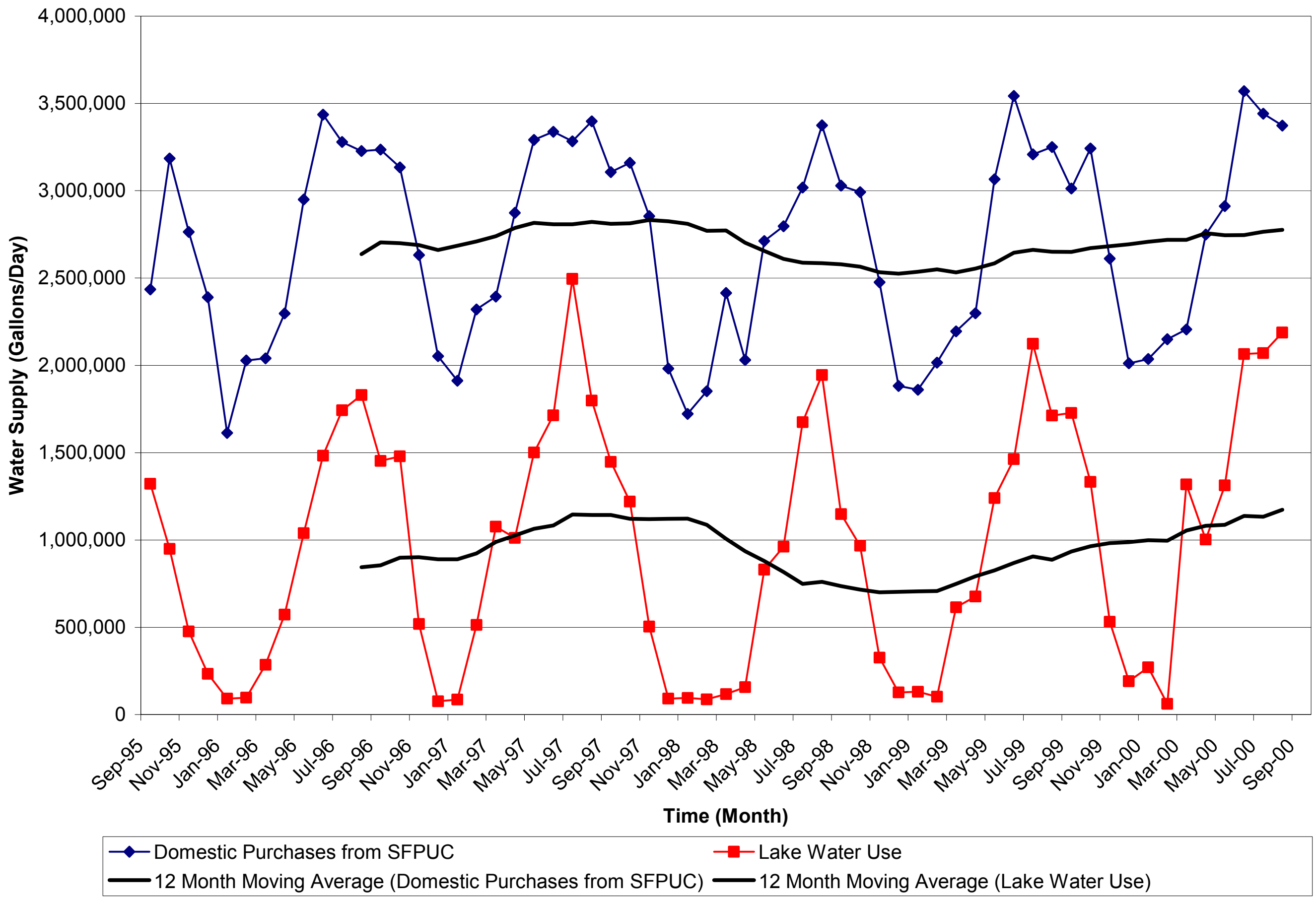
*Inclusive of recycled water

**GPCPD = Gallons Per Capita Per Day

APPENDIX C- HISTORICAL WATER USE

In order to accurately account for water conservation benefits from water conservation program savings, it is necessary to establish a baseline water use from historical data. The evaluation of historical water use for Stanford involved the analysis of available metering data between 1995 and 2000. The following graph (Figure C-1) presents the baseline historical use of domestic and lake water systems for Stanford. The 12-month moving average from 1995 to 2000 for the domestic system is increasing slightly and was at approximately 2.7 mgd for fiscal year 1999-2000, the base year for the 2000 GUP. The Master Plan report focuses specifically on water conservation for the domestic water supply system.

Figure C-1. Stanford's Historical Water Supply Production 1995-2000



The following graphs in Figures C-2 through C-9 present the detailed data for each of the seven categories described in Section 4.2 of the report. Each graph illustrates both seasonal patterns and general trends of use with a 12-month moving average displayed and linear trends in use. In addition, the end uses of the CEF water are presented in Figure C-10.

Student housing represents approximately 27% of total domestic use purchased from SFPUC. Figure C-2 below presents the historical domestic use for student housing with an average daily use of approximately 675,000 gallons per day. The linear trend and 12 month moving average indicates a general increase in water demand.

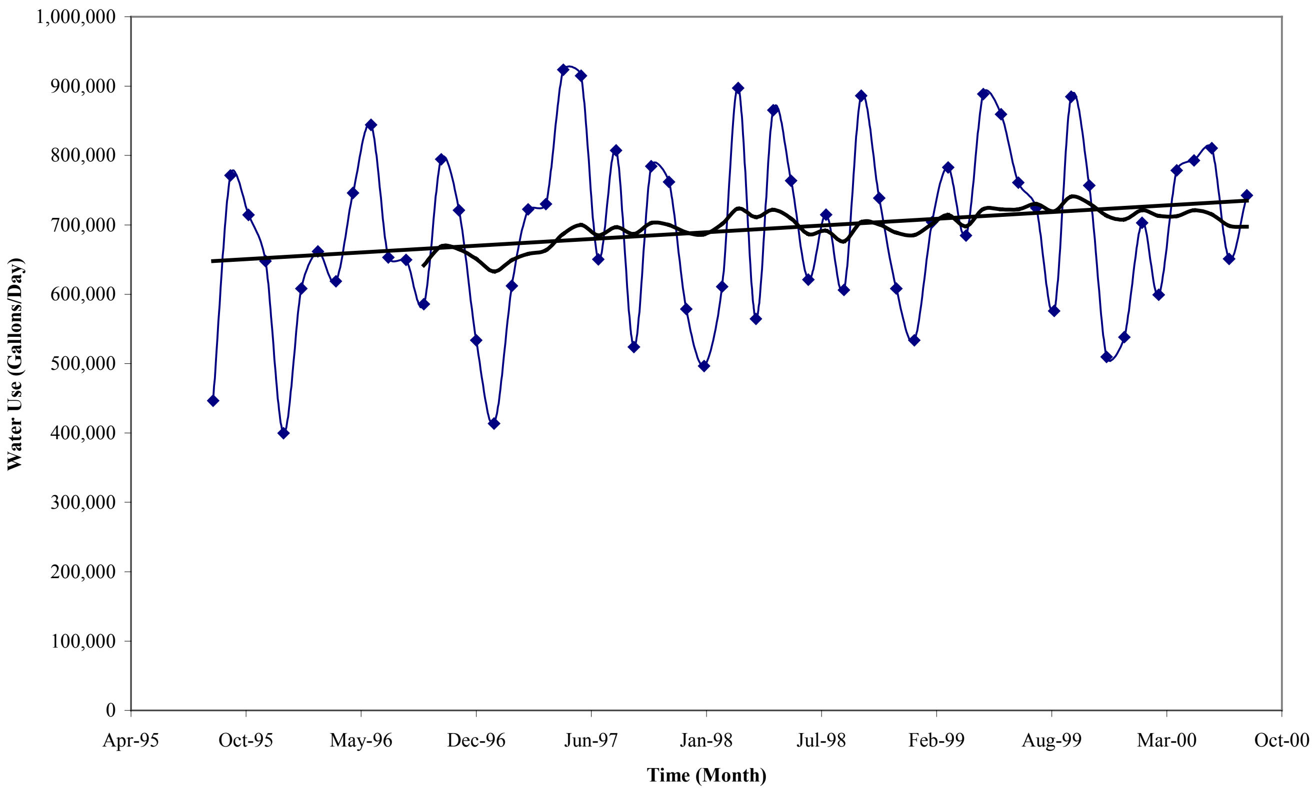


Figure C-2. Domestic Historical Monthly Water Use for Student Housing & Dining

Faculty Staff housing represents approximately 22% of total domestic use. Figure C-3 below presents the historical domestic use for faculty and staff housing with an average daily use of approximately 550,000 gallons per day. The linear trend and 12 month moving average indicates a general increase in water demand.

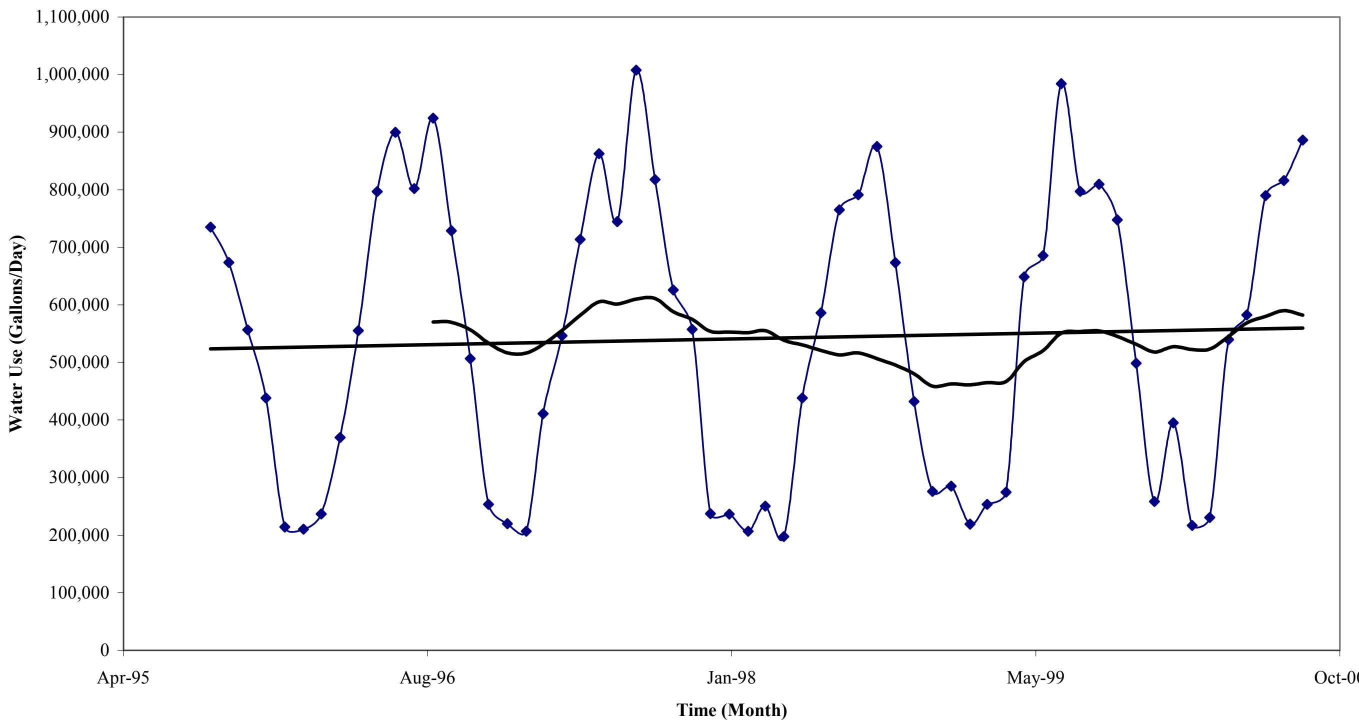


Figure C-3. Domestic Historical Monthly Water Use for Faculty/Staff Housing

Academic departments represent approximately 14% of total domestic use. Figure C-4 below presents the historical domestic use for academic departments with an average daily use of approximately 600,000 gallons per day. The linear trend and 12 month moving average indicates a general decrease in water demand. This downward trend is considered attributable to the metering program, which is systematically reducing the unmetered data with the installation of new meters. See the following Figure C-5 for the representation of unmetered versus metered use and note that the Academic metered data presents a relatively flat trend in use. The unmetered use was found to be 6.6 percent of the domestic supply. This indicates a relatively low level of leakage and other unaccounted for water for the domestic system.

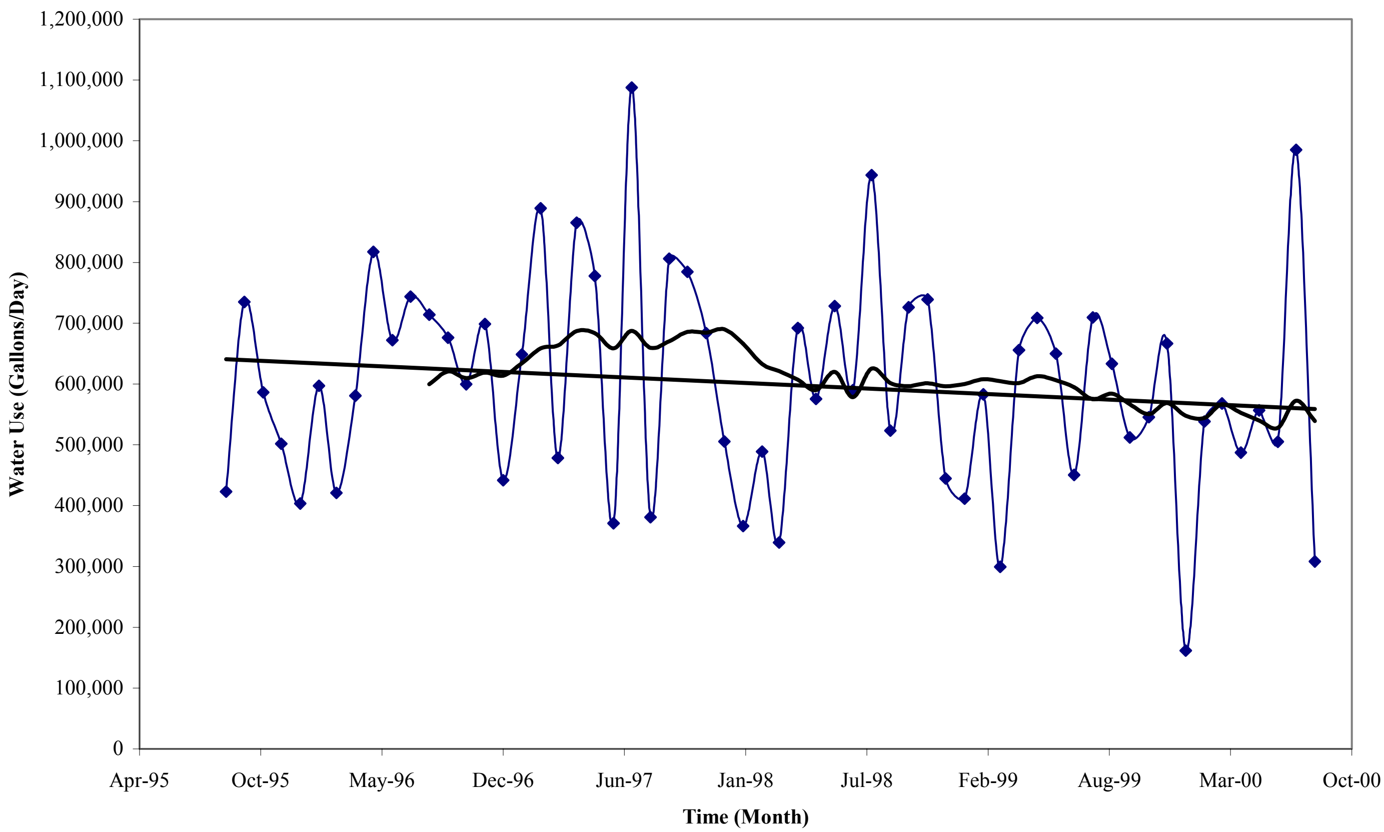


Figure C-4. Domestic Historical Monthly Water Use for Academic With Unmetered Data (or Unaccounted for Water)

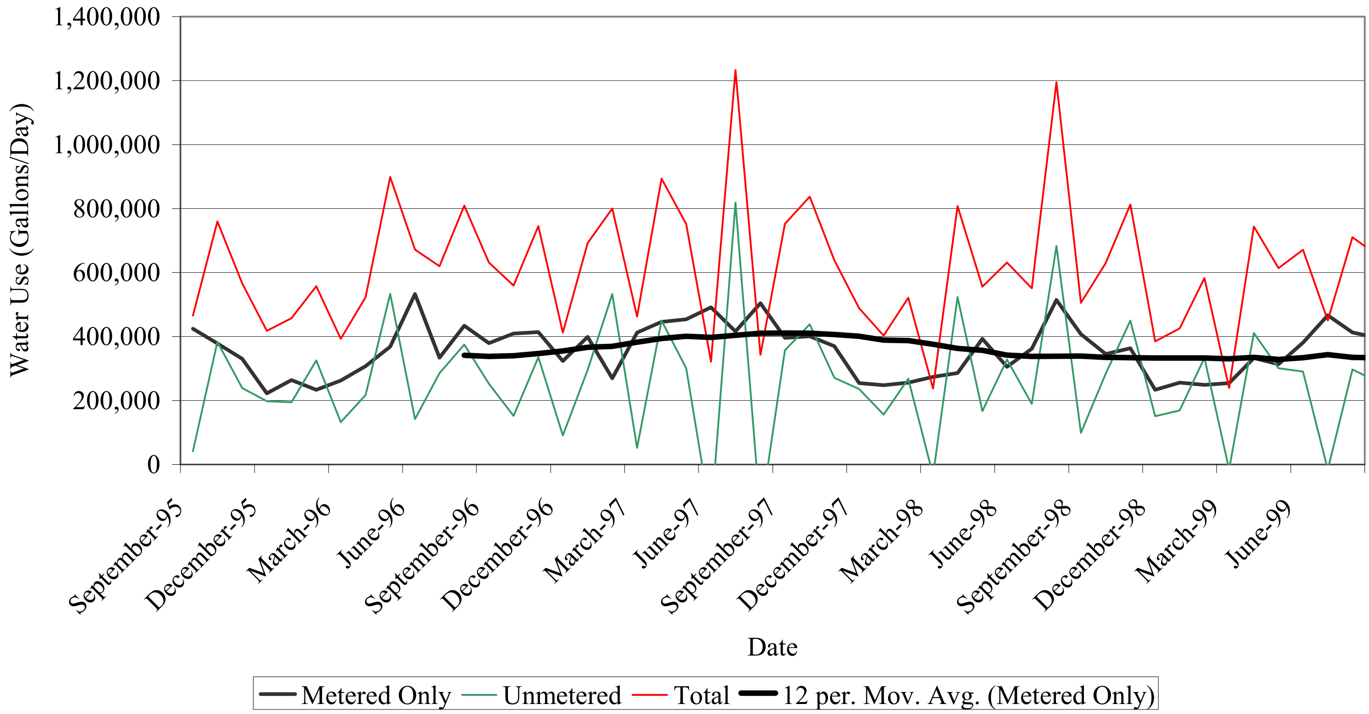


Figure C-5. Domestic Historical Daily Water Use for Academic without Unmetered Data

Commercial spaces represent approximately 3% of total domestic use. Figure C-6 below presents the historical domestic use for commercial spaces with an average daily use of approximately 60,000 gallons per day. The linear trend and 12 month moving average indicates a general increase in water demand.

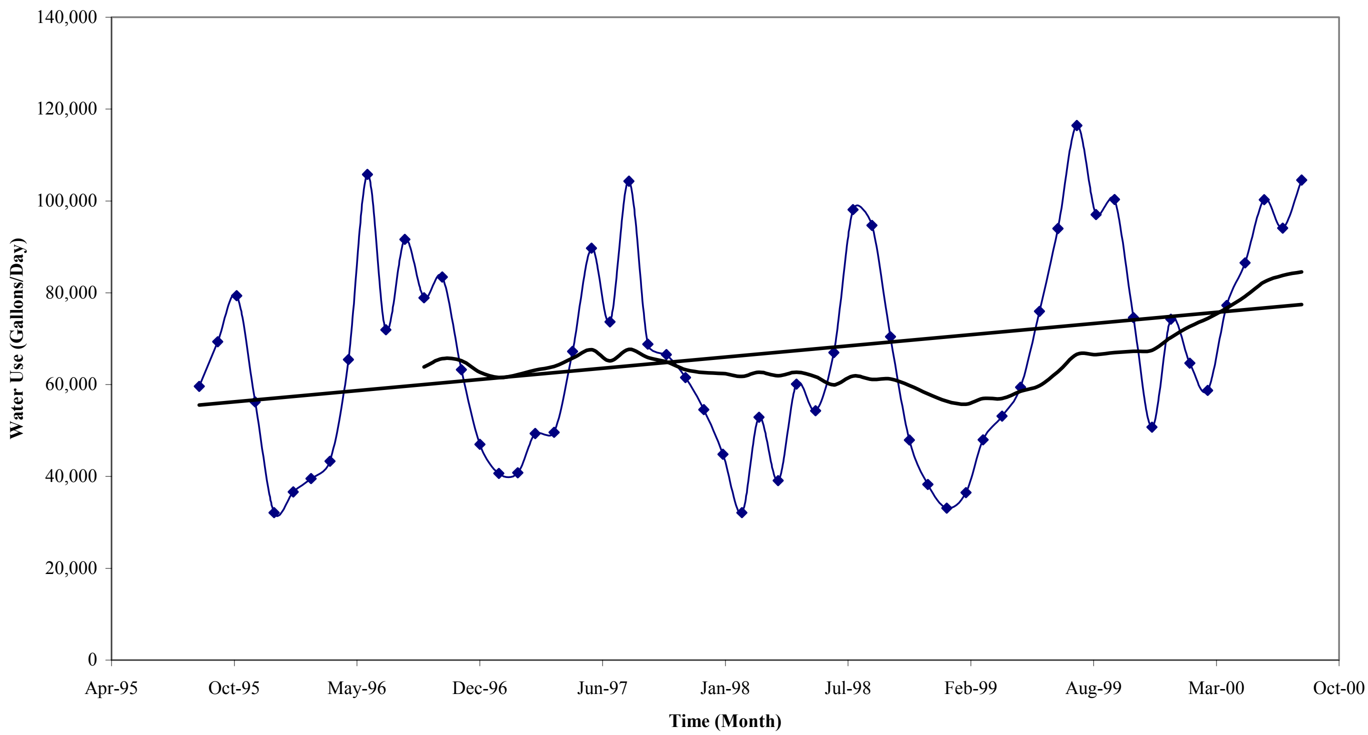


Figure C-6. Domestic Historical Monthly Water Use for Commercial Spaces

Medical School water use represents approximately 7% of total domestic use. Figure C-7 below presents the historical domestic use for Medical School with an average daily use of approximately 175,000 gallons per day. The linear trend and 12 month moving average indicates a general increase in water demand.

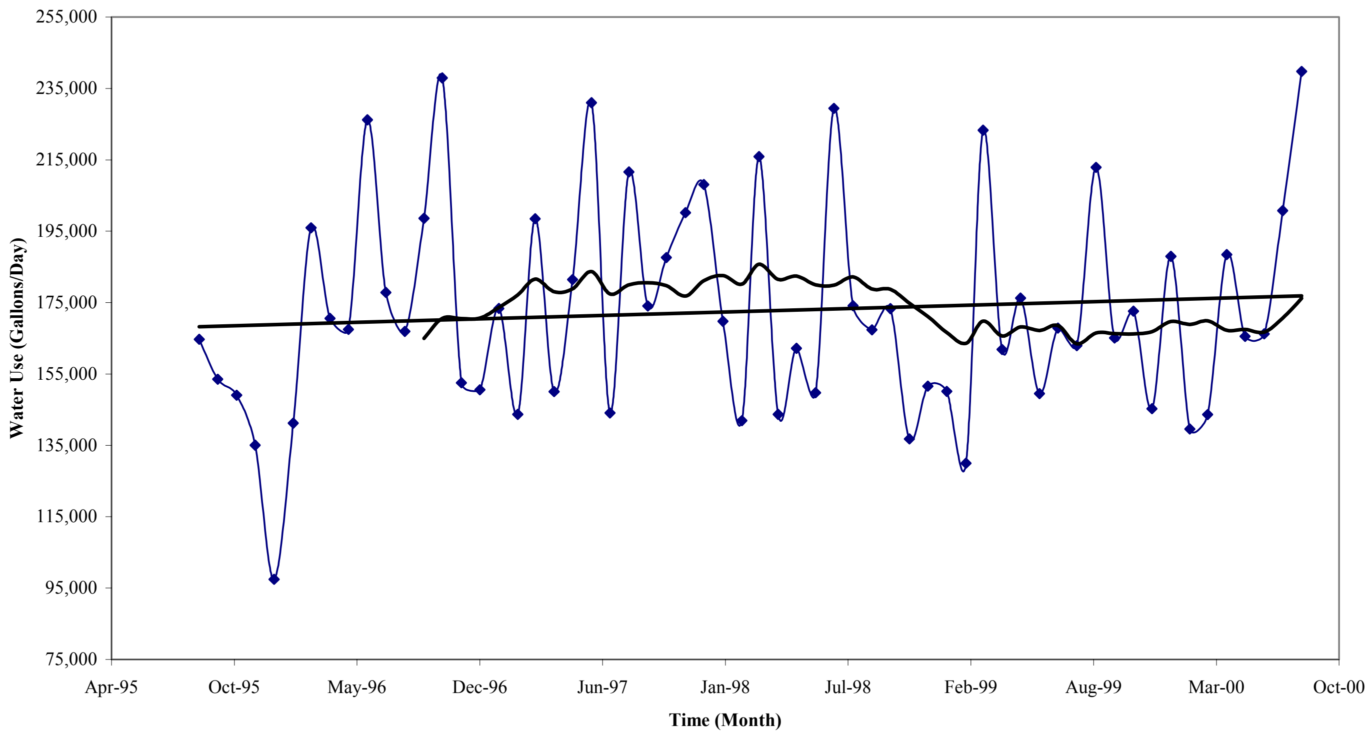


Figure C-7. Domestic Historical Monthly Water Use for Medical School

Athletics water use represents approximately 3% of total domestic use. Figure C-8 below presents the historical domestic use for athletics with an average daily use of approximately 75,000 gallons per day. The linear trend and 12 month moving average indicates a general increase in water demand.

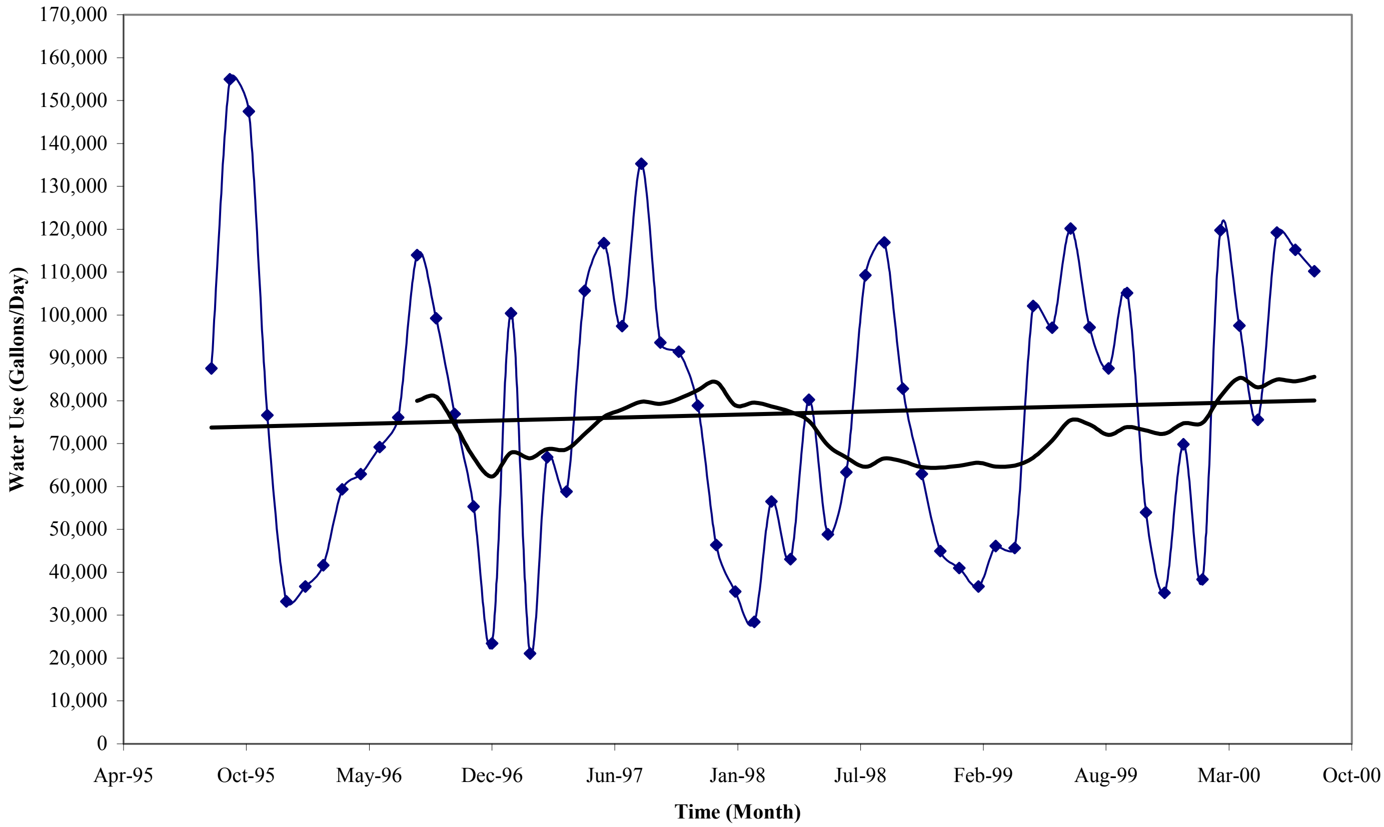


Figure C-8. Domestic Historical Monthly Water Use for Athletics

CEF water use represents approximately 22% of total domestic use. Figure C-9 below presents the historical domestic use for CEF with an average daily use of approximately 500,000 gallons per day. The linear trend and 12 month moving average indicates a general increase in water demand. The unusually high use in June 1999 of over 1,000,000 gallons per day was a result of firefighting water needs at the facility.

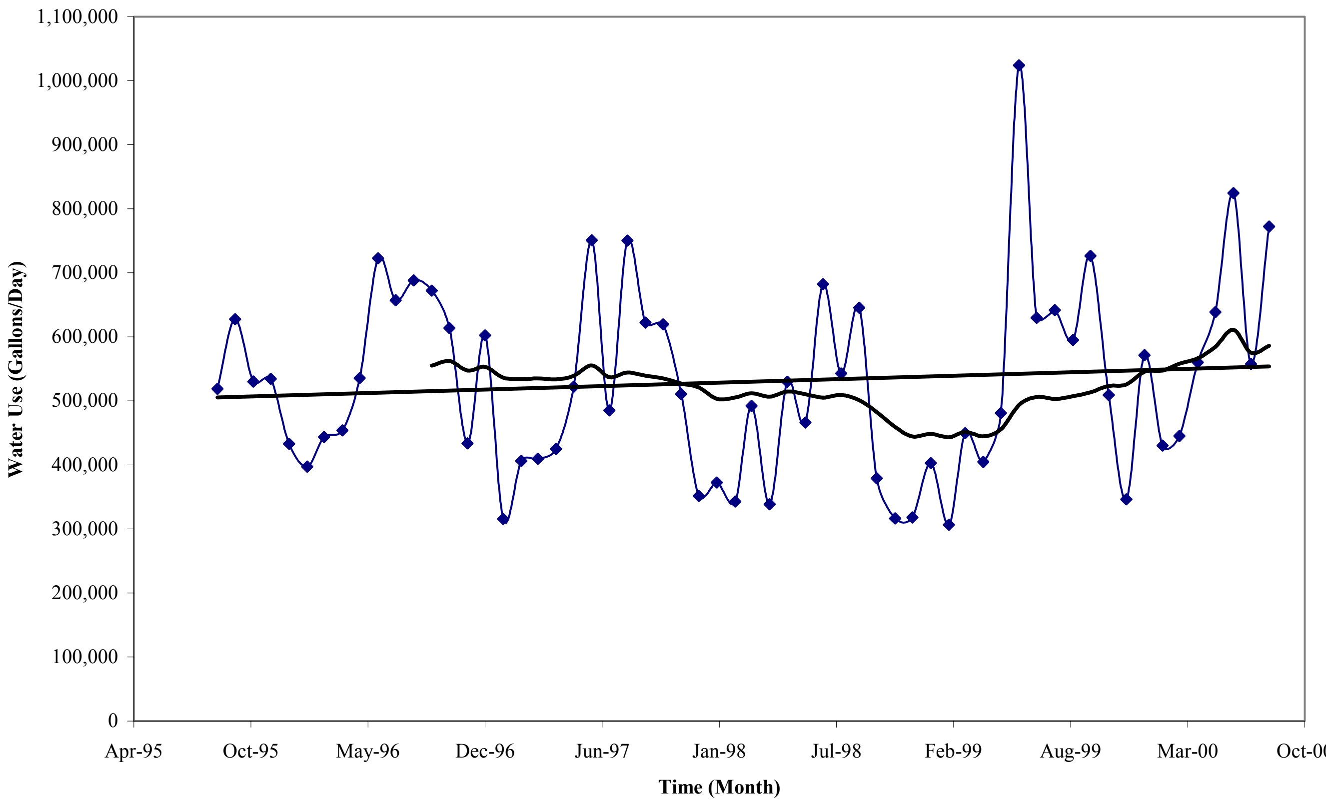


Figure C-9. Domestic Historical Monthly Water Use for Central Energy Facility (CEF)

For general reference the CEF water usage was further broken down into end uses and is presented in Figure C-10.

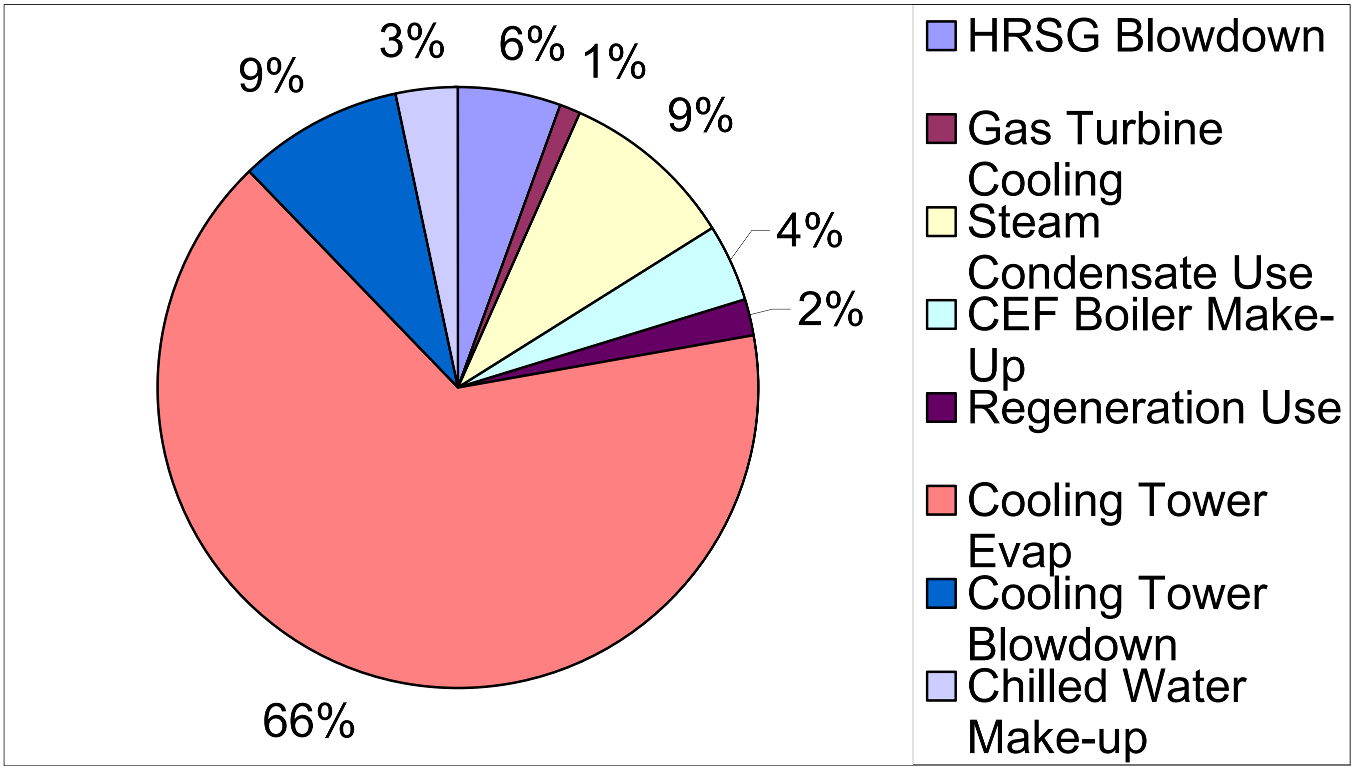


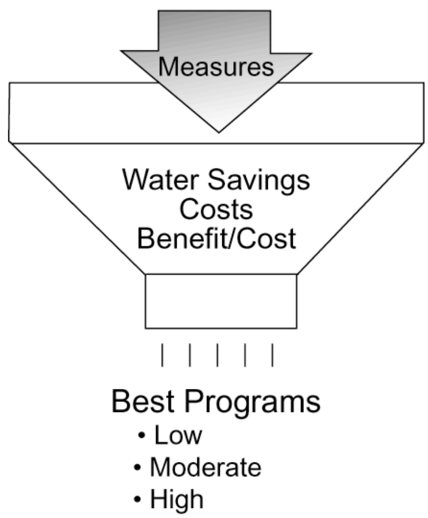
Figure C-10. Chart of CEF End Use

APPENDIX D – METHODOLOGY AND RESULTS OF EVALUATION OF LONG-TERM WATER CONSERVATION MEASURES

Introduction

The Master Plan Report presented a description of alternative water conservation measures considered for possible implementation and summarized the results of the benefit-cost analysis. This Appendix explains methodology for estimating the water savings, costs, and benefit-cost ratios for the measures is explained. From this analysis benefits and costs are compared in a present-value analysis and conclusions are drawn about which measures produce cost-effective water savings. This process can be thought of as an economic screening process, shown in Figure D-1.

Figure D-1. Evaluation Process



The text that follows assumes the reader is generally familiar with benefit-cost analysis, as it is used for evaluating conservation measures, so that the results can be emphasized and the description of the methodology can be brief. Additional background can be obtained from Maddaus et al.'s article "Integrating Conservation into Water Supply Planning" in *Journal AWWA* (November 1996).

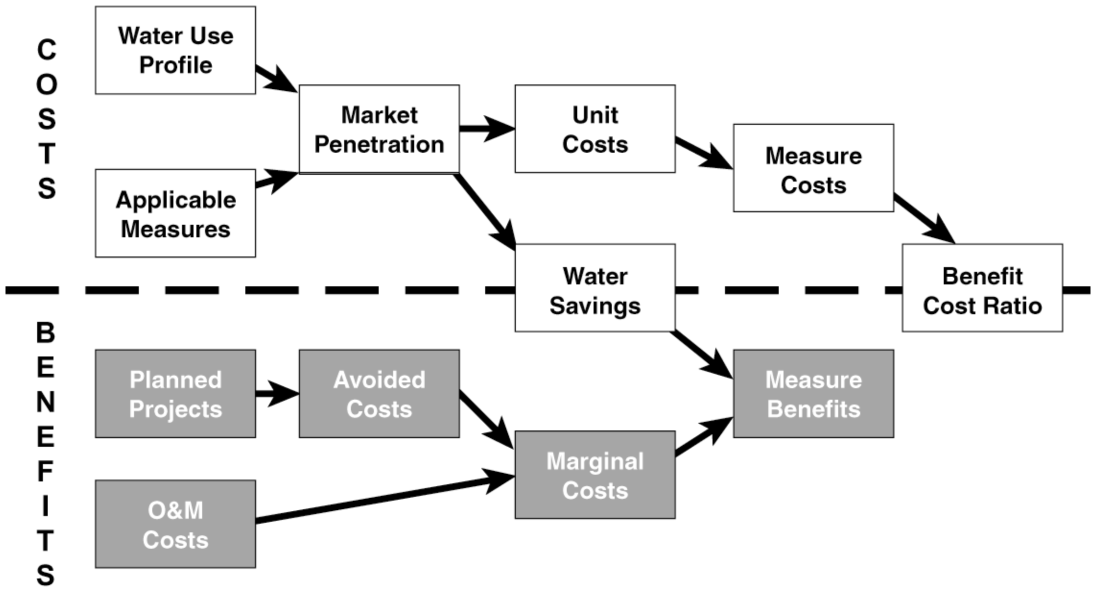
Overview of the Benefit-Cost Evaluation Methodology

The evaluation of alternative measures was done using benefit-cost analysis. The purpose of this analysis is to identify which of the above measures are cost-effective for Stanford to pursue. Benefit-cost analysis requires a locale-specific set of data, such as historical water consumption patterns by customer class, population and employment projections, age of housing stock, and prior conservation efforts.

The following nine steps are used to compute the water savings, costs and benefit-cost ratios, as shown graphically in Figure D-2.

1. Develop baseline water use projections without additional conservation. Projections should cover each key customer category and be broken down into indoor end uses and outdoor end uses. These were presented in Section 4 of the Master Plan Report.
2. Identify possible water conservation measures and screen the measures qualitatively to identify those that are applicable to the service area. Develop appropriate unit water savings and cost factors for each measure. The unit cost and savings were developed by using analogous data from work with Municipal systems (Beatty, 2002) because there are no similar data available for college campuses.
3. Estimate the affected population (or number of accounts) for each conservation measure by multiplying the total service area population (accounts) by the measure's projected market penetration or installation rate (in percent).
4. Estimate total annual average and peak day water savings. The water savings are computed by multiplying unit water savings, per measure, by a market penetration or installation rate, and then multiplying by the number of units in a particular service area (such as dwelling units) targeted by a particular measure.
5. Identify types of benefits to the water agency including capital projects that could be deferred or downsized and reduced operation and maintenance costs.
6. Quantify total benefits for each year in the planning period by multiplying average water savings by the computed value of the cost savings.
7. Determine initial and annual costs to implement the measures based upon pilot projects, local experience, and the costs of goods, services, and labor in the community. This is multiplied by the number of accounts participating each year and then added to overall administration and promotion costs to arrive at a total measure cost, which may be spread over a number of years.
8. Compare benefits and costs of measures by computing the present value of costs and benefits over the 30-year planning period.
9. Develop a recommended plan from the most attractive measures(s). Detail the plan by providing budgets, schedule and a staffing plan.

Figure D-2. Benefit-Cost Analysis Methodology



The Least Cost Planning Decision Making System

Benefit-Cost analysis has been used for 25 years to evaluate and prioritize potential demand management measures. Often the limiting factor in such analysis is the water savings assumptions. With the advent of recent and better data on how customers use water, such as provided by the American Water Works Association Research Foundation (AWWARF) Residential End Use Study, the water savings estimates can be made at the end use level. This increased level of complexity is justified by more reliable results. The task of computing estimated water savings and doing benefit-cost analysis is facilitated by the use of an end use model.

The model was used to analyze alternative measures for the Master Plan is called the Least Cost Planning Decision Making System (DSS), a Microsoft-excel based program, programmed in Visual Basic. Additional details are contained in "Benefit-Cost Analysis with an End Use Model", Proceedings AWWA Water Sources Conference, Las Vegas, Nevada, February 2002. The DSS Model has the following components:

- A breakdown of current water use by customer class and then by end use;
  Maddaus estimates are based on Stanford Utilities Metering Database for Faculty/Staff and Student Housing and on single family home water use from AWWARF (1999) Residential End-Use Study. For Academic and Athletic buildings, Maddaus estimates the toilet, urinal, and shower use separately, based on estimated occupancy and 4 flushes per person per day and 1 shower daily per person.

- Parameters to forecast growth in water demand;
- Fixture models to aid in calibrating the model to current water use conditions;
- A careful evaluation of the benefits in terms of operation and maintenance (O&M) cost savings and the present value of capital deferrals and/or downsizing;
- Worksheets for different types of conservation programs including fixture rebates, audits and other promotional programs, unaccounted for water reduction and pricing programs; and
- A way to combine individual measures into programs with multiple measures so as to avoid double counting water savings

The output of the model includes the following features:

- A baseline water demand forecast with no additional conservation beyond the current codes and standards already in place;
- Water savings, benefits, costs, and costs per unit water saved for individual conservation measures evaluated;
- The present value of benefits, costs and benefit-cost ratios for a combination of measures called a program;
- New demand forecasts with a conservation program in place.

Maddaus Water Management and others developed the model in 1999 by refining methods that had been used for many years. The model has been used for more than ten projects in the US and several in Australia since 1999.

The End-Use Methodology

The model performs its calculations at the end-use level. An end use could, for example, be the amount of water per day used in a single-family home to flush toilets, or wash clothes or irrigate. Every type of customer modeled has its water use broken down into end uses. The development of an accurate end-use model is a difficult but necessary exercise if accurate benefit cost analysis is to be undertaken and realistic estimates of water savings are to be made. Very few water utilities have detailed information about the end-use of water, although a number of end-use studies have been carried out in recent times that provide more detailed information on residential end-uses. The development of an end-use model requires the use of as much of the available information as possible.

In developing a model of water end use, the best approach is to use a combination of ”top-down” and “bottom-up” information to help us to determine the individual end uses. The approach is summarized in Figure D-3. Top-down information is information that allows broad estimates of internal and external water use to be derived and demand to be divided into different consumer categories. This includes:

- Water production data; and
- Customer meter (billing) database. The frequency of use per resident was based on the AWWARF (1999) Residential end-uses study for faculty/staff housing and dormitories. Maddaus assumed 4

flushes per employee per day for other buildings. The replacement rates for fixtures were based on recommendations developed by the California Urban Water Conservation Council.

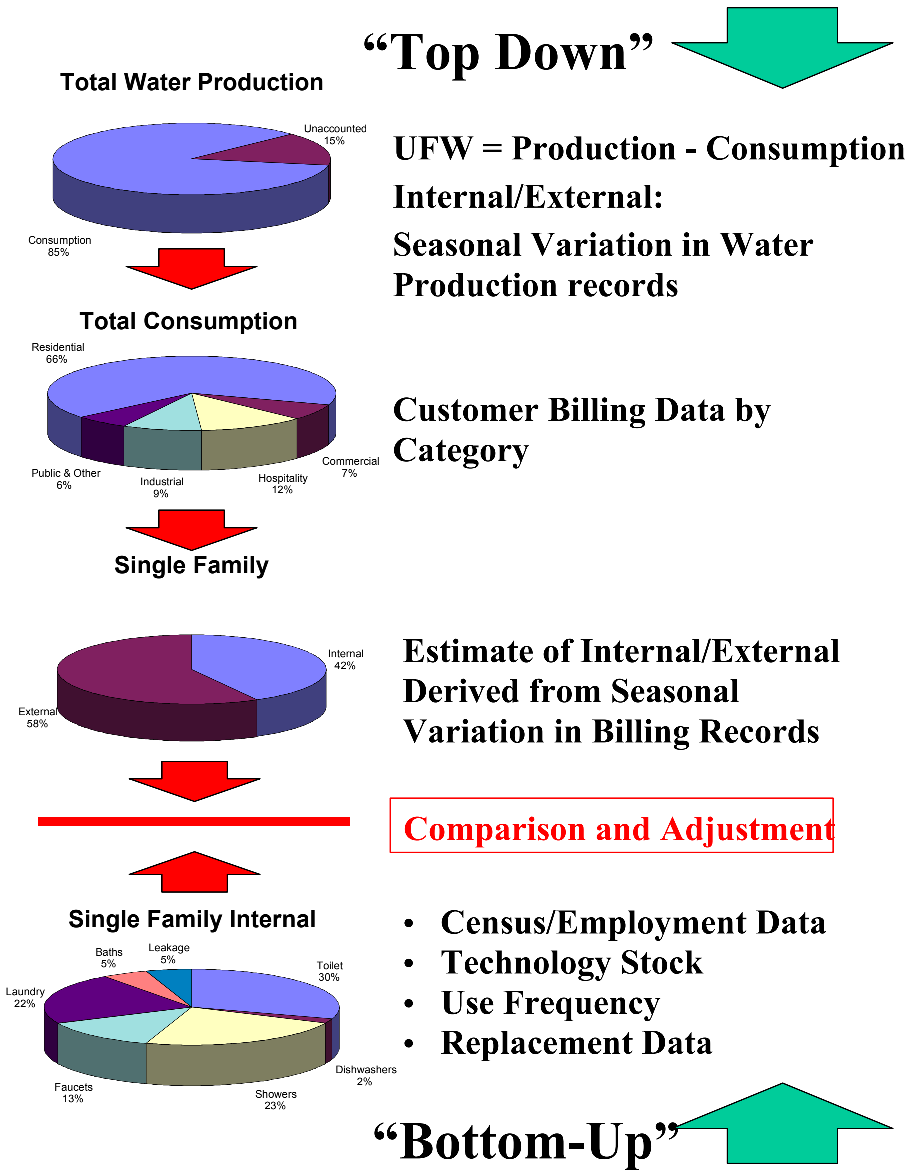


Figure D-3: Use of Available Data to Generate the End-Use Model

At the top of the end use model is the total water production record. Using this information and water consumption totals, the level of Unaccounted for Water (UFW) can be estimated. Consumption data from billing records can then be used to break the total consumption into different consumer categories. Seasonal fluctuations in billing records can also provide an indication of the level of internal and external use in each consumer category.

Bottom-up information is detailed information on water use and technology such as:

- Frequency of use per resident, student or employee;
- Stock of different types of water using appliances;
- Replacement rates for older appliance stock; and
- Housing and campus population data.

Model Calibration

The calibration of the end-use model is perhaps the most important step in the planning process. By combining top-down water consumption figures with bottom-up frequency of use and appliance ownership data, accurate estimates of end use can be made. The calibration process imposes a discipline on the model user to make the estimates of the breakdown in use agree with known point of use information. This provides the whole process with a reality check that ensures that the estimates of end use and the water savings that follow are in the right ballpark.

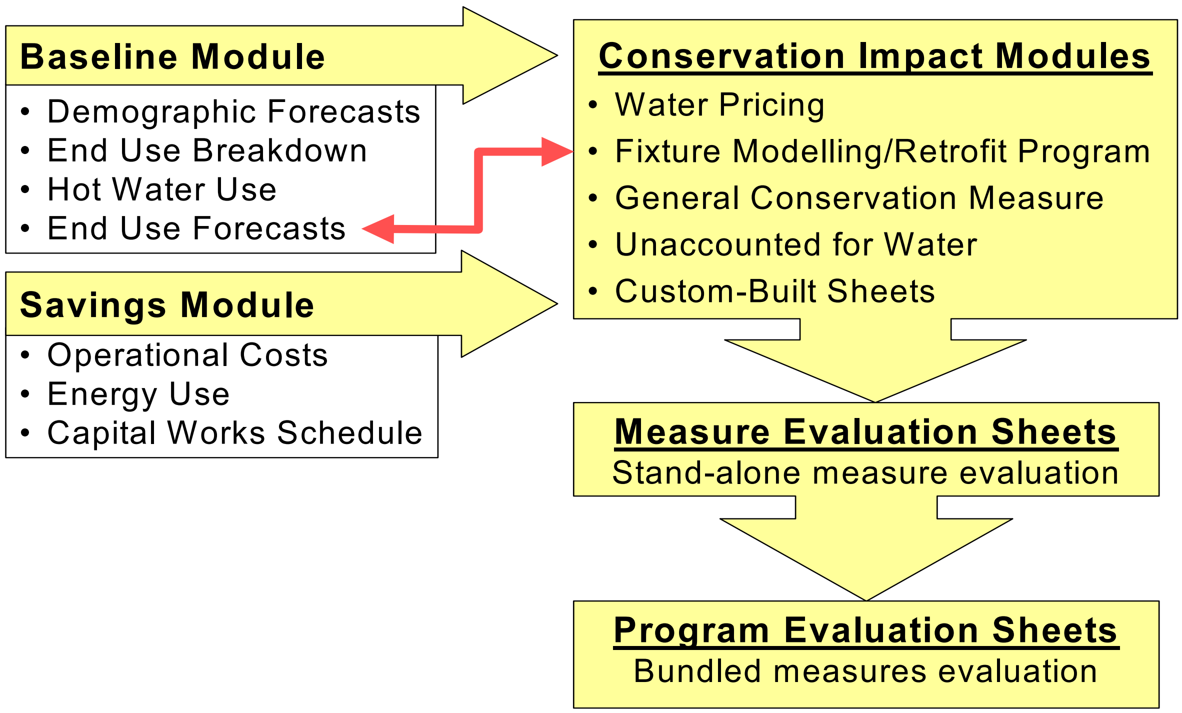
Steps in the model calibration process are:

1. Estimate the total amount of water use in gallons per account per day for each interior and exterior end use by customer class from analysis of the seasonal pattern of the Stanford Utilities Metering Data.
2. Set up a fixture model for each end use where a fixture or appliance code exists for each building type. For example a toilet fixture model would be needed for single-family and multi-family housing due to the Energy Policy Act of 1992. Another toilet fixture model might be needed for commercial buildings, student dormitories, etc.
3. Use the building age and retrofit history to estimate the current distribution of high, moderate and low efficiency fixtures in the current stock.
4. Estimate the current number of water users per account using demographic data.
5. Use the cited AWWARF Residential End Use Study to estimate the range in fixture use in uses per account user per day.
6. Estimate the natural replacement rate for each fixture and the expected changes in codes over time. The replacement rates for fixtures were based on standards developed by the California Urban Water Conservation Council (1992, 2000).
7. Calibrate the fixture models together so that the current total per capita or per employee use per day is within reasonable limits for each customer category. In calibrating the model the key parameter is frequency of use for the fixture being modeled, so the model is calibrated if the frequency of use is comparable to published data in the AWWARF 2000 study.
8. Use the above information to generate the baseline water use projection that reflects current codes.

Benefit – Cost Analysis with the DSS Model

The determination of the economic feasibility of water conservation programs depends on comparing the costs of the programs to the benefits provided. The water savings, cost estimating and benefit-cost analysis was performed using a program called Demand Management Least Cost Planning Decision Support System ("DSS") see Figure D-4.

Figure D-4. Structure of the DSS Model



The DSS model calculates savings at the end use level, such as the amount of water saved in a single family home or account per day that replaces toilets with low flush models as a result of toilet rebate program. Benefits are based on savings in water and wastewater facility O&M, as well as savings from deferring or downsizing any identified candidate future capital facilities. Facility design criteria, such as peak or average day water demand or average dry weather wastewater flow, are used to calculate future facility timing with and without conservation. Present value analysis is used to discount costs and benefits to the base year. From this analysis benefit-cost ratios of each measure are computed. When measures are put together in programs the interactions are accounted for by multiplying water use reduction factors, at the end use level, together. A water use reduction factor is 1.0 minus the water savings, expressed as a decimal. This avoids double counting when more than one measure acts to reduce the same end use of water.

Perspectives
Benefit-cost analysis can be performed from several different perspectives, based on who is affected. For planning water conservation programs for utilities, the perspectives most commonly used for benefit-cost analyses include the Utility and the Community. The "utility" benefit-cost analysis is based on the benefits and costs to Stanford. The "community" benefit-cost analysis includes the utility benefit and costs together with account owner/customer benefits and costs. These include customer energy benefits and customer costs of implementing the measure, beyond what the utility pays.

The time value of money is not ignored. The value of all future costs and benefits is discounted to 2000 (the base year) at the real interest rate of 3.0%. The DSS Model calculates this real interest rate adjusting the current nominal interest rate (assumed to be approximately 6.1%) by the assumed rate of inflation (3%). Cash flows discounted in this manner are referred to as "Present Value" sums throughout this report.

Menu of Water Conservation Alternatives

The list of measures selected for the evaluation process is shown in Table D-1. A description of the selected measures is given in Section 5 of the Master Plan Report. This Appendix covers the expected market penetration, water savings and costs of the measures.

Water Savings

Estimated water savings are useful to help utility planners forecast how future demands may be impacted by water conservation. Savings normally develop at a measured and predetermined pace; reaching full maturity after full market penetration is achieved. This may occur three to ten years after the start of implementation, depending upon the implementation schedule.

Methodology and Sources of Data
Data necessary to forecast water savings of measures include specific data on water use, demographics, market penetration, and unit water savings. These are described as follows:

Base Water Use
Base water use (without conservation) projections were developed through the year 2010 in Section 4. Base water use was projected to increase from 2.70 (mgd) in 2000 to just over 3.60 mgd in 2010 without the Master Plan. The base water use includes the effects of the current plumbing and appliance codes.

Demographics
Demographic data were presented in Section 4. Service area population, total dwelling units, building square footage, together with residential and non-residential demand, were used to evaluate measures.

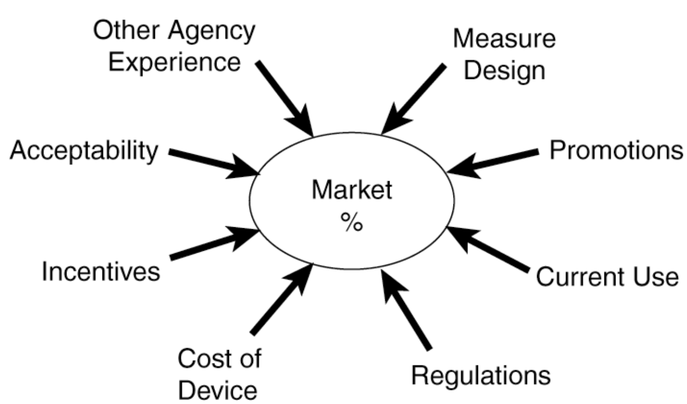
Table D-1. Measures Selected For Further Evaluation

No.	Measure	Measure Evaluated in Benefit/Cost Analysis
1.	Ultra Low Flush Toilet Replacement	YES
2.	Showerhead Retrofit	YES
3.	Urinal Replacement	YES
4.	High-Efficiency Washer Replacement	YES
5.	Public Outreach Programs	YES
6.	CEF Blow down Reuse	YES
7.	Faculty/Staff Housing Water Audits	YES
8.	Landscape Water Management	YES
9.	Selective Landscape Retrofit	YES
10.	New Water Efficient Landscape	YES
11.	New Landscape on Lake Water	YES
12.	ET Controllers	YES
13.	Selected Academic Areas on Lake Water	YES
14.	Football Practice on Lake Water	YES

Market Penetration

The market penetration (installation rate) for existing customers is the estimated percentage of customers that will be participating in the measure by the end of measure implementation. Estimates are based on measure design, and experience from similar measures implemented by other water agencies (see Figure D-3). Market penetrations adopted for use in this project are shown in Table D-2.

Figure D-3. Assess Market Penetration



The concept of market penetration can be explained by way of an example utilizing residential water surveys. If approximately 1,000 residential dwellings exist when a measure begins, and the ultimate penetration rate of 10 percent will be reached after three years, then 100 customers would have participated by the third year. Each year 33 new dwellings would be surveyed until all 100 had been audited. Certain measures require maintenance or repetition, i.e. they have a finite life. For example, surveys would need to be done every year in order to maintain savings because the effects of the surveys may have a limited life. Thus, if water savings from the surveys are assumed to last five years (the life of the measure), then additional surveys (in this case 33) or other appropriate follow-up with prior surveyed homes may be done every year to ensure the water savings are permanent.

If there are errors in market penetration estimates for each measure it could be due to the fact that they are based on previous experience, chosen implementation methods, and projected effort and funds allocated to the measure. The potential error can be corrected, through re-evaluation of the measure, as the implementation of the measure progresses. For example, if the market penetration required to achieve the needed savings turns out to be more or less than predicted, adjustments to the implementation efforts can be made. Larger rebates or more promotions may be used to increase the market penetration, for example. The process is iterative to reflect actual conditions and helps to ensure the market penetration and needed savings are achieved regardless of future variances between estimates and actual conditions.

End Use Water Savings

End use water savings, presented in Table D-3, are expressed as a percent reduction in water use per end use. The percentages only apply to the amount of water identified as the end use, not the entire category of use. End uses by customer category were described in Section 4. Long-term savings are those that are sustainable. Measure life is also shown in the table. When the measure life is exceeded the water savings erode, unless steps are taken to maintain them, such as replacing an expiring water audit with a new one.

Table D-2. Market Penetration of Conservation Measures

Measure	Applicable Customer Classes	% of Accounts Participating by 2010
Ultra Low Flush Toilet Replacement	SH, FSH ACD, ATH, LCS	61, 90, 80, 90, 90, 80
Showerhead Retrofit	ATH, FSH	55,70
Urinal Replacement	ATH, ACD, LCS, MSH	70, 81, 95, 90
High-Efficiency Washer Replacement	SH	80
Public Outreach Programs	ALL	100
CEF Blow down Reuse	ACD, SH, ATH, LCS, MSH	18-21
Faculty/Staff Housing Water Audits	FSH	30
Landscape Water Management	ACD, SH	25
Selective Landscape Retrofit	ACD, SH, ATH, LCS, MSH	--
New Water Efficient Landscape	ACD, SH, LCS, MSH	28, 39, 6, 27[1]
New Landscape on Lake Water	SH, ACD, ATH, LCS, MSH	28, 39, 6, 27[1]
ET Controllers	SH, FSH, ACD, LCS, MSH	90, 90, 70, 70, 70
Selected Academic Areas on Lake Water	ACD, MSH	100
Football Practice on Lake Water	ATH	100

Customer Types:

SH: Student Housing
FSH: Faculty/Staff Housing
ACD: Academic
ATH: Athletics
MSH: Medical School & Hospital
LCS: Leased Commercial Spaces
ALL: All customer types

(1) Targeted at new accounts only.

Table D-3. End Use Water Savings of Conservation Measures

Measure	Applicable Customer Classes	Water Use Reductions Per End Use	Measure Life, years
Ultra Low Flush Toilet Replacement	SH, FSH ACD, ATH, LCS	52% of Toilet use	permanent
Showerhead Retrofit	ATH, FSH	21% of Shower use	permanent
Urinal Replacement	ATH, ACD, LCS, MSH	75% of Urinal use	permanent
High-Efficiency Washer Replacement	SH	35% of Laundry use	permanent
Public Outreach Programs	ALL	3% all end uses	2
CEF Blow down Reuse	ACD, SH, ATH, LCS, MSH	80-100% of selected irrigation uses 75% of selected toilet uses	permanent
Faculty/Staff Housing Water Audits	FSH	5% Internal 25% Leaks and Exterior	5
Landscape Water Management	ACD, SH	10% all end uses	5
Selective Landscape Retrofit	ACD, SH, ATH, LCS, MSH	--	permanent
New Water Efficient Landscape	ACD, SH, LCS, MSH	15% of irrigation use	permanent
New Landscape on Lake Water	SH, ACD, ATH, LCS, MSH	100% of irrigation use	permanent
ET Controllers	SH, FSH, ACD, LCS, MSH	25% of irrigation use	permanent
Selected Academic Areas on Lake Water	ACD, MSH	15% of irrigation use	permanent
Football Practice on Lake Water	ATH	100% of irrigation use	permanent

Estimated Water Savings

The projected total water savings associated with the affected market are shown in Table D-4. The snapshot of annual savings is given for two specified years: 2005 and 2010. The total savings assume the measures begin in 2002. These savings are for measures acting alone, without interaction or interference from other measures. However, these savings are net of any plumbing code effect, which is the reason the savings could be reduced in the future, because the measure involves a plumbing fixture replacement that would have occurred anyway. The other reason savings could go down is if the measure life is exceeded and no action is taken to maintain the savings. Measure interaction is handled when packages of measures are put together as a program. Therefore the savings shown are approximations and may not be final estimates of savings, particularly where multiple measures target the same end uses, as is common with landscape and irrigation measures. As a point of reference the total baseline water production in 2000 is 2.70 mgd, increasing to 3.60 in 2010 without the Master Plan.

Table D-4. Projected Water Savings by Year (MGD)

Measure	2005	2010
Ultra Low Flush Toilet Replacement	0.07	0.10
Showerhead Retrofit	0.01	0.01
Urinal Replacement	0.02	0.03
High-Efficiency Washer Replacement	0.01	0.01
Public Outreach Programs	0.03	0.03
CEF Blow down Reuse	0.06	0.07
Faculty/Staff Housing Water Audits	0.03	0.04
Landscape Water Management	0.01	0.01
Selective Landscape Retrofit	--	--
New Water Efficient Landscape	0.01	0.03
New Landscape on Lake Water	0.04	0.10
ET Controllers	0.12	0.14
Selected Academic Areas on Lake Water	0.01	0.01
Football Practice on Lake Water	0.01	0.01

Costs of Measures

Costs were determined for each of the measures based on industry knowledge and past experience. Costs may include incentive costs, usually determined on a per-participant basis; fixed costs, such as marketing; variable costs, such as the costs to staff the measures and to obtain and maintain equipment; and a one-time setup cost. The setup cost is for measure design by staff or consultants, any required pilot testing, and preparation of materials that will be used in marketing the measure. Measure costs were estimated for each year between 2002 and 2010. Costs were spread over the time period depending on the length of the implementation period for the measure. Some of the costs occur uniformly over the planning period; others occur only in the first three to five years, after which implementation is finished and only the costs to maintain the measure are incurred.

Lost revenue due to reduced water sales is not included as a cost because the conservation measures evaluated herein generally take effect over a span of time that is sufficient to enable timely rate adjustments, if necessary, to meet fixed cost obligations.

The measure unit costs are shown in Table D-5. These are based on our experience with these measures.

Benefits

In our evaluation, the benefits are based on deferring the cost of a new well for Stanford and savings from reduced sewer flows. Specifically the benefits are based on the following assumptions:

- Cost of SFPUC water ($1,176 per million gallons currently)
- Cost of new well $1,000,000
- Operating cost of new well $150/million gallons pumped (energy and chemicals)
- Pump tax from Santa Clara Valley Water District at $330 per acre-foot pumped
- Maximum capacity of new well 500 gpm (0.72 mgd)
- Operating capacity of average 0.45 mgd
- Addition of new well is assumed if and when average day domestic demand reaches 3.25 mgd (which will occur about 2006 w/o additional conservation). This could be eliminated if additional conservation keeps domestic average daily use below 3.033 mgd.
- Cost of wastewater discharge to Palo Alto regional facility at $1000 per million gallons

The above benefits apply to reduction in indoor and outdoor use. Programs that reduce both will have benefits, however outdoor use reduction programs that reduce peak day water use will have the most impact on the timing of constructing a new well. Water supply capital projects are designed to meet peak day capacity needs, and the next increment of supply is constructed as the existing capacity approaches peak day demands.

Other benefits from the program include energy savings from the following measures: Showerhead Retrofit; High Efficiency Washers; and Faculty Staff Housing Water Audits. These benefits accrue to the water user (customer) and factor into their decision to participate in voluntary programs.

Table D-5. Unit Cost of Conservation Measures

No.	Measure	Utility Unit Cost
1.	Ultra Low Flush Toilet Replacement	$200-550/toilet
2.	Showerhead Retrofit	$25/unit
3.	Urinal Replacement	$400/urinal
4.	High-Efficiency Washer Replacement	$200 rebate/washer
5.	Public Outreach Programs	$50,000/year
6.	CEF Blow down Reuse	$550,000
7.	Faculty/Staff Housing Water Audits	$50/FSH unit
8.	Landscape Water Management	$1,000/acre
9.	Selective Landscape Retrofit	--
10.	New Water Efficient Landscape	$43,600/acre
11.	New Landscape on Lake Water	$1,000-10,000/account
12.	ET Controllers	$150-300/unit
13.	Selected Academic Areas on Lake Water	$25,000
14.	Football Practice on Lake Water	$10,000

Results of Benefit-Cost Analysis

Table D-6 shows a comparison of alternative measures and programs with respect to these criteria and provides the complete detail to allow selection of the individual measures and programs. Water savings are expressed two ways: the average over the 30-year forecast period and water savings in one year (2010). Net utility benefits are the utility benefits minus the utility costs. A negative value means that costs exceed benefits.

Table D-6 also shows the benefit-cost ratio from the utility and the customer or community perspective. A benefit-cost ratio greater than one means the present value of the benefits over 30-years is greater than the present value of the costs. Community benefit-cost ratios are higher for those measures that save hot water. Water savings over the DSS forecast period range from a high of 0.14 MGD to low of less than 0.01 MGD. The utility benefit-cost ratios range from a low of 0.29 for the New Water Efficient Landscape measure to 12.23 for the Football Practice Field on Lake measure.

Table D-6. Comparison of Conservation Measures

Measure	30-year Average Water Savings MGD	Utility Benefit Cost Ratio	Cost of Water Saved, $/MG
Ultra Low Flush Toilet Replacement	0.084	1.09	1,451
Showerhead Retrofit	0.007	2.77	581
Urinal Replacement	0.023	1.54	1,026
High-Efficiency Washer Replacement**	0.010	19.14	492
Public Outreach Programs	0.026	1.02	3,180
CEF Blow down Reuse	0.060	1.04	1,000
Faculty/Staff Housing Water Audits	0.037	3.46	733
Landscape Water Management	0.010	1.38	480
Selective Landscape Retrofit	***	***	***
New Water Efficient Landscape	0.022	0.27	3,230
New Landscape on Lake Water	0.086	6.72	132
ET Controllers on New Faculty/Staff Housing	0.124	0.96	321
Selected Academic Areas on Lake Water	0.013	5.86	163
Football Practice on Lake Water	0.011	12.31	78

* Caution: savings cannot be added without handling measure overlap water savings averaged over 30 years. Actual savings in 2010 may be higher.
** This measure's benefit-cost ratio includes a rebate of $200 per washing machine.
*** To be determined, the annual report will list specific projects completed during the reporting year and associated estimated water savings.

Combination of Measures into the Master Plan

The measures described above were evaluated to determine combined water savings, costs and benefits. In order to meet the water savings goal all measures listed in Table D-6 were selected for the Master Plan. Because the measures overlap the water savings from the individual measures cannot be simply added together. Measure interaction factors are used to account for the incremental reduction in end uses due to each measure (when more than one measure targets the same end use). For example, if two measures reduce the same end use 10 per cent then the effect of them working together is not the sum of the savings (20 percent), it is the product, expressed as a decimal. In this case the combined savings would be 1-(0.90*0.90=0.81) = 0.19 or 19 percent. Measure interaction is an important factor for Stanford as there are several measures that reduce landscape irrigation using different techniques, for example.

The Master Plan water savings, costs, benefits, and benefit-cost ratio are shown in Table D-7. The program has a benefit/cost ratio over 1.0.

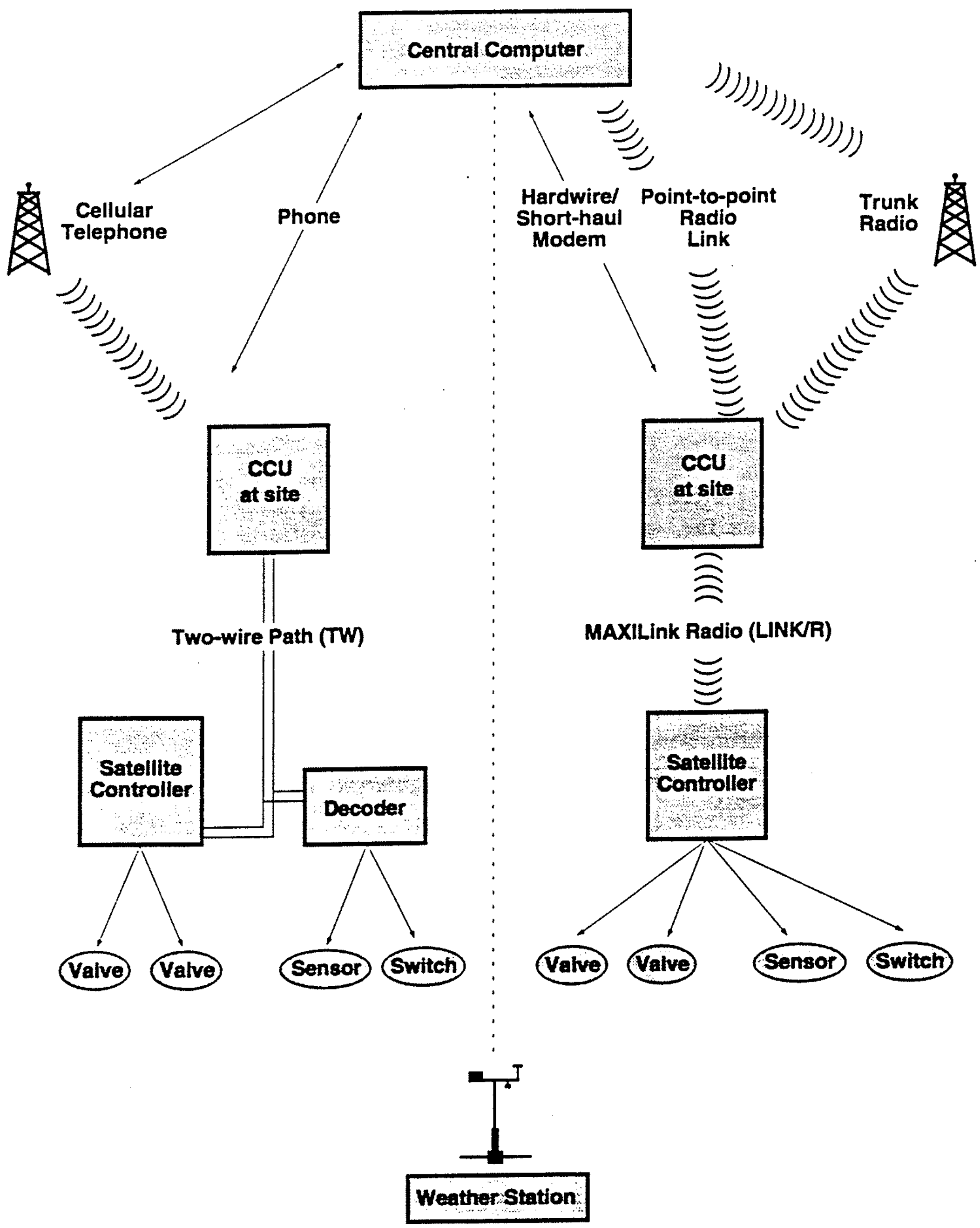
Table D-7. Estimated Savings and Costs of Water Conservation, Reuse and Recycling Master Plan

Savings/Costs	Master Plan
Water savings in 2005, mgd	0.38
Water savings in 2010, mgd	0.52
Total Cost 2002-2005, million $	2.75
Total Cost 2006-2010, million $	1.78
Present Value of Costs, million $**	4.90
Present Value of Benefits, million $*	7.59
Cost of Water Saved $/million gallons**	965
Benefit/Cost Ratio	1.55

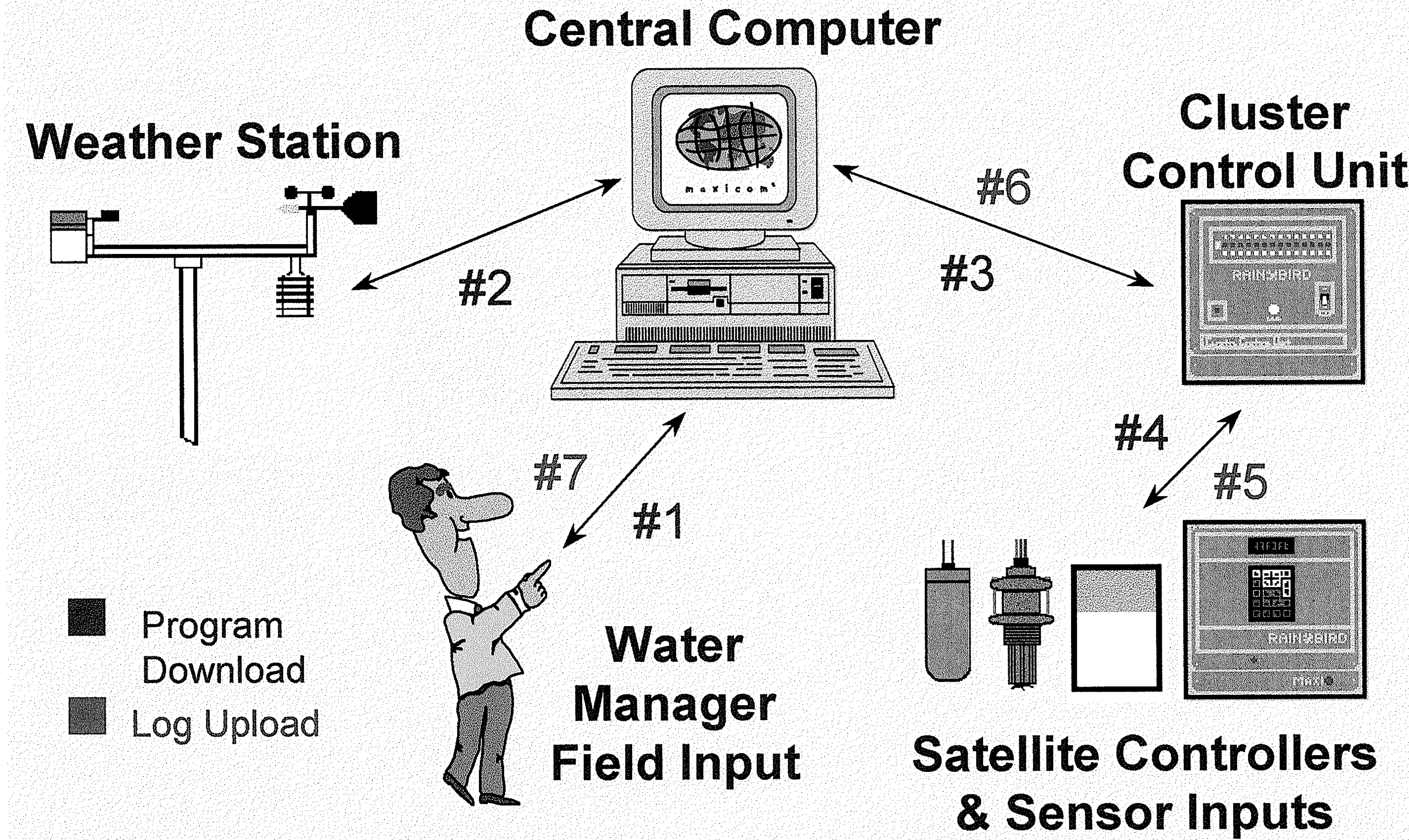
*Based on current cost of SFPUC water of $1,176 per million gallons.
**Present Value is based on 30-year actual costs and benefits.

Appendix E

Schematic information about evapotranspiration controllers, including Maxicom central control system.



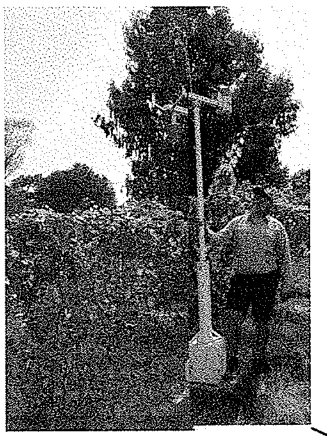
MAXICOM CENTRAL CONTROL SCHEMATIC



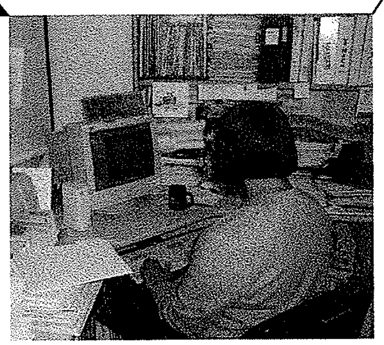
Source: Rainbird

Weather Station Data

Every day, rain or shine, the Grounds Department weather station, located near the Environmental Safety Facility, telephones a weather report to the Grounds Department Office at Bonair Siding. This weather station is a component of the Department's irrigation central control system. The weather data is processed by the central computer, a PC in the Grounds Office, which calculates sprinkler run times based on the daily ET (Evapotranspiration). The central computer then communicates the newly calculated irrigation schedules to the field controllers.



Weather station sends data to PC in Grounds Office daily



PC automatically computes water needs based on daily weather data.

PC sends revised schedules to field controllers and automatically runs the sprinklers.

Evapotranspiration is a measure of water lost both by evaporation from the soil and by transpiration from plant tissues, and provides a good indication of how much water needs to be applied by irrigation when rainfall is insufficient. Measured in inches per day, ET is calculated based on temperature, solar radiation, rainfall, humidity and wind measurements reported from the weather station. The daily reports from the weather station enable daily adjustment of schedules in all the system controllers, something that would not be possible manually. This can result in significant water savings; for example, a 1996 study of the Oval Lawn indicated that use of Maxicom with ET based scheduling resulted in a 27% water savings.

You can see the daily weather station data for the most recent month in the following table.

Source: Stanford University Grounds Dept. Web page.

Current Weather Station Data

Date	Minimum Temp (F)	Maximum Temp (F)	Total Solar Radiation	Total Rainfall	Average Humid-ity	Average Wind Run	Daily Evapo-transpir-ation
4/1/01	40.58	78.55	895.03	0.00	72.82	1.99	0.15
4/2/01	42.78	62.17	669.62	0.00	64.23	4.45	0.12
4/3/01	33.63	57.36	904.08	0.00	61.21	3.10	0.13
4/4/01	34.24	61.25	872.71	0.00	70.45	1.87	0.12
4/5/01	34.84	63.99	886.48	0.00	66.29	2.07	0.14
4/6/01	41.12	61.52	454.66	0.14	88.67	1.59	0.06
4/7/01	41.58	54.59	671.85	0.25	87.18	3.27	0.10
4/8/01	33.94	56.75	665.45	0.00	71.45	3.64	0.11
4/9/01	41.94	58.87	840.41	0.11	80.04	2.20	0.11
4/10/01	37.66	65.07	945.65	0.00	56.39	3.38	0.16
4/11/01	48.76	58.41	380.68	0.00	81.02	3.32	0.08
4/12/01	35.31	65.28	852.17	0.00	72.87	1.70	0.13
4/13/01	38.47	65.21	739.79	0.00	71.81	2.96	0.11
4/14/01	34.31	63.32	876.83	0.00	79.11	1.64	0.12
4/15/01	35.25	63.32	921.76	0.00	79.21	1.76	0.13
4/16/01	39.44	66.06	931.41	0.00	71.62	1.87	0.15
4/17/01	49.64	71.42	913.86	0.00	67.62	1.86	0.16
4/18/01	44.04	70.09	862.85	0.00	70.75	2.03	0.12
4/19/01	45.25	60.44	579.96	0.01	82.27	2.40	0.10
4/20/01	42.31	58.64	311.48	0.79	91.94	1.61	0.06
4/21/01	36.76	64.35	928.94	0.03	82.50	1.87	0.14
4/22/01	40.04	64.98	992.14	0.00	80.79	1.70	0.14
4/23/01	39.56	72.19	969.94	0.00	74.52	1.40	0.16
4/24/01	45.79	82.18	982.50	0.00	70.04	1.61	0.19
4/25/01	47.32	82.58	988.56	0.00	72.17	1.80	0.18
4/26/01	46.90	79.20	889.85	0.00	83.17	1.57	0.15
4/27/01	45.07	67.01	947.48	0.00	83.35	1.94	0.14
4/28/01	46.38	66.88	908.96	0.00	77.92	3.03	0.14
4/29/01	38.60	71.31	1004.47	0.00	61.66	2.88	0.19
4/30/01	44.94	76.06	1001.00	0.00	68.39	1.97	0.19

Components of Central Control Systems

In general, a central control system is made up of many pieces of monitoring and controlling equipment tied together by one or more communication types.

The main pieces of equipment for a central control system include:

- Central control computer and software
- Communications equipment to sites and between site field devices
- On-site processing equipment (Cluster Control Unit)
- Satellite controllers
- Sensors (flow, rain, etc.)
- Weather station

The "Central" in Central Control:

The central control computer is the main piece of equipment that interacts with the irrigation manager to oversee system management. The central computer retains all necessary information about the system. It keeps track of when and how long each device should operate. It calculates runtimes based on data entered by the irrigation manager or automatically gathered from weather stations. By utilizing the power of a personal computer, the central control system can automate many of the tasks required to effectively manage a large irrigation system.

Communications:

Communicating with the site(s) is very important in central control. A communication medium that is fast and error free is vitally important to system integrity. The most efficient communication type is a direct connection to a computer. This is, however, not practical for many systems. Telephone is a very secure and reliable medium, especially since the telephone system providers are responsible for maintaining the communications system. Installing radio communications is easy. However, there are issues (especially in busy urban areas) to be considered before obtaining available radio frequencies, including government regulations and monthly costs. Fiber optics is a very reliable and fast communications medium, but installation cost can be prohibitive.

Field Devices:

On-site processors (CCUs) are the real workhorses of the system. This middle-manager device receives the data and commands from the central computer and processes it for use by satellite controllers and sensing devices. Some systems have this built into satellite controllers but this limits its usefulness to the system as a whole.

Satellite controllers are the key interface in the field. These devices receive commands from the processor and implement them by monitoring sensors and controlling irrigation valves and other electrical switches. Such items as fountains and field lights can be controlled by satellite controllers.

Sensors:

Sensors monitor the system and surrounding areas, watching for problems or out-of-the-ordinary conditions. Flow sensors can monitor the hydraulic operation of the system and report any occurrences or high or low flow conditions. Wind sensors can relay excessive wind conditions and turn off irrigation, fountains and/or other devices when the wind conditions exceed your defined limit.

Weather Sources:

A weather source is one of many possible devices providing data for a database of ET information. Some of the different types of weather sources include weather stations, ET Monitors, Bulletin board systems, rain counters and historical databases. Weather stations monitor key weather functions and use these to calculate an Evapotranspiration (ET) factor. This is used by the system to calculate irrigation runtimes. Substantial water savings can be realized with these important devices.

Related Topics

Appendix F
National Plumbing Efficiency Standards, 1992;Consortium for Energy Efficiency, 2000-02

Energy Conservation Requirements for Plumbing Products

Energy Policy Act of 1992: Section 123

Summary of Standards

Faucets. The maximum water use allowed for any of the following faucets manufactured after January 1, 1994, when measured at a flowing water pressure of 80 pounds per square inch, is as follows:

Faucet Type	Maximum Flow Rate (gallons per minute or per cycle)
Lavoratory faucets	2.5 gpm
Lavoratory replacement aerators	2.5 gpm
Kitchen faucets	2.5 gpm
Kitchen replacement aerators	2.5 gpm
Metering faucets	0.25 gpc

Showerheads. The maximum water use allowed for any showerheads manufactured after January 1, 1994, is 2.5 gallons per minute when measured at a flowing pressure of 80 pounds per square inch.

Water Closets.

(1) The maximum water use allowed in gallons per flush for any of the following water closets manufactured after January 1, 1994, is as follows:

Water Closet Type	Maximum Flush Rate (gallon per flush)
Gravity tank-type toilets	1.6 gpf
Flushometer tank toilets	1.6 gpf
Electromechanical hydraulic toilets	1.6 gpf
Blowout toilets	3.5 gpf

(2) The maximum water use allowed for any gravity tank-type white two-piece toilet which bears an adhesive label conspicuous upon installation of the words "Commercial Use Only" manufactured after January 1, 1994, and before January 1, 1997, is 3.5 gallons per flush.

(3) The maximum water use allowed for flushometer valve toilets, other than blowout toilets, manufactured after January 1, 1997, is 1.6 gallons per flush.

Urinals. The maximum water use allowed for any urinals manufactured after January 1, 1994, is 1.0 gallons per flush.

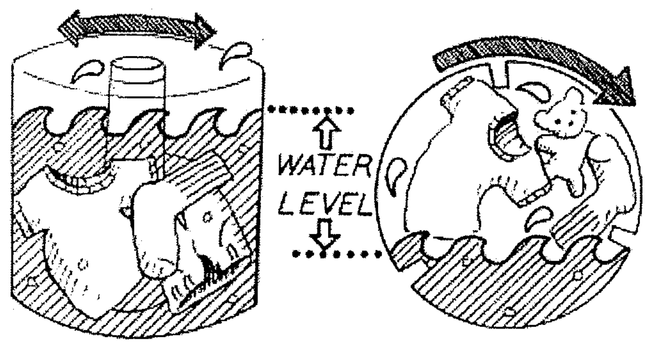
Appendix F. National Plumbing Efficiency Standards, 1992;Consortium for Energy Efficiency, 2000-02

Commercial, Family-Sized Clothes Washer Initiative

How does it work?

Commercial Clothes Washer main page
Residential Clothes Washer main page

Horizontal-axis technology enables washers to save energy and water



Conventional top-loading washers (left) use a large vertical drum. Most high-efficiency washers (right) utilize a horizontal-axis design; loading from the front, they tumble clothes through a much smaller pool of water. There are currently three high-efficiency washing machines on the residential market (Whirlpool, Staber and Fisher-Paykel) that are top-loading.

Horizontal-axis clothes washers save energy because they use less water. Most of the energy needed for clothes washing goes to heating the water.

Conventional washers use a large vertical drum to soak and wash the clothes. Most high-efficiency clothes washers have a horizontal-axis drum, which tumbles the clothes through a pool of water.

Recent technological innovations have resulted in vertical-axis washers that can achieve similar energy-efficiency levels. High-efficiency washers use up to 18 gallons less water per load and remove more moisture from the clothes with a high-speed spin cycle. As a result, energy costs can be reduced as much as 50 percent.

In addition, manufacturers say high-efficiency machines get clothes cleaner and are gentler to fabrics.

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http://www.cee1.org
One State Street, Suite 1400, Boston MA 02109-3529
617-589-3949 fax 617-589-3948
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Original photo courtesy Philip Greenspun

Commercial Programs

Commercial, Family-Sized Clothes Washer Initiative

On June 1, 2001, ENERGY STAR® established a category for commercial clothes washers. See the CEE press release for further details.

CEE launched the Commercial, Family-Sized Washer Initiative in 1998 as an offshoot of its highly successful Residential Clothes Washer Initiative. The commercial clothes washer initiative encourages the purchase and use of energy- and water-efficient washers for laundromats, multi-family buildings and institutions. These high-efficiency commercial washers are nearly identical to residential models available in retail outlets. The only differences are minor engineering changes, such as a coin box.

Like their residential counterparts, high-efficiency commercial washers save up to 50 percent of energy costs and use about 30 percent less water.

For this program, CEE uses high-efficiency specifications that were originally developed for its Residential Clothes Washer Initiative.

In addition to maintaining an up-to-date list of qualifying washers, CEE serves as an information clearinghouse for initiative news and new products.

Many qualifying washers utilize horizontal-axis technology, which saves energy and water.

In the United States, there are approximately 2-3 million commercial washers, which are replaced at a rate of about 10 percent per year. Approximately 42,000 of those replaced clothes washers are sold to laundromats. It should be noted that, although laundromats represent less than 20 percent of the market, washers in these locations are in use much more frequently on a daily basis.

NEWS

ENERGY STAR now includes commercial washers

On June 1, 2001, the ENERGY STAR® program added commercial washers to the 31 other labeled products. In the past, only residential washers could qualify for the label but ENERGY STAR has decided to develop a separate label for commercial models with volume of 3.5 cubic feet or less. In order to qualify for the label, the washer must meet the minimum Modified Energy Factor (MEF) requirement of 1.26.

For further information, See the CEE press release.

Energy and water benefits demonstrated in PNNL study
In December 2000, Battelle Pacific Northwest National Laboratory (PNNL) released a study on the energy and water use of resource-efficient commercial clothes washers in a real world setting. The study, commissioned by Southern California Edison (SCE), was set in a senior citizens community of 18,000 residents, Leisure World in Laguna Woods, Calif.

The goal of the project was to demonstrate and verify the energy, water and monetary savings of the efficient commercial washers as well as their performance. Specifically, the study focused on whether the savings from reduced water and energy consumption compensated for the higher first cost and whether the community residents liked the machines.

Three laundry buildings, containing four conventional washers each, were metered to determine baseline water and energy use, and then replaced with efficient washers from Maytag, Speed Queen and Whirlpool. Data in the study are based on approximately 350 cycles for each washer.

Water savings ranged from 10.5 gallons/cycle (28 percent) to 22.5 gallons/cycle (59 percent) over the baseline washer. Energy use was reduced by 0.35 kWh/cycle (20 percent) to 1.16 kWh/cycle (67 percent). These water and energy savings produced monetary savings as well. Calculated for electricity and water rates in SCE's service territory, the washers saved from $47-139 annually.

The final report from the Laguna Woods Washer Demonstration is available on-line.

Fort Hood commercial washer study finds big savings
A commercial clothes washer study described in the May 2000 Federal Energy Management Program's *Technology Installation Review* contains interesting and important results for the efficiency community.

The study is the first comprehensive, field-based study of efficient family-sized commercial washers. In the laundry facilities of three nearly identical barracks, metering equipment was installed. Baseline data was gathered from the conventional machines over a two-month time period in 1997, and included 1,050 wash cycles.

After the baseline metering, each laundry room was equipped with high-efficiency machines from a different manufacturer. Maytag, Alliance Laundry Systems, Staber and Whirlpool participated in the study. Metering of the high-efficiency clothes washers took place over 17 months, from February 1998 through July 1999.

Findings include that the four high-efficiency brands saved 0.06 kWh/load (23 percent) on motor and controls electricity use. Annually, the machine energy savings is 140 kWh, and the hot water energy savings is 8.1 million Btu/machine. In addition, the four brands saved an average of 5.6 gallons of hot water (62 percent), 11.0 gallons of cold water (42 percent), and 16.6 gallons of total water (47 percent) per load. Annually, total water savings is 38,780 gallons/machine.

An on-line version of the report is available on the FEMP web site(www.eren.doe.gov/femp).

RESOURCES/LINKS

Multi-Housing Laundry Association

Coin Laundry Association

CONTACT

For more information about CEE's Commercial, Family-Sized Clothes Washer Initiative, contact Rebecca Foster at 617-589-3949, ext. 225, or rfoster@cee1.org.

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http://www.cee1.org
One State Street, Suite 1400, Boston MA 02109-3529
617-589-3949 fax 617-589-3948
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