PROFESSIONAL PROJECT FOR THE MASTER OF CITY AND REGIONAL PLANNING

Water Conservation for the County of San Luis Obispo

Products:

1. Background Report for Water Conservation Handbook
2. Handbook of Water Conservation Technologies and Practices

California Polytechnic University, San Luis Obispo
City and Regional Planning
June, 2010

Product 1:

**BACKGROUND REPORT FOR THE WATER
CONSERVATION HANDBOOK**

BACKGROUND REPORT FOR THE WATER CONSERVATION HANDBOOK

A Professional Project

presented to the Faculty of California Polytechnic University,
San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree
Master of City and Regional Planning

by

Dimitri Theodore Antoniou

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COMMITTEE MEMBERSHIP

TITLE: Background Report for the Water Conservation Handbook

AUTHOR: Dimitri Theodore Antoniou

DATE SUBMITTED: June, 2010

COMMITTEE CHAIR: Chris William Clark, JD, Lecturer, Cal Poly CRP

COMMITTEE MEMBER: Adrienne Greve, PhD, Assistant Professor, Cal Poly CRP

COMMITTEE MEMBER: John McKenzie, Environmental Planning Staff, County of San Luis Obispo

ABSTRACT

Background Report for the Water Conservation Handbook

Dimitri Theodore Antoniou

This study is an academic research project completed to satisfy the California Polytechnic Master Thesis Requirement for the Master Degree of City and Regional Planning in the College of Architecture and Environmental Design. The County of San Luis Obispo Planning and Building Department is the client for this professional project. The project was requested by the County of San Luis Obispo to assist in its water conservation efforts and to help achieve a 20 percent per capita reduction of water use by the year 2020. The project consists of two documents: *A Handbook of Water Conservation Technologies and Practices* (Handbook) and the *Background Report for the Water Conservation Handbook* (Background Report).

The Handbook is intended to provide a quick guide to various water conserving fixtures and appliances that developers and residents throughout the County of San Luis Obispo can reference for personal use. The Handbook includes information on the type of technology, the benefits in terms of water saving potential, and the cost of implementation. The Handbook is organized based on Indoor and Outdoor water uses.

The Background Report is a supplemental document for the Handbook which provides more in depth descriptions and examples on each technology. The Background Report also provides history on water conservation issues in California and San Luis Obispo. It looks at two case studies: one, on the water conservation efforts in Phoenix, Arizona, and two, on a plumbing retrofit project on the Cal Poly Campus that was awarded LEED certification for its water savings. Furthermore, the Background Report explores case studies in the use of community participatory planning to produce water conservation plans. The studies focused on a Community Plan development in Arroyo Grande, California, and on an Integrated Regional Water Management Plan in the Greater Los

Angeles Region. The Background Report concludes by providing some cautionary advice on water conservation technologies and provides future recommendations for the county of San Luis Obispo to improve its water conservation efforts.

Key Words: Water Conservation, Technology, Water Use, Indoor Water Use, Outdoor Water Use, Drought, Handbook, Collaboration, Community Participation.

Background Report for the Water Conservation Handbook

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1.0 INTRODUCTION

This study is an academic research project completed to satisfy the California Polytechnic Master Thesis Requirement for the Master of City and Regional Planning in the College of Architecture and Environmental Design with the County of San Luis Obispo Planning and Building Department as a Professional Client.

The project was requested by Environmental Planner, John McKenzie, in order to assist the county in reducing their per capita water consumption 20 percent by 2020. The project consists of two documents: *A Handbook of Water Conservation Technologies and Practices* (Handbook) and the *Background Report for the Water Conservation Handbook* (Background Report). The Handbook includes technologies for indoor and outdoor water use that can be implemented throughout the county. It provides brief details on each technology such as its intended use, water savings, and implementation cost. The handbook is supported by a comprehensive document that includes more detailed research on the technologies, case studies of other water conservation efforts, and current trends of dealing with water issues through Urban Planning. The two products are stand alone documents but the information in the Handbook is supplemented by the comprehensive background document, *Background Report for the Water Conservation Handbook*.

1.1. NEED FOR STUDY

The County of San Luis Obispo is at a critical time, as the county's water demand increases and the supply of clean good quality water is diminishing. The concern for its water supply and water quality has prompted several water conservation efforts throughout the county (PMC, 2009).

Currently, the County of San Luis Obispo is in the process of updating its General Plan's Conservation Element to include a Water Resources section. The Water Resources section covers the main issues relating to water in the county and provides the goals, objectives, policies, and implementation strategies for the county to reduce its

water consumption, improve water quality, and better manage the natural resources that it has.

The Draft Water Resources section identifies 6 Water Resource Goals (WR) for the County of San Luis Obispo. The goal that is addressed by this study is:

- **Goal WR 4:** Per capita potable water use in the county will decline by 20 percent by 2020.

For the County to meet this goal, several policies and implementation strategies were identified. Each policy and strategy gives the County a general direction to developing its own programs to meet the goal. This Water Conservation Handbook and Background Report is one of the many tools that the County can use to help meet some of the policies under this goal. The policies and strategies that influenced this project are listed below:

- **Policy WR 4.1 Reduce water use:** Employ water conservation programs to achieve a 20 percent reduction in per capita water use by 2020.
- **Implementation Strategy WR 4.1.4 Expand public education programs for water conservation:** The County and all other water purveyors in the county will collaborate with local nonprofit and educational organizations, such as the Partners in Water Conservation, to expand water conservation education programs countywide.
- **Policy WR 4.3 Water conservation:** The County will be a leader in water conservation efforts.
- **Implementation Strategy WR 4.3.3 Reduce water use in County operations:** Reduce exterior and interior use of water in County-owned, operated, or financed facilities through efficient technologies, design and management practices, and other conservation efforts.

Per the County of San Luis Obispo's request, this study includes various water conserving technologies and practices that can be implemented in buildings throughout the county to help achieve a 20 percent water use reduction per capita by the year 2020 (WR Goal 4). This study will help the county achieve this goal by providing information on the technologies that are available to assist people reduce their daily water consumption.

1.2. APPLICATION OF STUDY

This project is intended to aid the County of San Luis Obispo in its water conservation efforts. This document was developed in order to accomplish the following goals:

- Reduce County of San Luis Obispo's per capita water use 20 percent by 2020
- Educate the county Planning Staff on water conservation technologies
- Develop a list of water conservation technologies for indoor and outdoor water use

The document's intended purpose is to provide a list of water conservation technologies that developers within the county can choose from to implement in their projects.

Projects may include new housing developments, commercial construction, and building retrofits. The document is not limited to developers. Homeowners, city planners, and officials can also benefit from the educational information in the document. The county of San Luis Obispo may use this document for in-house staff development or communitywide educational applications. The project provides information in the following areas:

- Available water conservation technologies and practices
- Research on the application, water savings, and cost of each technology
- Overview of water conservation issues and efforts in California and San Luis Obispo
- How Urban Planning and the plan development process can contribute to water use reduction
- Water saving possibilities from new technology in buildings and landscapes

2.0 WATER ISSUES IN CALIFORNIA

California is the third largest state in the United States with an area of 160,000 square miles, a population of almost 37 million and a projected population of 60 million by 2050. The state is bound by four distinct mountain ranges, the coastal ranges on the west, the Sierra Nevada's on the east, the Cascade Range in the north, and the Tehachapi Mountains in the south (Macdonald, 2007).

Water needs in California are met through a water storage and delivery system of reservoirs, aqueducts, power plants and pumping plants. Water is distributed to 29 urban and agricultural water suppliers in Northern California, the San Francisco Bay Area, the San Joaquin Valley, the Central Coast, and Southern California. The water supply must meet the needs of the San Joaquin Valley agricultural production which accounts for one third of the nations produce, the large urban areas such as Los Angeles, San Diego, San Jose, and San Francisco, and the many other cities and agricultures throughout the state. Currently, 70 percent of the water supply goes to urban areas and 30 percent for agriculture (MacDonald, 2007)

2.1. CALIFORNIA'S DROUGHT

Drought conditions are measured by various factors depending on the end user's needs. The water supply districts consider factors such as rainfall/runoff and amount of water in storage. However, in general a drought or a dry year can be determined by comparing average precipitation to historical averages. California receives 75 percent of annual precipitation between November and March, and 50 percent of that occurs between December and February. A typical water year would produce about 100 inches of rainfall over the North Coast, 50 inches over the Northern Sierra, 18 inches in Sacramento, and 15 inches in Los Angeles. In a dry year the annual totals can fall to as little as one third of these amounts (California Department of Water Resources, 2010).

Identifying drought years is critical for the planning of future water needs for the state of California. Because drought effects have a slow onset, there is more time for water

suppliers to plan and prepare for these conditions. Even though there is more time to prepare for drought, the impacts increase as the length of the drought increases. This is because carry over supplies in reservoirs continue to be depleted and water levels in groundwater basins decline as the drought continues. In drought years, the demand remains the same but the input of water is reduced compared to a normal year. If drought persists and no actions are taken, then water supply will eventually be lost.

Water supply and quality are critical issues in California because of the arid climate, large population, and persistent drought years that the state has experienced recently. California has been in a state of drought since 2007 and is now preparing for its fourth consecutive year of drought. Following dry year 2007, there was optimism that 2008 would bring enough snowpack and precipitation to alleviate conditions caused by that dry year. However, 2008 ended with the driest spring on record resulting in another dry year. In February 2008, Governor Arnold Schwarzenegger introduced a seven-part plan for improving the Sacramento-San Joaquin Delta water supply. As part of the plan he directed state water agencies to develop a plan that would help California reduce its per capita water use 20 percent by 2020. Shortly after this, Governor Schwarzenegger issued executive order S-06-08 and a Central Valley State of Emergency Proclamation, marking the first statewide drought declaration in California (California Department of Water Resources, 2010).

2.2. WATER CONSERVATION

California has responded to the continual drought through a variety of programs and plans. For example, in 2009, the state finalized the 20x2020 Water Conservation Plan and a water conservation program was launched to assist California in reaching its water use reduction of 20 percent per capita by 2020 (California Department of Water Resources, 2010).

The 20x2020 Water Conservation Plan was the result of the Governor's request for water agencies to develop a plan to meet a 20 percent per capita water reduction by 2020. The current water use in California is 192 gallons per capita, daily. With the implementation of this plan, the water use will be reduced to 154 gallons per capita daily. This amounts to a 1.59 million acre-feet savings. The plan focuses on improving an understanding of the variation in water use across California, promotes legislative initiatives that incentivize water agencies to promote water conservation, and creates evaluation and enforcement mechanisms to ensure that regional and statewide goals are met (California Department of Water Resources, 2010).

As part of the educational portion of the water conservation efforts in California, the "Save Our Water" project was developed. It is a public education program that was developed by the Department of Water Resources and the Association of California Water Agencies. The program is designed to educate Californians on the state's water challenges and encourage them to reduce the amount of water they use every day. The program includes water saving tips, educational material, and various resources and tools to aid in the reduction of water use in California (California Department of Water Resources, 2010).

3.0 RESEARCH APPROACH AND FRAMEWORK

This section details the approach for conducting research and explains the organizational structure of the entire project. The research element of the project consists of secondary research sources that include professional planning documents, case studies, and industry standards and recommendations related to water conservation. The project is divided into several chapters based on California Polytechnic University, San Luis Obispo City and Regional Planning graduation requirements. The final product consists of two separate products: a handbook of water conservation technologies and a detailed document containing relevant background research and explanations for the abbreviated handbook. Further details are provided in the following section.

3.1. APPROACH

The approach for this project was to gain as much knowledge as possible related to water conservation and available water conserving technologies through secondary research methods. The majority of the information was acquired through a broad research approach which included various sources described in this section.

3.1.1. PLAN DOCUMENTS AND CASE STUDIES

The use of plan documents was crucial in the development of this project. Because the project includes recommendations for current water conservation approaches and technologies, it is important to gain an understanding of how the planning industry is currently dealing with this issue. Furthermore, the plans provide examples of different approaches that are actually being implemented in different jurisdictions, developments, and construction projects. The plans demonstrate how certain approaches could be used and also provide concrete examples of benefits and costs for implementing water conservation technologies.

The case studies serve two separate purposes with regard to this report. First, they provide a real example of water conservation efforts at a large citywide scale, and second, they show how implementing water conserving appliances and practices can save water in a real structure.

The case study of the citywide efforts, in this case Phoenix, Arizona, was chosen to provide an example of what has been done in other jurisdictions dealing with water conservation issues. The City of Phoenix was chosen because of its arid climate and severe water supply issues. The efforts in Phoenix serve as a model of what actions worked and what could be applied in other jurisdictions. The second case study provides a smaller scale example of how water conserving technology can contribute to the overall water conservation efforts of the community. In this case, Cal Poly, San Luis Obispo, did a major retrofit project in order to reduce water consumption. The project was chosen to serve as a model for how other organizations in the same county can make improvements and reduce their water usage and water cost.

3.1.2. GENERAL RESEARCH

The objective of the final product is to provide a handbook with water conservation technologies that can be used in new construction and retrofit projects to reduce water consumption. To achieve this objective, a research matrix was developed to aid in the research process. An example is shown below in Table 01. The matrix was a guide to keep the research organized and complete. The research matrix was then modified to be used in the document to provide the actual information for each of the water conservation technologies that were researched.

Table 01. Example of Research Matrix for Water Conservation Technologies

Technology	Source (Website/Article)	Water Savings	Traditional Water Use	Cost
Duel Flush Toilet	www.H2ouse.org	5.4 gpf	7 gpf*	\$200
Faucet Aerators	Mayer et. al.	1.5 gpm	3 gpm*	\$5
Low Flow Showerhead	County of Santa Barbara	2 gpm	7 gpm	\$30
Compost Toilet	www.H2ouse.org	7 gpf	7 gpf	\$1,000
Washing Machine	Mayer et. al.	20 gpl	45 gpl	\$400

*GPF refers to Gallons per Flush and is used to measure toilet water use.

*GPM refers to Gallons per Minute and is used to measure water flow rate.

This research matrix was used during the entire research process. When valuable information or a new water conserving technology was discovered, it was added to the research matrix. Once this table was complete, the information for each water conserving technology was assimilated into a coherent description and included as part of the final product.

3.1.3. OTHER

This portion of the research included any other sources of information that were gathered. These included professional consultations, educational background and knowledge, and relevant regulations and industry standards. Professional consultations included regular meetings with Chris Clark, Cal Poly Professor, Planning Professional and Land Use Lawyer. These consultations provided direction and feedback on the progress of the project. The educational background in city and regional planning helped to provide a better understanding of the information that was gathered and also made the research more efficient and effective. Finally, there are many regulations and standards that apply to the manufacturing and use of water using devices in the United States. It was important to identify relevant regulations and include them in the research and development of this project.

3.2. FRAMEWORK

The framework for this project can best be explained by using an outline. Below is the outline that was used to complete the project. The outline describes what the final products will entail and further explains the specific sections for each product.

3.2.1. PRODUCTS

1. THE HANDBOOK: Contains technology and methods for reducing water use in various types of buildings throughout the county of San Luis Obispo. The main purpose of the Handbook is to provide developers and homeowners with viable options to choose from in order to reduce water consumption and meet the county's overall water use goals.

2. BACKGROUND REPORT: A supplemental document to the handbook which includes the necessary background research to support the techniques mentioned in the handbook. The Report is intended to provide information on each technique and explain why and how they can be used to reduce water consumption. The report also includes various chapters described in the outline below.

3.2.2. OUTLINE

- I. Water Conservation Technology and Practices Handbook (**Product 1 Above**)
 - A. Indoor Water Use
 - B. Outdoor Water Use
- II. Background Report for Water Conservation Handbook (**Product 2 Above**)
 - A. Introduction
 - i. Need for study
 - ii. Application of handbook
 - B. Water issues in California
 - i. California's Drought
 - ii. Water Conservation
 - C. Research Approach and Framework
 - i. Approach
 - ii. Framework
 - iii. Literature Review
 - D. Planning for Water Conservation
 - i. Case Studies
 - 1. Phoenix, Arizona

- 2. California Polytechnic State University, San Luis Obispo, California
- ii. Collaboration and Community Participation
 - 1. Arroyo Grande, California
 - 2. Los Angeles, California
- E. Water Conservation Technology
 - i. Indoor Water Use
 - ii. Outdoor Water Use
- F. Potential Problems with water conservation approaches
- G. Conclusions
 - i. Additional Programs
 - ii. Future Recommendations

The two products can be used as standalone documents or supplements to each other. The Handbook is intended to provide a quick reference guide for developers to use when determining what water conservation technology is available to use on new construction projects. It provides just the necessary information such as cost and savings. For further detailed explanations, The Background Report can be referenced. The Background Report not only provides more details on each technology but also the basis for the research and other relevant information to the topic of water conservation in general.

3.3. LITERATURE REVIEW

The Literature Review section includes a list of all of the sources that were referenced and used to produce this study. The review is organized into major categories that mimic the research approach and sections of the entire document. Sections are divided into research on Regulations and Manufacturing Standards, Water Use Statistics and Background Information, Case Studies, and Water Conservation Technology.

3.3.1. REGULATIONS AND MANUFACTURING STANDARDS

1. **United States Congress. (1992, October 24). *Energy Policy Act of 1992*. Washington D.C., U.S.A: The United States Government.**

The Energy Policy Act of 1992 was signed into law by the United States President George H.W. Bush in 1992. The purpose of the act was to promote the use of renewable energies by providing financial incentives to renewable energy developers and therefore reduce reliance on fossil fuels. The act also provided the first industry wide manufacturing standards for household appliances and fixtures in the United States as regulated by the U.S. Government. It provided specific limitations on energy consumption and water use for appliances such as toilets and sink faucets. The Energy Policy Act of 1992 led to many more regulations and increasing efficiency standards in the years to come. This source provides the specific water efficiency standards for household appliances as well as it contributes to the history of water conservation and awareness in the United States. It is a strong reference point for many of the regulations pertaining to water conservation technologies. The text of the act consists of a summary matrix that outlines the specific standards for each household appliance, including proposed increases in standards for future years.

2. **United States Environmental Protection Agency. (2004). *Guidelines for Water Reuse*. Washington D.C: Office of Water.**

The Guidelines for Water Reuse is a document that the United States Environmental Protection Agency published in 2004 which includes state and federal standards for recycling water, information regarding the theory and the need for recycling water, and all of the specific considerations that must be made for recycling water based on the intended use of the water. The document is divided into 8 different chapters. The chapters discuss current water use and demand in the United States, the need for recycling water, the different applications of recycled water, case studies of cities and counties that recycle water, and the specific regulations for recycling water based on the intended final use. The document serves as an in depth resource on recycling water. It provides details on the regulations on recycling water and on the potential applications of recycling water. It also provides some valuable statistics for

water use in the United States. The main focus of this article is to provide information for the recycled water portion of the final product.

3. U.S. Environmental Protection Agency. (2010). *Products*. Retrieved March 2010, from Energy Star: <http://www.energystar.gov/>

The United States Environmental Protection Agency has an Energy Star Labeling program which sets guidelines for appliances to meet lower energy requirements than the standard appliances. If an appliance meets these specific requirements it can obtain the Energy Star label. This source provides information on the standards for every household and commercial appliance or fixture that is eligible for the energy star program. The website provides the specific standards for each product, links to studies on the water use of these appliances, and links to purchase Energy Star qualified appliances. The main purpose of this source is to provide the specific standards for each of the water conservation technologies outlined in the project and to provide a comparison between the non efficient water using appliance to the more water efficient one with an Energy Star label.

4. Consortium for Energy Efficiency. (2009). *Super Efficient Home Appliances Initiative, Dishwasher Specification*. Boston: Consortium for Energy Efficiency.

The consortium for Energy Efficiency provides a summary table that compares the Federal Government's household dishwasher efficiency standards to the Energy Star efficiency standards. The table is broken up by compact and standard size dishwashers. It looks at the efficiency standards for energy and water use for both the Federal Government requirement and the Energy Star program for both size dishwashers. This document's main purpose is to serve as a comparison of different efficiency standards for home dishwashers.

5. Pennsylvania Department of Environmental Protection. (2005). *Pennsylvania Stormwater Best Management Practices Manual: Section 6 Structural BMPs*. Harrisburg: Pennsylvania DEP.

The Department of Environmental Protection for the state of Pennsylvania published a Stormwater Best Management Practices Manual which includes specific guidelines and practices recommendations for dealing with stormwater runoff. The Manual presents several different approaches for dealing with stormwater such as the use of pervious pavement and green roofs. Furthermore, it provides specific design elements on measurement tools to determine how to best manage storm water in a particular area. It also provides historical information and technical information on the different technologies, such as, the specific material composition and manufacturing process of pervious asphalt. The main purpose of this manual is to provide technical information for water conserving technologies such as pervious pavements, the specifics of their application, and critical limitations and concerns to maximize their effectiveness.

6. Senate Agriculture and Water Committee. (2003). *Water and Land Use Planning: Assessing the Effects of SB 221 and SB 210*. Tracy, CA: Senate Agriculture and Water Committee.

This is a report that was published two years after the passing of two Senate Bills related to water and land use planning. The focus of the report is to assess the implications and effects from the two bills. The document begins with a summary of the requirements of the two Senate Bills and then discusses the implications from the bills. The report also provides some historical information of land use and zoning laws as they were before the new bills to highlight how the changes would affect past legislation. The report serves as a resource for understanding some history of water conservation, land use, and zoning laws. Furthermore, the report provides a thorough explanation of the two bills and how they affect city and county projects and water supply.

7. California Department of Water Resources. (2009). *Model Water Efficient Landscape Ordinance AB 1881*. Washington D.C: Office of Water.

The California Department of Water Resources wrote a Model Landscape Ordinance that was adopted by the State Legislature as AB 1881 in 2006. The ordinance requires cities, counties, charter cities, and charter counties to adopt landscape water conservation ordinances by January 1, 2010, or they must adopt this one if they do not develop their own. It includes requirements for establishing water budgets, irrigation design, landscape design, grading design, irrigation scheduling, maintenance schedules, irrigation efficiency, and dealing with recycled water and storm water. The ordinance serves as a resource for the landscape irrigation portion of the product. It provides valuable water use data and techniques for improving outdoor water use.

3.3.2. WATER USE STATISTICS AND BACKGROUND INFORMATION

8. Loux, K. E. (2004). *Water and Land Use: Planning Wisely for California's Future*. Point Arena: Solano.

This book covers everything from California water issues to land use planning and includes a step by step guide for collecting data, conducting analysis, and preparing an integrated resource plan. The book is very useful and relevant to this study because of the background information it provides. It gives an overview of the history of water issues in California, legislative and regulatory framework of water law, and much more. The main purpose of this book is to provide a reference for almost any issue related to water conservation or water regulations in California.

9. California Department of Water Resources. (2010). *Outdoor Residential Water Use, Appendix B. Sacramento: California Department of Water Resources.*

This appendix provides technical calculations and statistics on outdoor water use for the entire state of California. The appendix shows the methods used to calculate water use estimates for all the regions of California. Furthermore, the appendix provides methods for determining the amount of water savings possible based on the different types of surfaces used in residential and commercial landscape. This appendix can be used by individual homeowners or business owners to determine how much water they currently use and waste for landscaping. The most important information for the final product is the breakdown of outdoor water use by geographic region in California. The appendix includes a summary table that gives the percentage of residential outdoor water that is used in urban areas and non urban areas for every region. It also provides the water use by months of the year.

10. PMC. (2009). *County of San Luis Obispo General Plan, Water Resources Appendix. San Luis Obispo: County of San Luis Obispo.*

The County of San Luis Obispo General Plan, Water Resources Appendix 10 provides information on the current state of water supply and quality on the County. It also provides a description of the current County Codes that directly affect water conservation. It explains the County's Title 8 and Title 19 code that regulates new and existing plumbing fixtures based on different areas of the County. The Appendix also provides information on all of the County's groundwater basins and how much water remains. This document provides information on the current state of water issues in San Luis Obispo and is valuable for this project to ensure that all of the information is current and accurate as described by the County of San Luis Obispo General Plan.

11. PMC. (2009). *County of San Luis Obispo General Plan, Water Resources Chapter. San Luis Obispo: County of San Luis Obispo.*

The County of San Luis Obispo General Plan, Water Resources chapter provides information on the current state of water supply and quality on the County. It provides an introduction to the issues specific to San Luis Obispo, such as increasing water quality issues and a need for better land use planning to reduce water consumption. The chapter provides a set of goals, policies, and implementation strategies to deal with the issues in San Luis Obispo. Some of these goals are directly related to the purpose of this project. For example, the County has a goal to reduce per capita water use 20 percent by 2020. The technologies described in this project are one step towards achieving this goal. The purpose of this resource on the development of this document is to provide current information on water issues in San Luis Obispo. The General Plan goals also explain the need for action in water conservation efforts. Finally, the chapter has useful maps of the County's water sources.

12. California Urban Water Conservation Council. (2009). *H2ouse Water Saver Home*. Retrieved April 2010, from www.H2ouse.org

This is a comprehensive website resource put together by the California Urban Water Conservation Council that provides background information on water use in the United States, water conservation tips, water conservation technology, and links to more resources and information. The website is organized by using an interactive model of a house depicting the different parts of a house that use water. Each room contains the particular water using appliance that would usually be found in that area of the house. The user can click on the water using appliance and then read information specific to that appliance. The website is an essential reading and resource in regards to water conservation in California. Not only does it provide some of the most accurate and up to date information but it has links to some of the other leading agencies and resources on water conservation. The website's main contribution to the final project is that it provides specific water use and water conservation strategies for each water using appliance or fixture in a common residential unit.

13. Gober, R. C. (2006). *Climate Variability and Residential Water Use in the City of Phoenix, Arizona*. *Journal of Applied Meteorology and Climatology*, 46, 9.

This is a study that was done in Phoenix, Arizona to see how changes in climatic variables between 1980 and 2004 affected outdoor water use in the City of Phoenix. The study looked at variables such as mean temperature, total annual precipitation, and annual mean Palmer hydrological drought indexes. The study found that annual water use increased with higher temperatures, lower precipitation, and drought. The conclusion was that even though water use is affected as the climate varies, people's perception and watering practices are more important than the landscape's actual need for water. This highlights an important point and solidifies the fact that education and behavior change is a crucial aspect to conserving water. This study provides direct justification for this professional project since the sole purpose of the project is to provide educational materials on the available water conserving technologies. This project provides a plethora of water conservation technologies and techniques that if people were to adopt them, they would surely see improvements in the amount of water they use.

14. United States Department of Agriculture. (2009). *Using Technology to Save Water*. Washington D.C: United States Department of Agriculture.

This is an article that discusses new advancement in the use of technology to manage water use for agricultural practices. The article discusses computer modeling software, the use of satellite data, remote sensors, and other technologies that are being explored to determine water needs and help cut back on water use. The article also discusses how the change in global climate and earlier snowmelt are altering when water becomes available for crops. This article provides information on the overall state of water issues such as water supply, water need, and water conservation. It is a brief article that has some valuable information for the overall larger picture of water conservation in the U.S. and more specifically for the more

arid regions such as California, New Mexico, and Arizona. The main purpose of this resource is to provide educational information on the problem of water supply currently and in the future for these arid States.

15. California Department of Water Resources. (2010). *20x2020 Water Conservation Plan*. Sacramento: State of California.

The 20x2020 Water Conservation Plan was a plan that was developed in response to the Governor of California's request for the residents of California to reduce their per capita water consumption 20 percent by the year 2020. The request was made in an executive order which delegated the Department of Water Resources to develop a plan for meeting this goal. This plan entails the implementation strategies and policy changes necessary to reach this goal. The plan's primary purpose is to provide regulatory background related to water issues in the State of California and detail the water conservation goals and efforts for the State.

16. California Department of Water Resources. (2010). *Drought FAQ*. Sacramento: State of California.

This is a document published by the State of California Department of Water Resources that includes a question and answer type information on the drought conditions of California. It explains the difference between drought and normal years and the implications from drought. It also provides some history of water issues in California and the future goals and direction that the state is heading in regards to water conservation. The primary purpose of this document is to provide information on drought years in California and history of water issues.

17. California Department of Water Resources. (2010). *Recent California Drought*. Sacramento: State of California.

This document is published by the State of California Department of Water resources. It is intended to provide information on the current state of California's Drought. It gives information on what a drought is and on the current water levels in California. It provides information on past droughts in California and discusses the implications of persistent drought. Its primary purpose is to provide information on California's current water condition and history of water issues in the State.

3.3.3. CASE STUDIES

Los Angeles, California

- 18. Brown and Caldwell. (2006). *Integrated Water Management Strategy Technical Memorandum*. Los Angeles.**
- 19. City of Los Angeles. (2009). *The Greater Los Angeles County Integrated Regional Water Management Plan Highlights Brochure*. Los Angeles.**
- 20. Department of Water and Power. (2005). *Urban Water Management Plan*. Los Angeles: City of Los Angeles.**

These three sources provide the information for the case study on the Los Angeles collaborative planning effort. They include plan documents that were the result of a huge collaborative planning effort in the Los Angeles region. The plans provide all of the information for the collaborative efforts and plan document development for the Integrated Regional Water Management Plan developed in the Los Angeles area. The plans primary purpose is to provide information on the process and the success of the efforts in Los Angeles. The plans also provide all of the data and examples for the Los Angeles case study in the collaborative planning section of this study.

- 21. Brock, E. (2007). Programs keep the well from running dry. *American City & County* , 122 (6), 20-21.**

This article emphasizes the importance of educational programs to help conserve water. It discusses the United States WaterSense program and the educational programs that Phoenix, Arizona has used in their water conservation efforts. This article served many purposes but its primary goal is to highlight the importance of education and community awareness in the implementation of a water conservation program.

- 22. Shankman, S. (2009, August 24). Water Cops Crack Down in Drought Areas. *Wall Street Journal* , p. A.5.**

This article provided an example of water conservation efforts and accomplishments in the City of Los Angeles, California. It specifically discusses the recent efforts that Los Angeles has made to reduce their water consumption. It talks about city ordinances, programs, and enforcement efforts that the City has employed. The purpose of this article is to provide an example of how other cities are dealing with water conservation. It also reinforces the fact that water conservation efforts need to be creative and comprehensive in order to make a real difference.

Arroyo Grande, California

- 23. City of Arroyo Grande. (2010). *Water Conservation*. Retrieved April 2010, from www.arroyogrande.org**

This source includes the current state of water issues in Arroyo Grande. The website provides current information of water supply and water concerns in the City. It serves as a reference for the Arroyo Grande case study in the collaborative planning section of this document.

Phoenix, Arizona

- 24. The City of Phoenix Water Services Department. (2005). *Water Resources Plan 2005 Update*. Phoenix: Water Services Department.**
- 25. United States Environmental Protection Agency. (2002). *Cases in Water Conservation: How Efficiency Programs Help Water Utilities Save Water and Avoid Costs*. Washington D.C.: Office of Water.**

These two sources provide information on the water conservation plan and efforts in Phoenix, Arizona. The water resources plan update is the water plan for all of Phoenix. It has a lot of the water use data and information for the city and the approach that the city took towards water conservation. The study from the U.S. EPA is a quick look at 17 different cities and their approaches to water conservation. Each case study provides quick facts of the cities' approach, accomplishments, and a summary of their efforts. It provides information on the city of Phoenix, Santa Monica, Goleta, and more. The study also includes historical information on the water issues in those areas.

California Polytechnic State University, San Luis Obispo

- 26. Cal Poly. (2010). *Facility Services*. Retrieved April 2010, from Sustainability: <http://www.afd.calpoly.edu/sustainability/planning.asp?pid=4#Minor>**
- 27. Cal Poly Facility Services. (2008). *LEED Certification Project Overview*. San Luis Obispo, California, United States of America.**
- 28. Elliot, D. (2008). *Facility Offices East LEED Application Report*. San Luis Obispo, California, United States of America. Retrieved from Awards.**

The Cal Poly Facility Services department was the project manager for a retrofit project that resulted in the first LEED certification for a building on the Cal Poly campus. The above sources provide the information on the project, the overview of the project details, and the award application for the LEED certification. The three sources provide all of the necessary information on the retrofit project in the Facility Offices East building for the case study in this professional project.

29. Elliot, D. (2009, March). *Facility Offices East Plumbing Retrofits*. San Luis Obispo, California, United States of America.

30. Elliot, D. (2009, March). *Facility Offices East Irrigation Retrofits*. San Luis Obispo, California, United States of America.

Dennis Elliot is the Sustainability Director for the Facility Services at Cal Poly San Luis Obispo. These two sources are data sets obtained from Dennis Elliot through email and personal communication. They provide the data on water usage before the retrofit project at the Facility Offices East building and the water usage after the water fixture retrofit. The data provided the technical information for the case study on the retrofit project on the Cal Poly campus. One of the data sets is on the indoor water usage and the other one is for outdoor water fixtures used for irrigation.

3.3.4. WATER CONSERVATION TECHNOLOGY

Indoor Water Use

The following sources are organized together because they all provide similar information on different water conservation technologies for fixtures and appliances with indoor applications. The difference in the sources is the type of technology that they describe. Each source is listed below with a brief description of the specific water conservation technology that it discusses. The purpose of these sources is to provide information on water saving benefits from each technology compared to a similar non water conserving technology. The benefits/water savings from the different types of technologies are important for this project because they provide detailed explanations of each technology. These explanations can aid the user of the guide to decide which technology is appropriate for their use.

31. United States Environmental Protection Agency. *High-Efficiency Lavatory Faucet Specification*. Office of Water. Washington D.C.: EPA WaterSense.

This source has specific information on bathroom sink faucets and aerators. It includes criteria for manufacturing and specifics of flow rates for the different lavatory fixtures.

32. Metaefficient. (2010). *The Guide to Highly Efficient Things*. Retrieved February 2010, from Metaefficient.

This source provides a comparison between various kitchen and bathroom faucet aerators. It reviews the different aerators available on the market today with their specific flow rate and intended use. It also provides cost information for the various technologies.

**33. National Geographic Society. (2009). *The Green Guide for Everyday Living*. Retrieved February 2010, from National Geographic:
http://www.thegreenguide.com/buying-guide/washing-machines/product_comparison**

This source provides a comparison of different models of energy and water efficient clothes washing machines. It also includes the specification of the different models and prices.

34. PlumbingSupply. (2010). *Green Plumbing*. Retrieved February 2010, from PlumbingSupply.com: <http://www.plumbingsupply.com/welcome.html>

This website has many different brands and models of every plumbing fixture available, water conserving or not. It serves as a comprehensive guide for comparing the cost and the performance of any type of water using fixture.

35. Reichardt, R. K. (2006, February 1). *Hold the Water*. Retrieved February 2010, from American School & University: http://asumag.com/mag/university_hold_water/

This site focuses on the use of water saving technologies for schools and universities. It discussed automatic fixtures, low flow toilets, and urinals.

- 36. Save Water Project. (2010). *Toilets*. Retrieved April 2010, from Water Saving Toilets for Water Lovers: <http://www.savewaterproject.com/>**

This site features different water conserving technologies based on their own recommendations and preferences. Currently the site features information on low flow toilets and dual flush toilets. It provides flow rates and prices of different models.

- 37. State of Michigan. (2006, March). *Resources & Environment*. Retrieved March 2010, from Water Efficiency: http://www.michigan.gov/documents/CIS_EO_GLM_Water_conservation_156170_7.pdf**

This source discusses the major water using appliances and fixtures in a house. It includes toilets, washing machines, faucets, showerheads, and landscaping.

- 38. Consortium for Energy Efficiency. (2009). *Super Efficient Home Appliances Initiative, Dishwasher Specification*. Boston: Consortium for Energy Efficiency.**

See 3.3.1 Regulations and Manufacturing Standards

- 39. United States Environmental Protection Agency. (2010). *Products*. Retrieved March 2010, from Energy Star: <http://www.energystar.gov/>**

Outdoor Water Use

The following sources are organized together because they all provide similar information on different water conservation technologies for outdoor applications. The difference in the sources is the type of technology that they describe. Each source is listed below with a brief description of the specific water conservation technology that it discusses. The purpose of these sources is to provide information on water saving benefits from each technology compared to a similar non water conserving technology. The benefits/water savings from the different types of technologies are important for this project because they provide detailed explanations of each technology. These explanations can aid the user of the guide to decide which technology is appropriate for their use.

- 40. Concrete Delivers. (2010). *Pervious Concrete Pavement: An Overview*. Retrieved February 2010, from National Ready Mixed Concrete Association: <http://www.perviouspavement.org/index.html>**

This source describes the uses and benefits of pervious pavement. It details specific applications and the various types of materials used for pervious pavement.

- 41. Rain Harvest Co. (2009). *Products*. Retrieved April 2010, from Rain Harvest: <http://www.therainharvestco.com/>**

This source gives examples of different rain harvesting systems available today. In addition, it provides cost for each system. It has detailed information on installation of the various rain harvesting applications. This source also gives some general information on rain harvesting and how these systems work.

- 42. Salt River Project. (2010). *Water Services*. Retrieved April 2010, from Smart irrigation controllers reduce outdoor water use: <http://www.srpnet.com/water/smartirrigation.aspx>**

This source provides information on the water saving possibilities from smart irrigation controllers. It also provides tips for conserving irrigation water.

- 43. Stryker, J. (2009). *Smart Controllers for Irrigation Systems*. Retrieved April 2010, from Irrigation Tutorials: <http://www.irrigationtutorials.com/faq/smart-controllers.htm>**

This source provides information on the water saving possibilities from smart irrigation controllers. It has a very detailed description of the different types of smart controllers available and how each technology works. It also provides tips for conserving irrigation water.

- 44. Texas Water Development Board. (2005). *The Texas Manual on Rainwater Harvesting*. Austin: Texas Water Development Board.**

A complete manual on rainwater harvesting that includes the benefits, the various types of systems available, guidelines for installation, and cost estimates. The manual has information on each component of the rain harvesting system and how they all work. The manual is a very strong resource for understanding how rain harvesting works and what benefits it may provide.

- 45. Toolbase Services. (2001). *Permeable Pavement*. Retrieved February 2010, from NAHB Research Center: <http://www.toolbase.org/Technology-Inventory/Sitework/permeable-pavement>**

This website provides information on the various types of pervious pavement technology and the benefits and applications of each.

- 46. California Urban Water Conservation Council. (2009). *H2ouse Water Saver Home*. Retrieved April 2010, from www.H2ouse.org**

See 3.3.1 Regulations and Manufacturing Standards

- 47. California Department of Water Resources. (2009). *Model Water Efficient Landscape Ordinance AB 1881*. Washington D.C: Office of Water.**

See 3.3.1 Regulations and Manufacturing Standards

- 48. Pennsylvania Department of Environmental Protection. (2005). *Pennsylvania Stormwater Best Management Practices Manual: Section 6 Structural BMPs*. Harrisburg: Pennsylvania DEP.**

See 3.3.1 Regulations and Manufacturing Standards

- 49. Bastian, R. (2006). The Future of Water Reuse. *BioCycle* , 47 (5), 25-27.**

The focus of this article is on the need for water reuse and its various applications. It provides some data on water use and presents a valid case for increasing the use of recycled water. It also looks at some other areas in the United States such as Florida that has been using recycled water for many purposes. Finally, the article describes the many applications and benefits from using recycled water.

Commercial Appliances

- 50. Food Service Technology Center (FSTC). (2010). *Promoting Energy Efficiency in Food Service*. Retrieved March 2010, from Water-Using Appliances: <http://www.fishnick.com/>**

The Food Service Technology Center is a program that is funded by the California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission. It is located in San Ramon, California and conducts various research on commercial appliances as well as

publish research and best practice guides for the food service industry. This resource provides information on the various water using appliances in a commercial food service operation. The website also provides details on how non conserving appliances work and provides comparable water conserving alternatives. The site also provides water saving statistics for the various appliances.

51. Karas, A. (2005). *Evaluating the Water Savings Potential of Commercial “Connectionless” Food Steamers*. San Ramon: FSTC.

This source is a study conducted by the Food Service Technology Center for the Municipal Water District of Los Angeles and the East Bay Municipal Utility District of Oakland, California. The purpose of the study was to determine how much water could be saved in the State of California by replacing boiler based food steamers with water saving, connectionless food steamers. The study provided empirical data for the comparison of traditional, non water conserving food steamers to more water efficient ones. The study's primary use in the research project was to provide information on commercial food steamers for the food service appliance section.

52. United States Environmental Protection Agency. (2010). *Commercial Dishwashers for Businesses and Operators*. Retrieved April 2010, from Energy Star: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COH

The United States Environmental Protection Agency provides multiple resources on water consuming appliances on their Energy Star website. This source focused on commercial dishwashers. The main purpose of the site was to provide water consumption data for the different types of dishwashers available to business owners and operators. The site also provides a large database of dishwasher models from all of the major manufactures. This database includes the manufacturer's name, model, energy consumption, and water rating. This database was very useful for identifying different dishwashers on the market that could be used in place of non water conserving ones.

53. United States Environmental Protection Agency. (2009, April). *Dishwasher Calculator*. Retrieved April 2010, from Energy Star: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCommercialDishwasher.xls

The United States Environmental Protections Agency provides many different calculators on their Energy Star program website. This particular calculator is designed to help business owners determine the potential savings from using an Energy Star dishwasher compared to a non Energy Star one. The calculator was used in this project to determine the savings in water for the various types of commercial dishwashers. Dishwashers generally vary by their wash load capacity. The website and calculator provided specific details on every type of dishwasher and how much water and energy it consumes.

3.3.5. COST INFORMATION

All of the following references provide cost information for the various water using appliances. Various websites, distributors, manufacturers, and companies are listed with the corresponding appliance that each one carries. The matrix below provides a concise display of where the cost of each was found.

Table 02. Cost Matrix for Technologies

	Home Depot	Sears	Lowes	The Great Indoors	American Standard	WaterWise Tech. International	Sun- Mar Corp.	SaveWaterUS	Amazon.com	PlumbingSupply.com	Rain Bird	Cyber-Rain	Water Saver Technologies	U.S. EPA	Rain Harvest Systems	Webstaurantstore.com	Foodservicewarehouse.com	Katom.com	Plumbersurplus.com	WaterWiseTech
Clothes Washer	X	X	X						X											
Point of Use Tankless Heaters	X								X											
Residential Dishwashers		X		X																
Sink Aerators	X							X	X											
Automatic Fixtures										X										
Toilets					X															
Compost Toilets							X													
Urinals						X														
Showerheads	X								X											
Commercial Dishwashers																X				
Ice Makers																		X		
Food Steamers																X	X			
Pre-Rinse Spray Valves																		X	X	X
AQUS Water Recycling													X							
Smart Irrigation											X	X								
Drip Irrigation	X		X																	
Pervious Pavement														X						
Mulch	X		X																	
Rain Harvest															X					

- 54. United States Environmental Protection Agency. (2009, April). *Dishwasher Calculator*. Retrieved April 2010, from Energy Star:**
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCommercialDishwasher.xls

The United States Environmental Protections Agency provides many different calculators on their Energy Star program website. This particular calculator is designed to help business owners determine the potential savings from using an Energy Star dishwasher compared to a non Energy Star one. The calculator was used in this project to determine the savings in water for the various types of commercial dishwashers. Dishwashers generally vary by their wash load capacity. The website and calculator provided specific details on every type of dishwasher and how much water and energy it consumes.

4.0 PLANNING FOR WATER CONSERVATION

This section provides a brief overview of how water conservation is being addressed in the planning profession. It provides two separate case studies of water conservation efforts: the first is for the City of Phoenix, Arizona, which has a city wide water conservation effort in place for over 20 years, and the second is for a retrofit project at Cal Poly, San Luis Obispo, to reduce water consumption at the university. The final portion of this section discusses how collaboration and community input is used to plan for water conservation. These case studies look at two separate planning initiatives that relied on community participation and collaboration to produce their plan documents.

4.1. CASE STUDIES

The case studies serve two separate purposes. The first purpose is to provide a real example of water conservation efforts at a large citywide scale and the second to show how implementing water conserving appliances and practices can save water and money in a real application. The City of Phoenix, Arizona is the first case study and the retrofit project at the Cal Poly, San Luis Obispo campus is the second case study.

4.1.1. CITY OF PHOENIX, ARIZONA

Background and Water Issues

Phoenix, Arizona is the fifth largest city in the United States, with a population of approximately 1.5 million people. It is located in the Salt River Valley in central Arizona in the northern reaches of the Sonoran Desert. Phoenix has an arid climate and is amongst the hottest of any populated areas in the United States. On average, the temperature reaches or exceeds 100 degrees Fahrenheit on 110 days a year. These conditions and the large population of the city make water use and supply a critical consideration for Phoenix (The City of Phoenix Water Services Department, 2005).

The City of Phoenix provides a good case study for water conservation efforts because of its long history of awareness and commitment to the wise use of water. The city has

had a full water conservation program since 1982 and adopted a comprehensive water conservation plan in 1986. It has been proactive in the planning for water conservation through community education programs, recharge and reclamation programs, and innovative city ordinances. All of these efforts, combined with community participation and wise water use practices, have secured the city's water supply and reduced the overall water use despite population growth. The following case study will take a closer look at the specific efforts and programs that helped Phoenix accomplish a sustainable water use program for the entire city (The City of Phoenix Water Services Department, 2005).

Water Conservation Approach

The approach that Phoenix has taken includes a comprehensive water conservation plan and a water conservation program that focuses on education and awareness of wise water use.

Water Conservation Plan

Phoenix approved their water conservation plan in 1986. The plan included five water conservation programs:

- Water pricing reform
- Indoor residential water conservation
- Industrial and commercial water conservation
- Plant and turf irrigation efficiency
- Water-efficient landscaping

In Phoenix, 70 percent of the water delivered is for residential uses, so focusing on residential water use was a major emphasis of the plan. The city developed a water rate structure with three seasonal variations based on the city's seasonal costs with summer rates that are almost double the winter rates. Furthermore, the city provided free low water using fixtures such as showerheads and aerators for all homes built before 1980. It provided installation, educational materials, and maintenance support for community members (United States Environmental Protection Agency, 2002).

Phoenix has supported its water conservation plan by amending plumbing codes and creating many city ordinances that regulate the use of water in many different ways. For example, in 1990 Phoenix updated its plumbing code to require water-conserving fixtures in all new construction or renovation. That code was two years ahead of the U.S. government's requirements expressed in the Energy Policy Act of 1992. (EPA) (United States Environmental Protection Agency, 2002).

Community Education

Providing education to people is the first step in a long term water conservation program. By providing resources and educational materials on the science of water, where it comes from, and how to use it wisely without waste, ensured that the current population and future population of Phoenix are aware of the importance of water and therefore act appropriately when it comes to using water. The City of Phoenix has developed an educational program complete with teaching curriculums for schools and a comprehensive website that provides literature and interactive tools on water use and conservation (Gober, 2006).

The educational program is called Project WET (Water Education for Teachers) which is a complete curriculum that has been correlated with the Arizona State Standards for Science, Language Arts, Social Studies, and Math (The City of Phoenix Water Services Department, 2005). The program includes workshops, educator's guides, and classroom materials. All of these resources are provided to all classroom teachers and non-formal educators working within the City of Phoenix water service area free of cost. The program provides teaching materials for every grade, from kindergarten through high school. The materials come in both English and Spanish and include a teacher's guide that can be ordered from the city's website. The material focuses on the properties of water and how it moves through natural systems (Brock, 2007). The topics advance based on the grade level. This ensures that every student is receiving education on water throughout their public school education.

The City of Phoenix has a well developed website that provides literature and interactive tools for their water customers. The site is organized by topics such as Your Home, Your Business, Your School, Water News, and Your Water. Each area of the site provides detailed information on water use and conservation for the specific application listed above. For example, clicking on the “Your Home” link will open a quick facts page that provides the user quick tips for saving water throughout the house. Furthermore, it provides information on water use based on indoor use and outdoor use. Within the Indoor and Outdoor sections, the site has information on all of the water consuming appliances and fixtures that a house would have in those categories. Looking at the Landscape section in Outdoor water use the user can find guidelines for creating water conserving landscapes, links to information on the types of irrigation technology, and links to more resources on water conservation. The site is organized like this for every section of a house and each page provides guides and tools for the homeowner to achieve water conservation on their own (City of Phoenix, Your Home, 2010).

Water Conservation Success

The City of Phoenix, Arizona has been very successful in its water conservation efforts. It has been able to make considerable water use reductions and also secure its water supply for the next 50 years (City of Phoenix Water Resource Plan Update, 2005). Some more of its accomplishments are listed below

- 100 percent metered connections to the water supply system
- Separate storm sewer and sanitary sewer systems
- Seasonal water rate structure
- 20 percent decrease in per capita water use in 20 years
- Reduced reliance on groundwater from 35 percent in 1984 to 3 in 2010
- Research and innovation on water conservation technology
- Central irrigation weather based controls for parks and recreation facilities
- Xeriscaping programs throughout the community
- Over 90 percent of water "reclaimed" from wastewater treatment facilities is reused

4.1.2. CAL POLY, SAN LUIS OBISPO

Background and Water Issues

California Polytechnic State University, San Luis Obispo (Cal Poly), is a polytechnic teaching institution located on the Central Coast of California, between Los Angeles and San Francisco. The campus is 6,000 acres, including the main campus and six ranches. Cal Poly is committed to protecting the environment through its sustainability and water conservation efforts throughout the campus (Cal Poly, 2010). This case study presents a retrofit project that Cal Poly undertook in order to reduce its water use. It provides an example of how existing buildings and organizations in San Luis Obispo County can make improvements to reduce their water consumption. Projects like this contribute to the overall water conservation efforts of a city or jurisdiction and are necessary in order for that city to achieve its water use goals.

In 2007, Cal Poly received a Best Practices Award at the Sustainability Conference at University of California Santa Barbara for a renovation and retrofit project campus wide to reduce Cal Poly water consumption. This project included the replacement of plumbing and irrigation fixtures throughout the campus (Cal Poly Facility Services, 2008). For this case study, the Mathematics and Science building project within the campus wide project will be looked at in closer detail. This project included a complete overhaul to achieve the United States Green Building Council's Leadership in Energy and Environmental Design for Existing Buildings (LEED EB) certification. The project consisted of various retrofits to reduce energy and water consumption. Focusing on the water portion for this case study, the building made many improvements including bathroom facilities, plumbing and irrigation infrastructure, and state of the art technology (Cal Poly Facility Services, 2008).

Water Conservation Approach

In 2007, Cal Poly elevated its commitment to sustainability by setting a goal to achieve LEED-EB certification in at least one existing building every two to three years. The first building to undergo a sustainable makeover was the 27,100 square foot Faculty Offices

East Building. This building was built in 1991 and is the home to the College of Science and Mathematics. The project took 18 months and was accomplished entirely through the use of resources from the Cal Poly campus such as faculty members of the building, Cal Poly Electric, Plumbing, and Carpenter Shops, Engineering Services, Landscape Services, Custodial Services, and project managers and administrators from the Facility Services. The project included many improvements to departmental practices and procedures, technology, and water using appliances throughout the building. The water conservation efforts focused on reducing indoor water use from bathroom facilities and outdoor water use from landscape irrigation (Elliot, Facility Offices East LEED Application Report, 2008).

Indoor Water Use

The indoor water conservation efforts included the upgrade of six restrooms. Toilets and urinals were replaced with Ultra-Low Flow versions, 1.28 gpf and 0.125 gpf respectively. All sink faucets were equipped with aerators of 0.5 gpm. Furthermore, on all fixtures, touchless sensed valves were selected to reduce water use and improve personal hygiene. Table 03 below compares the original water use and fixtures to the new retrofitted ones and shows the water savings for one year (Elliot, Facility Offices East Plumbing Retrofits, 2009).

Table 03. Comparison of Indoor Water Use in 2007 to 2009

	2007	2009
Toilets	1.6 gpf	1.28gpf
Urinals	1.6gpf	0.8gpf
Aerators	N/A	0.5 gpm
Automatic Shut off	N/A	All Fixtures
Water Use (gal)	267,036	79,288
Savings (gal)		187,748

Outdoor Water Use

The outdoor water use at the Facility Office building is entirely for irrigating the landscape. The irrigation is an automated system that uses potable water and is divided

into 18 independent stations, 14 of which are conventional overhead spray and 4 are drip irrigated. The landscape is dominated by woody tree, shrub and groundcover plantings that account for 93 percent (15907sq.ft.) of the total on-site natural area. Turf grass accounts for the remaining 7 percent (1197sq.ft.) (Elliot, Facility Offices East Irrigation Retrofits, 2009).

The outdoor water conservation efforts included a water audit for the entire irrigation system, the use of organic mulch, reprogramming of the irrigation system, and the elimination of wasteful water uses such as hoses and sprayers for cleaning patios and walkways. The water audit revealed leaks and identified needed repairs and modifications to improve the efficiency of the system. Once the needed repairs were completed, the irrigation system was reprogrammed according to the maximum historical evapo-transpiration rate. The system is equipped with a smart irrigation controller that receives actual weather data from the California Irrigation Management Information System (CIMIS) and is reset monthly based on actual evapo-transpiration rate compared to the historical high. Furthermore, the use of organic mulch was implemented throughout the landscape. The mulch helps to reduce evaporation of water and maintain the soil moisture. It also contributes to preventing weed seed germination and controls erosion. Finally, through education and awareness, the project was able to eliminate wasteful practices of water use such as cleaning patios with hose sprayers by the custodial services at Cal Poly.

These efforts were able to eliminate wasteful runoff from overwatering and poor spray pattern control. The project determined that the existing system was overwatering using 138 percent of the evapo-transpiration rate. After the retrofitting and adjusting, outdoor water use was reduced by 75.1 percent which resulted in an annual dollar savings of \$1,100 (Elliot, Facility Offices East LEED Application Report, 2008).

Water Conservation Success

This case study shows how projects geared towards water conservation can provide real savings in water and money. The example at Cal Poly took 18 months to implement

and had a total project cost of \$23,500. With the total annual savings in water cost at \$3,600 the project will pay for itself in 6 and one half years (Elliot, Facility Offices East LEED Application Report, 2008). This project highlights how some simple retrofits and improvements in practices can make a significant improvement in the performance of the building and the effects on the environment. Below is a summary of the major water saving accomplishments from this project.

- First LEED EB building on any CSU campus
- Annual savings of 460,000 gallons of water
- Annual cost savings of \$3,600
- Indoor water use reduction by 74.8 percent
- Indoor retrofits saved an average of 221,000 gallons of water a year
- Indoor water cost savings of \$2,500 were achieved
- Elimination of Paper Towels resulted in a cost reduction of 95 percent
- Irrigation based on historical weather and evapo-transportation rate
- Outdoor water use reduced by 75.1 percent
- Outdoor retrofits saved an average of 232,000 gallons of water a year
- Annual outdoor water cost savings of \$1,100 were achieved
- Repairs and maintenance throughout the building improved efficiency of all retrofits and installed systems

4.2. COLLABORATION AND COMMUNITY PARTICIPATION

Planners use a myriad of approaches and tools combined with their expertise and community input to arrive at solutions to problems in our cities and communities. This section provides a close look at how collaboration and community participation contribute to the creation of plan documents for the purpose of water conservation.

Two separate plan documents were looked at: The Arroyo Grande Community Plan and the Los Angeles Integrated Regional Water Management Plan (IRWMP), both of which were developed with a large emphasis on community participation.

4.2.1. ARROYO GRANDE

Water Issues in Arroyo Grande

The City of Arroyo Grande is located on the central coast of California in the County of San Luis Obispo and has a population of 15,851.

The City of Arroyo Grande is currently in a “Severely Restricted Water Supply Condition” (City of Arroyo Grande, 2009). The city is consuming 95 percent to 99 percent of their annual available water supply. This fact has alarmed the city officials and residents and brought water conservation issues to the top of their priority list (City of Arroyo Grande, 2010). In response, the city developed a partnership in 2009 with Cal Poly and a graduate level City Planning class to develop a community plan that updates the conservation and open space element of the General Plan. As a part of the Conservation element, water conservation was one of the most prevalent concerns for the city. The author of this Background Report was a participant in the Arroyo Grande Plan development, and therefore will serve as the main resource for information.

Plan Development

The Cal Poly class was contracted to produce two documents: Existing Conditions and a Community Plan. The purpose of these two documents was to develop ideas and future goals for the city of Arroyo Grande. Water conservation is amongst the main

issues considered as well as all the issues contained within the entire conservation element of the General Plan. The development of the Existing Conditions document will be described in this section.

This analysis will show how community participation techniques were used in a particular planning environment to develop ideas and directions for a community based on their feedback. The analysis is observational and will attempt to show the positive contributions of community participation in the planning process.

Community Participation Process

The community participation process that is described here includes the first portion of the Community Plan development, the Existing Conditions document. This portion of the process consisted of two community meetings and the final product was a document that included existing conditions research throughout Arroyo Grande, community input, and future aspirations for the community of Arroyo Grande.

Community Participation was a key factor in the establishment of future goals for the City of Arroyo Grande. The community was involved in this process through community meetings, community outreach efforts, a website, and contacts with various city personnel and officials. The various efforts are explained below.

Outreach Committee

A community outreach committee of 4 students was established in the Cal Poly planning class. The committee members' primary responsibilities were to contact community members and inform them of the partnership between Cal Poly and Arroyo Grande. They were also responsible for informing the residents of the community meetings that would allow members of the community to express their ideas and concerns regarding the general plan update.

The outreach committee contacted the community by emailing all city personnel, making telephone calls, handing out flyers, and engaging in personal interactions. According to the outreach committee, email use was the most successful.

Success for the outreach committee was based on the amount of people they were able to contact in the most efficient way; email was the most successful strategy. The team sent email blasts to all city employees. This method helped to draw the attention of city planners, the mayor of Arroyo Grande, fire fighters, and the police chief. According to the outreach committee, approximately 150 people were contacted throughout Arroyo Grande. The outreach efforts were continuous from October through November of 2009. The committee worked throughout the two months, informing the community and trying to get as many people as possible interested and involved so that they would come and participate in the community meetings.

Community Meetings

The Community meetings served as the main medium for community input and participation throughout the process. The development of the Existing Conditions document was conducted approximately over three months. Throughout this time, two community meetings were held and community outreach was conducted before and in between meetings. The process for the two meetings is described below.

Meeting 1

The first community meeting was conducted to gather information regarding the issues and concerns that members of Arroyo Grande may have. The community members were divided into small groups. Each group consisted of community members, a student facilitator, and a student note taker. The small groups were used to discuss the community members' concerns and ideas. The facilitators used a structured read around to allow each community member an opportunity to voice their opinions. The facilitator of each group gathered the community members' ideas into concise themes that were then shared with the entire community in the meeting. These themes were recorded onto a large whiteboard for the community to see.

Following the meeting, the Cal Poly planning class collected the notes taken by each small group. Every individual idea was recorded onto a spreadsheet. Overlapping ideas were consolidated. Each idea was then categorized by relevant general plan issue areas. The final spreadsheet was shown on the class website for the public to view. Providing the feedback on the website gives the community the opportunity to compare their input with the final plan document and see how the ideas were incorporated.

Meeting 2

The purpose of the second community meeting was to develop a vision for the future of Arroyo Grande. The information gathered from the first meeting was used to develop goals for the future of Arroyo Grande. The Cal Poly planning class used the consolidated list from the first meeting, combined with their background research, to develop ideas and goals for the future of Arroyo Grande.

The meeting was an informational presentation of the background research that the planning class conducted. The class presented current trends in planning and how other communities are dealing with similar issues, then presented the community input, and finally presented recommendations for the future of Arroyo Grande. The meeting was then opened for community feedback to ensure that all of the community input was accounted for.

Website

The Cal Poly Planning class created a website that the public can access to see the progress of the planning efforts. The website shows the community participation efforts conducted thus far. The community input from the first meeting was posted on the website. This list includes every comment made by every participant in the meeting. The site also shows the entire presentation from the second community meeting. These resources are valuable because community members can compare the final plan to the actual input that was given.

Conclusion

In this example, structured read arounds, power point presentations, and feedback sessions were used to gather community input. These methods worked well for the educational purpose that the class provided. However, the community input efforts had significant shortcomings on the diversity of participants that attended the meetings and the number of participants. The first meeting attracted 35 guests and the second 28. The majority of these people were city officials, employees, or city planners, with few residents attending. The community input therefore potentially did not represent the true issues and concerns of the community of Arroyo Grande. In a city with a population close to 16,000 people, receiving input from an average of only 32 people means that it is unlikely that all of the different views and issues of the community would be accounted for.

Community outreach efforts and collaboration should be more inclusive and should encompass a representative group of people to ensure that as many views and opinions of the community members are included in the final document as possible.

4.2.2. LOS ANGELES

Water Issues in Los Angeles

The City of Los Angeles has a population of nearly 3.8 million people and is the second largest city in the United States (City of Los Angeles, 2009). The majority of water supply for Los Angeles is not local and therefore, the city is heavily dependent on water transport systems to bring water to the city. As the water supply throughout California is threatened from drought, the City of Los Angeles is severely impacted. It must continually plan for the conservation and reduction of water use to sustain the city's needs.

This example looks at the recently completed Integrated Regional Water Management Plan (IRWMP) for the greater Los Angeles region. This collaborative planning effort included five districts throughout Los Angeles County, including parts of Orange County, San Bernardino County, Riverside County, and Ventura County (Brown and Caldwell, 2006).

The plan document that was developed is a result of an enormous collaborative effort including over 90 cities, several counties, water districts, regulatory agencies, stakeholders, and community members. The plan development process was completed in 12 months and includes water management strategies for the area for the next 20 years (Brown and Caldwell, 2006).

Plan Development

In response to the state of California's integrated water management plan grant program (Department of Water [DWR]), six agencies in the greater Los Angeles region submitted grant applications in May of 2005 to support the development of an IRWMP. These agencies included the Santa Monica Bay Restoration Commission, the City of Los Angeles, the Watershed Conservation Authority, the Upper San Gabriel Municipal Water District (MWD), the Central and West Basin MWDs, and the City of Downey. The DWR granted \$1.5 million dollars on the condition that the six agencies produce a single

consolidated plan for the entire region (Integrated Water Management Strategy Technical Memorandum, 2006 (City of Los Angeles, 2009)).

Planning Process

The planning process resulted in a series of technical memorandums (TM) outlining the different aspects of the water management plan. The technical memorandum, Integrated Water Management Strategy, is the document that outlines the collaborative and community input efforts that were utilized to produce the entire Integrated Regional Water Management Plan and it will be looked at closer in the following sections.

Integrated Water Management Strategy

The collaborative effort included 96 cities, agencies, stakeholders, and community members. In order to manage the stakeholder input process and accommodate geographic variation, the region was divided into five sub regions: North Santa Monica Bay Watersheds, the Upper Los Angeles River Watershed, the Upper San Gabriel River and Rio Hondo Watersheds, the Lower San Gabriel and Los Angeles Rivers Watersheds, and South (Santa Monica) Bay Watersheds (Integrated Water Management Strategy Technical Memorandum, 2006). An organizational structure was developed to manage the collaborative process which is described below.

Organizational Structure

The IRWMP created a leadership committee to oversee the entire process and five sub-regional steering committees. The regional sub committees represented the five regions of the entire planning process. Their main purpose was to conduct the community outreach efforts and community workshops (Brown and Caldwell, 2006).

The leadership committee had 11 seats. The chair was the Los Angeles Flood Control District. Five seats were given to a representative from each of the five regional sub committees. The remaining five seats were given to specialists that represented five specific water management focus areas. Each sub regional committee included agencies, cities, and stakeholder representatives from that region. The structure is

shown in Figure 1 (Integrated Water Management Strategy Technical Memorandum, 2006).

Figure 1. Los Angeles Committee Organizational Structure

Source: Data retrieved from LAIRWMP, Compiled by Antoniou, Dimitri, 2009

This structure allowed communication between all the involved parties. The community members and stakeholders that served in the sub committees could share their views and opinions to the leadership committee through this hierarchical structure. If a community member or stakeholder expressed an idea at a workshop in a particular region, the representative for that sub regional committee would report that concern at the meetings held by the leadership committee. This structure ensured that community input from all of the participating regions would be included in the entire planning process (Brown and Caldwell, 2006).

Community Participation Process

The community input process provided valuable information for forming a vision, principle statements, goals, and strategies for the IRWMP. The first five community workshops were dedicated to the development of a vision. The vision would clearly define the future and guide all of the planning and implementation processes. The community input was recorded and clearly referenced when developing the vision statement. All of the community statements were included in the TM to show the clear connection to the vision statement that was developed. Furthermore, the community input statements were organized based on the underlying principles. All of the similar

principles were lumped together. The result was a concise list of principles that represented all of the community input. The same process was used to develop goals, objectives, and strategies (City of Los Angeles, 2009).

This community input process was conducted in 12 months and included 25 community workshops. The sub regional committees conducted the workshops and gathered the community input. They would draft visions statements, principles, goals, and objective statements. These drafts would then be presented to the leadership committee to make edits and include their input. The corrected drafts were then presented at the community workshops. This process continued throughout the plan development and the leadership committee had the final word on adopting the statements. This structure allowed the expertise of the leadership committee to override the community input. All of the input was considered but there were some issues where expertise was needed to develop realistic goals and strategies (Integrated Water Management Strategy Technical Memorandum, 2006).

Conclusion

This planning effort was much larger in scale and scope of work. However, the approach that was used clearly paralleled the one used in the Arroyo Grande case. The leadership committee and sub regional committee structure accomplished the same goals that the community outreach committee did in Arroyo Grande. The case in Los Angeles was much more complex and involved a higher level of expertise. This was addressed by including different specialists within the committee structure. Their expertise was integrated with the community input to develop goals and principles that represented the views of all the people involved in addition to the needed expert advice. The Integrated Water Management Strategy Technical Memorandum outlined all of the community outreach efforts. This document was published as a part of the IRWMP. It was very useful for identifying how the community input was integrated into the development of the entire planning process.

5.0 WATER CONSERVATION TECHNOLOGY

This portion of the Background Report provides more detail on the various technologies described in the Handbook. The technologies are common household and commercial appliances and fixtures that consume water. The items included here are water efficient compared to the older technology that did not include water saving features.

This section is organized by indoor and outdoor water use. Within the indoor and the outdoor sections, the various fixtures and appliances that would be found indoors and outdoors are included respectively. Descriptions are provided of the actual technology and in cases where various technologies are available, each one is described. Then, any important regulations or industry manufacturing standards that apply to the specific technology are described. Finally the water savings of the technology and the purchase cost of the item are included. The cost figures are estimates and are provided to give the reader a rough idea of the price range. The reader should be cautious of these costs as prices may vary based on a number of factors, including manufacturer and location.

5.1. INDOOR - APPLIANCES

5.1.1. CLOTHES WASHERS

According to the United States Department of Energy, the average American household washes almost 400 loads a year (DOE, 2010). This can amount to tremendous water consumption depending on how much water the machine consumes per load. The national average clothes washer load volume is about 41 gallons (United States Congress, 1992, California Urban Water Conservation Council, 2009). Therefore, the average household in America uses 16,400 gallons of water a year just on washing clothes. With the implementation of the Energy Star program in the United States, washing machine technology has greatly improved, thus reducing load volume from 41 to as low as 10 gallons per load. The following section further discusses the improvements in washing machine technology.

Description

There are two main types of clothes washers. The traditional, top loading washers and the newer, more efficient front loading ones. There are top load model that have higher efficiency technology compared to older models but the front load provides the greatest savings. Both types of washers are described below.

Table 04. Types of Clothes Washers

Type	Description	Savings	Cost
Top Load (Standard and Energy Star)	Traditional washing machine. Clothes are loaded from the top, they use the most water but are the cheapest initially.	Cheaper but not as efficient.	\$350-\$1,000 (See Lit. Review)
Front Load (All Energy Star)	Clothes are loaded from the front. Require much less water but are more expensive.	More expensive and most efficient. Lowest *water factor rating is 3.2 gal/cycle/ ft ³	\$500-\$2,000 (See Lit. Review)

Note: * Water Factor is equal to the total water used per cycle in gallons divided by the capacity of the washer in cubic feet.

Regulations

Washer technology has been affected by different types of programs and regulations in the United States. Some of the most influential have been the Energy Policy Act

(EPAAct) of 1992 and the Energy Star Program that began under the Clinton Administration and created by the Federal Environmental Protection Agency in partnership with the Department of Energy in 1992. The EPAAct had direct effect on the manufacturing of washers while the Energy Star program provided consumers with rebates and incentivized the production of energy efficient appliances (United States Congress, 1992).

In 1992, the Federal government enacted the EPAAct in order to reduce energy reliance on fossil fuels and protect the environment. The bill established the Production Tax Credit (PTC), which provided incentives for the investment in renewable energies such as solar and wind. Furthermore, the bill established energy and water saving standards for household and commercial appliances. The bill had a direct effect on the manufacturing of toilets, showerheads, faucets, and laundry machines (United States Congress, 1992).

The EPAAct of 1992, initially only specified energy requirements for certain household appliances such as clothes washers. At that time, the Energy Star program had established a water factor measurement for washers. The EPAAct proposed a water factor requirement of less than or equal to 9.5 gal/cycle/ft³ to be adopted effective in 2005 (United States Congress, 1992). The Energy Star program, which is described below, established more aggressive water use requirements in order for household washers to receive the Energy Star label (U.S. Environmental Protection Agency, 2010).

The Energy Star program began as a voluntary labeling program to identify and promote energy efficient products. It began primarily with labels on computer products. Later, in 1995 the program was expanded and began using labels on home appliances such as heating and cooling systems. In 2006, the program grew significantly and its labels can now be found on a myriad of products, from office equipment to even new homes and commercial buildings. The program sets guidelines for appliances to meet lower energy requirements than the standard appliance. If an appliance meets the specific requirement it can obtain the Energy Star label. The current water use

standards under the Energy Star program for residential clothes washers are shown below:

Table 05. Washing Machine Regulations

Before 2009	2009	2011
*WF $\leq$ 8.0 gal/cycle/ft ³	WF $\leq$ 7.5 gal/cycle/ft ³	WF $\leq$ 6.0 gal/cycle/ft ³

*WF: Water Factor is the water consumption unit used to measure washing machines.

Energy Star has been a driving force behind the more widespread use of such technological innovations as efficient fluorescent lighting, power management systems for office equipment, and low standby energy use. The program helped consumers save about \$17 billion in 2009 from reduced energy use (U.S. Environmental Protection Agency, 2008)

Savings

Savings from washing machines come from a decrease in water and energy use. The savings directly depend on the type of washer currently in place. Washing technology has improved drastically and today machines are capable of operating with more than half of the water of older technology. Water efficiency of washing machines is measured by the Water Factor (WF) (described above). The lower the water factor, the more efficient the machine is. The following table compares the water use of an old washing machine with that of an average priced high efficient machine that is available today.

Table 06. Water Use for Clothes Washers

Water Use Comparison	Water Factor	Gallons/Cycle
*Standard Top Load	11.4	40
*Average High Efficient Front Load	3.6	14.4

*Standard Top Load: Whirlpool 3.5 Cu. Ft. WTW5300VW

*Average Front Load: Samsung 4.0 cu. Ft. WF218ANW

The two different machines shown (Green Energy Efficient Homes, 2010) above are a good example of how much water can be saved by replacing an existing washing machine. The water savings not only conserve water but save on utility bills. Replacing an existing washing machine is cost effective because of the dramatic reduction in

water and energy use that the new machine provides. A little more upfront investment for a new washing machine will pay itself off after a few years of use.

Cost

Water efficient washing machines can be purchased from the same suppliers that carry traditional washing machines. The following table is an example of the cost of water efficient machines, one being top load and the other front load.

Table 07. Washing Machine Cost

Machine Type	Price
Top Load Whirlpool WTW57ESVW	\$480.00 (Amazon.com)
Front Load Samsung WF218ANW	\$749.00 (Various vendors)

5.1.2. POINT OF USE TANKLESS WATER HEATERS

Description

Point of use water heaters are used to provide hot water on demand at the source of the hot water demand. The point of use tankless water heater is relatively small and will usually fit inside a sink cabinet or in a closet. They are typically dedicated use heaters meaning the unit serves one sink / faucet or one shower. This technology eliminates the wait period for hot water to warm the cold water pipes and reach the desired demand at the correct temperature. This can provide significant water savings for the user and reduce the cost of heating water by reducing water waste (Green Energy Efficient Homes, 2010).

Regulations

There are no current regulations or standards that affect the water efficiency of hot water heaters for homes or commercial uses. However, the U.S. Department of Energy's Energy Star program does have requirements for manufacturers to meet in order to obtain the Energy Star label. The energy efficient models focus on reducing the cost of heating water by being more energy efficient (U.S. Environmental Protection Agency, 2010).

Savings

The on demand water heater saves water by eliminating the wait period for hot water to reach the demand point. On average, a household shower takes 2 minutes to reach the desired hot temperature (California Urban Water Conservation Council, 2009). If that showerhead has a flow rate of 2 gallons per minute, then 4 gallons of water would be wasted. In this example, an on demand water heater would provide hot water as soon as the shower is turned on and the 4 gallons of water would be saved.

Cost

Point of use heaters can be purchased from the same suppliers that carry traditional tank heaters. The following table is an example of Energy Star water efficient tankless point of use heaters.

Table 08. Point of Use Tankless Water Heaters Cost

Heater	Price
Ariston Point of Use Water Heater (6 Gal)	\$199.00 (Home Depot)
Ariston Point of Use Water Heater (2.5 Gal)	\$159.00 (Amazon.com)

5.1.3. DISHWASHERS

Description

The home dishwasher is one of many appliances that consume water and energy on a daily basis in the United States. The national average dishwasher load volume is currently 9.3 gallons (California Urban Water Conservation Council, 2009). With the addition of dishwashers into the Energy Star program in 1996, there has been some improvement in energy and water efficiency technology in these appliances.

Regulations

In the United States, the U.S. Consortium for Energy Efficiency (Federal Standard) and the U.S. Energy Star program (Energy Star) develop different performance standards for energy and water efficiency of dishwashers. The Federal Standards are a minimum requirement that manufacturers must meet while the Energy Star program is a voluntary labeling program that has stricter requirements. The energy efficient models focus on reducing the cost of dishwashing and lowering the water use per cycle.

Savings

The greatest savings in energy and water can be accomplished by using Energy Star approved dishwashers since their standards exceed the Federal Standards. The table below outlines the savings and improvements in water efficiency that can be met by using an Energy Star dishwasher compared to the Federal Standards for dishwasher manufacturing (Consortium for Energy Efficiency, 2009).

Table 09. Home Dishwasher Water Use

Standard Size Dishwasher ($\geq$ 8 place settings + six serving pieces)		
Standard	January 1,2010	July 1,2010
Energy Star	$\leq$ 5.8 gallons/cycle	$\leq$ 5.0 gallons/cycle
Federal Standard	$\leq$ 6.5 gallons/cycle	NA

Compact Size Dishwasher ($<$ 8 place settings + six serving pieces)		
Standard	January 1,2010	July 1,2010
Energy Star	$\leq$ 4.0 gallons/cycle	$\leq$ 3.5 gallons/cycle
Federal Standard	$\leq$ 4.5 gallons/cycle	NA

Cost

The following table shows the cost of a compact dishwasher and a standard dishwasher, both with an Energy Star Label.

Table 10. Home Dishwasher Cost

Dishwasher Type	Gallons/Cycle	Price
Compact Kitchen Aid KUDD03ST	2.7	\$594.00 (The Great Indoors)
Standard Frigidaire FGHD2433	3.68	\$467.49 (Sears)

5.2. INDOOR - FIXTURES

5.2.1. SINK FAUCETS

Faucets are found in every building type and serve multiple purposes. Faucet use represents almost 16 percent of total indoor residential water use in the United States (Save Water Project, 2010). The two main approaches for reducing indoor water use from faucets are through the use of aerators and automated on/off technologies. The following section describes the benefits of each of these two technologies and provides details for the different aerators available today.

Description - faucet aerators

A faucet aerator is a small metal device with a screen that screws onto the faucet spigot. A faucet aerator adds air to the stream of water by breaking the water into fine droplets. The added air reduces water flow rate, reduces splashing, and increases areas of coverage and wetting efficiency. Aerators effectively reduce the amount of water used per minute and increase the overall effectiveness of the faucet (California Urban Water Conservation Council, 2009). They can be applied to any sink spigot in a residential, commercial, or industrial building.

Several aerator technologies exist to accommodate different uses, such as kitchen sinks and bathrooms, and to provide more options for consumers. The following table shows some of the most commonly available aerators.

Table 11. Faucet Aerators

Name	Example	Use	Cost
Standard Aerator		Kitchen or bathroom sinks. Ranges in flow rate from 0.5 to 2.2 gpm. Higher flow rate is recommended for kitchen use.	Least expensive of all aerators at \$1.95. Prices vary based on brand and quality. (Amazon.com)
Flip Aerator		Kitchen or Bathroom sinks. This aerator has a fingertip on/off switch to control water flow while maintaining water temperature. Usually 2.2 gpm	This aerator is still very inexpensive but a little more expensive than the standard aerator. They can be found for under \$7. (Amazon.com)
Swivel Aerator		Ideal for kitchen sinks because of its swivel design which allows for easy dish washing and sink cleaning. This aerator also has an on/off control. Usually 2.2 gpm	Can be found for under \$7. (Amazon.com)
Vacuum Aerator		Preferred in bathrooms because of low flow. The vacuum aerator uses the least amount of water at 0.375gpm but also comes in 0.5 and 0.7 gpm.	The most expensive of aerator designs at about \$25 each. (SaveWaterUS)

Regulations - faucet aerators

In addition to reducing reliance on fossil fuels and establishing the Production Tax Credit, the Energy Policy Act of 1992 established energy and water saving standards for household and commercial appliances. The bill had a direct effect on the manufacturing of toilets, showerheads, faucets, and laundry machines.

The EPA Act required that household and commercial bathroom faucets be manufactured at 2.2 gallons per minute (gpm) at 60 pounds per square inch (psi) or less. This requirement led to the development of several technologies in sink faucets, the aerator being the easiest and least expensive, water saving method developed.

Savings - faucet aerators

Water

Prior to the EPA Act, conventional sink faucets had a flow rate of between 2.75 and 5.00 gpm. With the new technology of aerators, this flow rate has been reduced to 0.375 gpm for the most expensive aerators and for the cheaper, most common aerators to around 1.5 gpm. This reduced flow rate can provide huge cost, water, and energy savings in household and commercial uses. The table below displays the national water usage from residential faucets. As determined by a study conducted by Mayer, et al. in 1999, the national water usage from residential faucets is:

Table 12. Faucet Water Use

Sink Faucets	National Average
Daily per Capita Use	10.9 gallons
Average Faucet Flow Rate	1.3 gpm

In a home that uses more efficient aerators with a flow rate of 1.0 gpm, the average per capita use would be reduced to 8.0 gallons per day. This equates to a savings of more than 1,700 gallons a year.

Wastewater

Both water usage and wastewater are charged on utility bills in California. Using low flow aerators can reduce water consumption and in turn reduce wastewater production, thus saving even more money on utility bills. The savings in wastewater is directly related to the amount of water consumption. Therefore, a reduction in water use of 1,700 gallons of water per year translates to a 1,700 gallon reduction in wastewater as well.

Energy

The use of low flow aerators can also have impacts on energy consumption. Many people run the faucet, wasting water, until hot water comes out. This can result in many wasted gallons of water because on average 73 percent of water used from faucets in the United States is hot water (California Urban Water Conservation Council, 2009). By reducing the flow rate of the sink faucet, less water will be wasted before the water reaches the desired temperature. A simple example is illustrated below to show how an aerator can reduce hot water consumption.

Example

Assume a sink is equipped with a 2.2 gpm aerator and it takes 2 minutes for the water to get hot. This means that 4.4 gallons of water would be wasted to reach a higher temperature. If that aerator was replaced with a 1.5 gpm aerator, then only 3 gallons of water would be used for the water to get hot. This results in savings of 1.4 gallons of water. This is a saving in water usage, wastewater, and hot water consumption.

The amount of savings gained from changing the aerators will depend on the current flow rate and condition of faucets to be changed. The higher the flow rates and older the current faucets are, the greater the initial savings will be by replacing/adding aerators. Because the aerators are so cheap, it is a guaranteed investment since reducing the flow rate of the faucets will save water and money. Finally, full savings from aerators will only be achieved if faucets are free of leaks and well maintained.

Automatic Faucets

Automatic Faucet technology was developed around the 1950's and it was first produced for commercial use in the late 1980's. They were first used in airport restrooms but can now be found in restaurants, hotels, casinos, malls, and residential properties.

Several different technologies exist for automatic faucets. The most commonly used is an infrared sensor powered by a single battery or connected to an electrical line. The touchesless faucets combine aerator technology with low flow rates to provide the most water saving capabilities in faucets available today. The table below gives an example with further details.

Table 13. Automatic Faucet

Automatic Faucet	Description	Savings	Cost
Motion sensor, touch less faucet. It comes equipped with aerator and low flow of 0.5gpm. Flow rates range from 0.5 to 1.6gpm.	Low flow rate and automatic on/off provides maximum water saving ability. Can save up to 70% compared to standard faucets.	Average cost is \$200 but can range from \$100-\$500. (PlumbingSupply.com)

5.2.2. TOILETS / URINALS

Toilets are the highest residential indoor water consuming appliances in the United States. According to a study done by the American Water Works Association Research Foundation (United States Environmental Protection Agency, 2008) almost 30 percent of household water consumption is from flushing the toilet. The average person flushes their toilet 5 times per day. Depending on the amount of water per flush that the toilet uses, many people could easily consume approximately 20 gallons of water a day just from flushing the toilet (United States Environmental Protection Agency, 2008). The use of low flush toilets in households and commercial buildings can significantly reduce the water use per person by reducing the amount of water used per flush.

Description

There are several different technologies used in designing toilets. Each technology serves a slightly different purpose and can achieve different levels of water savings. With the passing of the EPAct, toilet manufacturers were forced to develop new designs and methods for toilets that perform as well as traditional models but use much less water. The section below describes some of the various types of toilets and urinals and their purpose.

Gravity-fed Toilets		Water Use: 1.6 gpf or less
Description	Gravity-fed toilets are the most common type installed in private homes. As the name implies, gravity-fed toilets rely on gravity to flush waste. When the handle is pushed, a flush valve opens, and the water in the tank drains into the bowl. The water pulls waste through the toilet's trap and into the drain.	
Savings	Savings depend on current toilet flow rate. Older toilets flushed at 3.5gpf. Replacing one of these can save 4,000 gallons a year.	
Cost	\$200-600+; Design and manufacture influence higher price. (American Standard)	

Pressure-Assist Toilets		Water Use: 1.6 gpf or less
Description	Pressure-assist toilets are suitable for any installation where tank-type toilets are required, including offices, buildings, restaurants and residences. The system uses line pressure to create a pressurized flush, which, in turn, pushes the waste out of the bowl. Each technology is only available with specially designed bowls	
Savings	Savings depend on current toilet flow rate. Older toilets flushed at 3.5 gpf. Replacing with one of these can save 4,000 gallons a year per toilet.	

Cost	\$200-600+; Design and manufacture influence higher price. (American Standard)
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Dual Flush Toilets Water Use: Short Flush 0.8; Normal Flush: 1.6 gpf	
Description	Dual-flush toilets give users two flush options: Tilt the handle up for liquid waste, which uses a reduced water amount per flush. Or push the handle down for a standard flush
Savings	Savings depend on current toilet flow rate. Older toilets flushed at 3.5gpf. Replacing one of these can save 4,000 gallons a year.
Cost	\$200-600+; Design and manufacture influence higher price. (American Standard)

Compost Toilets Water Use: None	
Description	Toilets which use little or no water and treat toilet wastes on-site for reuse as valuable compost. They work by providing an enclosed environment for the natural process of aerobic decomposition. A good alternative to septic systems and good for rural areas or cottages and cabins.
Savings	Savings depend on current toilet flow rate. Reduces wastewater by 97 percent and waste becomes usable fertilizer.
Cost	\$800+; Design and manufacture influence higher price. Most expensive but their use is specific and not applicable in most residential or commercial buildings. (Sun-Mar Corp.)

Low Flow Urinals Water Use: 0.125 - 0.25 gpf	
Description	These incorporate a flushing system that utilizes water for the sanitizing rinse and odor removal. However, the mixing of water and urine produces ammonia like smell when units are not flushed. A number of flushing mechanisms are used to wash fluids into the sewer plumbing system. Some of these include automatic infrared sensors, voice activation, and timed interval flushing, as well as traditional manual operations.
Savings	Savings depend on the flow rate of current urinals. If the current urinal has a flow rate of 1.5 gpf than savings could reach over 6,000 gallons per year. Assuming 5000 flushes per year, a urinal of 0.25 gpf would use 1,250 gallons compared to 7,500 gallons for a 1.5gpf urinal.
Cost	\$250-1,000+; The lower the flow rate the more expensive. (WaterWise Technologies International)

Waterless Urinals Water Use: None	
Description	These urinals utilize a cartridge insert filled with a chemical sealant that allows urine to pass through, but then traps it below, preventing odors from being released. These inserts are usually fully biodegradable or recyclable.
Savings	No water use. Typical urinals use anywhere from 7,000 to 15,000 gallons of water per year. A waterless urinal would use zero.
Cost	\$250-1,000+ (WaterWise Technologies International)

<i>Automatic Flush Toilets and Urinals</i>		<i>Water Use: 1.6 gpf or less</i>
Description	Automatic flush technology was developed around the 1950's but wasn't produced for commercial use until the late 1980's. They were first used in airport restrooms but can now be found in restaurants, hotels, casinos, malls, and residential properties. Several different technologies exist for automatic toilets. The most commonly used is an infrared sensor powered by a single battery or connected to an electrical line. The touches less toilet valves are combined with low flush volume technologies to provide the most water saving capabilities in toilets/urinals available today.	
Savings	The main savings from these toilets are the reduction of a flush handle which helps reduce the spread of germs. The toilet can also save water by preventing people from over flushing.	
Cost	Slightly more expensive than the corresponding (from the flush mechanism point of view) non-automatic models. (PlumbingSupply.com)

The flusher works by means of an infrared sensor that adapts to its surrounding. Once the user enters the sensor's effective range and then steps away, the sensor initiates the flushing cycle to flush the fixture

Figure 2. Automatic Flush Toilet

Regulations

In 1992 the Federal government signed the Energy Policy Act (EPAAct) in order to reduce energy reliance on fossil fuels and protect the environment. The bill established the Production Tax Credit (PTC), which provided incentive for the investment in Renewable energies such as solar and wind. Furthermore, the bill established energy and water saving standards for household and commercial appliances. The bill had a direct effect on the manufacturing of toilets, showerheads, faucets, and laundry machines.

The EAct required that household and commercial toilets be manufactured at 1.6 gallons per minute (gpm). This requirement led toilet manufacturers to redesign their products to meet consumer standards while reducing water consumption.

Savings

Toilets

Because of the EAct of 1992 all new toilets in residential and commercial uses are required to use 1.6 or less gpf. Therefore, in any new construction all toilets will use less water than the older technology. The benefits of low flow toilets are much higher when retrofitting existing standard toilets that use more than 1.6gpf with the new low flow technology. The typical savings from replacing an old toilet with a 1.6gpf toilet are shown below.

Table 14. Toilet Replacement Savings

Current Model	Savings	Percent
7 gpf	5.4 gpf	77%
5 gpf	3.4 gpf	68%
3.5 gpf	1.9 gpf	54%

The dual flush toilet provides an opportunity for further water savings compared to the common 1.6 gpf toilet by providing an option for a smaller flush for liquid waste. The smaller flush usually uses 0.8 gpf, half of the water consumption of the standard flush. In theory, this model would save half as much water as a standard toilet for every 0.8 gpf. However, due to the unpredictability of human behavior and the uncertainty of people's ability to actually use the small flush when appropriate the savings for this toilet are difficult to quantify.

Another alternative to the 1.6 gpf toilet is the compos toilet. Many models today operate with no water consumption. The technology has greatly improved since their initial development, eliminating any odor or sanitary issues. However, the compost toilet is not an ideal solution in every setting. It is expensive and provides a good alternative to septic systems. It is more ideal for single family residences or for very rural homes that

are not connected to a sewage line. Furthermore, the idea of the compost toilet is hard for many people to get accustomed to and embrace. The strongest benefits are that it does not use water and almost all of the waste it produces is biodegradable and usable.

Urinals

Low flow and waterless urinals provide a huge water saving opportunity for commercial developments. Because of the EPA Act, urinal technology has improved significantly. Most urinals today use about 1.6 gpf compared to older models that may have used up to 4 gallons per flush. Although this is a huge improvement, there are better technologies available.

Ultra Low Flow Urinals

Ultra low flow urinals use 0.125-0.25 gpf. Using these urinals in place of the more standard 1.6 gpf urinal can save significant amount of water. According to Cindy Pollock (2006) in her article Hold the Water, the average urinal today operates at about 1.6 gpf and is flushed about 70 times per day. This results in a usage of approximately 40,000 gallons of water per year per urinal. Installing an ultra low flow urinal with a 0.25 gpf flow rate would use 6387.5 gallons per year. That's a savings of almost 34,000 gallons of water per urinal per year.

Waterless Urinals

Waterless urinals provide the largest savings. An average urinal with a 1.6 gpf flow rate uses approximately 40,000 gallons of water a year. Replacing these urinals with waterless urinals can save up to 40,000 gallons of water per year per urinal. The waterless urinal also provides many advantages such as no water use, reduced odor due to the biodegradable sealant used by most technologies, and the ease of installation because no water pipe is required.

5.2.3. SHOWERHEADS

Showers represent a large water consumer in residential units. In the average American house, the shower accounts for 16.8 percent of total indoor water use (PlumbingSupply, 2010). Prior to the EPA Act of 1992, the flow of shower heads ranged anywhere from 5 to 8 gallons per minute. With the average shower time at approximately 8 minutes per person, one shower could consume up to 64 gallons of water. Improvements and innovations in showerhead technology have led to a much greater reduction in water use from showers.

Description

Low flow shower heads range in flow rate from 0.5 to 2.5 gpm. There are a few different technologies currently being used in order to achieve this lower flow rate compared to the older 5-8 gpm showerheads. Some showerheads have self pressurizing technology that adjusts flow rate based on water pressure and other use the infusion of air, much like faucet aerators to reduce water flow. The following table shows some of the more common shower heads available today.

Table 15. Showerheads

Type	Example	Description	Cost
Standard Low Flow (simplest)		The simplest and the cheapest showerhead operates at 1.5 gpm. Mixes water with air to reduce flow. The added air reduces water temperature slightly.	Less than \$8. (Amazon, HomeDepot)
Non-Aerated Massaging Head		Non-aerated, so the flow rate is a little higher at 1.75gpm. No added air means the water temperature will not be reduced. A little more expensive because of the massage spray feature.	Around \$20 (Amazon, HomeDepot)

Self Pressurizing Aerated		This model adjusts flow rate based on water pressure and also has a water velocity control valve. It also uses air to reduce flow. Maximum flow rate is 1.5gpm but can be less if water pressure is high.	Between \$20 and \$35 (Amazon, HomeDepot)
Vacuum Flow Restriction		Water enters a vacuum chamber and is mixed with air which allows the lowest flow rate of all technologies at as low as 0.5gpm. This is also the most expensive.	Between \$60 and \$80 (Amazon, HomeDepot)

Regulations

In 1992 the Federal government enacted the Energy Policy Act (EPAAct) in order to reduce energy reliance on fossil fuels and protect the environment. The bill established the Production Tax Credit (PTC), which provided incentive for the investment in Renewable energies such as solar and wind. Furthermore, the bill established energy and water saving standards for household and commercial appliances. The bill had a direct effect on the manufacturing of toilets, showerheads, faucets, and laundry machines.

The EPAAct required that household showerheads be manufactured at 2.5 gallons per minute (gpm) at 80 pounds per square inch (psi). This requirement initiated showerhead manufacturers to redesign their products to meet consumer standards while reducing water consumption.

Savings

Low flow showerheads can save households tremendous amounts of water per shower and per year. Replacing old showerheads will provide the largest amount of savings and the amount will directly depend on the flow rate of the existing showerhead. A new

construction can opt for a low flow showerhead which will provide savings compared to older structures with older technology.

Because of the EAct, all residential showerheads are required to operate at 2.5 gpm. A family of four that is looking to install showerheads in their home can meet the EAct requirement by purchasing any showerhead on the market. However, doing a little extra research and investing in more advanced showerheads can save a home much more water. A showerhead that has a flow rate of 1.5 gpm or less can save a family up to 50 percent compared to a house with showerheads that operate at 2.5 gpm.

5.3. INDOOR - FOOD SERVICES

The commercial food service industry is the largest water consumer outside of residential use in the United States. The water efficiency of kitchen appliances used for preparing food and washing dishes can be improved by making wise decisions when purchasing.

The cost for commercial appliances is extremely variable. This is due to many factors: quality, manufacturer's reputation, endless options and features, variations in capacity and energy consumption, geographic location, high number of manufacturers (both domestic and international), to mention but a few. Some of these appliances are quite expensive. Therefore, it is very important to approach the purchasing process very carefully and expend the necessary effort to understand all the variables involved and how they may affect the intended use of the appliance to be purchased.

The following section provides information on four high water consuming commercial appliances: Dishwashers, Pre-Rinse Spray Valves, Ice Makers, and Food Steamers. It also provides an indicative cost for each, as obtained from an internet search without any price bidding or negotiations.

Regulations

Federal regulations exist (EPA Act) for the commercial appliances, regulating mainly the energy used. California follows the federal regulations for this equipment. Furthermore, the United States Energy Star Program applies to all commercial appliances. Units that meet the Energy Star requirements are more water and energy efficient than the traditional ones.

5.3.1. DISHWASHERS

Description

The dishwashing process (spray valves and dishwashers) is one of the largest water consumption processes in commercial food service industry. Dishwashers can be categorized as one of three main types: “Under Counter” used in low volume restaurants and resembling the house dishwashers, “door-type” used in medium volume restaurants, and the “conveyor” type used in high volume restaurants. Each of these three types can contain one or more racks and they can be further categorized by the sanitation method they employ: either “High Temp” (that applies potable hot water to the surface of wares) or “Low Temp” (that applies normal temperature potable water and a chemical sanitizing agent to the surface of the wares) (Food Service Technology Center (FSTC), 2010). The water used by all types is measured in gallons per rack. There has been much improvement in the efficiency of commercial dishwashers. For example, in the 1990s, the most efficient dishwashers used 1.5 gallons of water per rack. Today, machines are available at below 1.0 gallon per rack (Karas, 2005) The Energy Star specifications for the various types of dishwashers are:

Table 16. Energy Star Commercial Dishwashers

Washer Type	High Temp Water Efficiency in g/rack	Low Temp Water Efficiency in g/rack
Under Counter	<= 1.00	<= 1.70
Single Door	<= 0.95	<= 1.18
Single Tank Conveyor	<= 0.70	<= 0.79
Multiple Tank Conveyor	<= 0.54	<= 0.54

Savings

The Energy STAR Calculator (United States Environmental Protection Agency, 2009) was utilized to compute annual water savings for the High Temp models (that are generally more water efficient than the corresponding Low Temp models) for each of the above washer types:

Table 17. Commercial Dishwashers Water Use and Savings

Washer Type	Racks / day	Conventional Unit		Energy Star		Annual Savings (Gal.)
		Gallons / Rack	Annual Water Use (Gal.)	Gallons / Rack	Annual Water Use (Gal.)	
Under Counter, High Temp	75	1.98	54,202	1.00	27,375	26,827
Door Type, High Temp	280	1.44	147,168	0.95	97,090	50,078
Single Tank Conveyor, High Temp	400	1.13	164,980	0.70	102,200	62,780
Multi Tank Conveyor, High Temp	600	1.10	240,900	0.54	118,260	122,640

Cost

Cost varies based on various factors as mentioned above. The following table provides a quick look at the possible cost of the different types of dishwashers.

Table 18. Commercial Dishwashers Representative Costs

Washer Type	Make	Cleaning Racks/Hr	Gallons / Rack	Cost
Under Counter, High Temp	Hobart LXIH-3	30	0.74	\$4,000 (Webstaurantstore)
Door Type, High Temp	Hobart AM15-6	58	0.74	\$8,000 (Webstaurantstore)
Single Tank Conveyor, High Temp	Jackson AJX-44 Vision	225	0.68	\$11,800 (Webstaurantstore)
Multi Tank Conveyor, High Temp	Champion 462-64	278	0.45	\$25,400 (Katom.com)

5.3.2. ICE MAKERS

Description

Every restaurant requires the use of ice, produced by commercial ice machines. Ice machines can utilize one of two technologies: air-cooled or water-cooled technology. The air-cooled systems are much more water and energy efficient than the water-cooled ones, and are therefore, recommended by the California Food Service Technology Center (FSTC). There are two types of air-cooled based machines: the “standard” models and the Energy Star models. Water efficiency in Ice Makers is measured by two components: gallons of potable water used to make 100 pounds of ice and gallons of water used by the condenser to make 100 pounds of ice. The big advantage of the air

cooled machines is the absence of a condenser. A typical condenser uses around 150 gallons of water per 100 pounds of ice. The potable water used to make 100 lbs of ice ranges between 16-25 gallons for all types of machines (Food Service Technology Center (FSTC), 2010). Therefore, a machine with a condenser can use and waste up to 150 more gallons of water than an air-cooled system.

Figure 3. Ice Maker

Savings

The following table shows a typical water use of the three types of ice machines based on 450 pounds per day ice production. The data was produced using the FSTC Calculator for commercial ice machines:

Table 19. Commercial Ice Machine Water Use and Savings

Machine Type	Annual Water Use in gallons	Annual Water Savings in gallons compared to Water Cooled models
Water Cooled	285,795	
Air Cooled Standard	45,990	239,805
Air Cooled Energy Efficient	32,850	252,945

Cost

Cost varies based on various factors. The following table provides a quick look at the possible cost of the ice makers for commercial applications.

Table 20. Ice Makers Representative Costs

Machine Type	Model	Water Use: Gallons/100 lbs		Cost
		Ice	Condenser	
Water Cooled	Ice-O-Matic ICE1806HW_B100PS	22	139	\$6,610 (Katom.com)
Air Cooled	Ice-O-Matic ICE1406FA_B100PS	20	NA	\$5,417 (Katom.com)

5.3.3. FOOD STEAMERS

Description

Food steamers are amongst the most energy efficient kitchen appliances. There are two types of food steamers: one that uses a boiler and another one that is a closed system,

without a boiler and drain, typically referred to as

“connectionless” steamer. Connectionless steamers use

considerable less water than the boiler based ones, and thus

they are recommended by the FSTC. A boiler based steamer

can consume up to 40 gallons of water per hour while the

connectionless steamer consumes as little as 2 gallons per hour.

Figure 4. Food Steamer

Savings

A study, sponsored by the Metropolitan Water District (MWD) and the East Bay Municipal Utility (EBMUD), on the potential water savings of replacing boiler based food steamers in California with connectionless ones, produced the following empirical water use data (Karas, 2005).

Table 21. Food Steamers Water Use

Steamer Type	Avg Daily Use (Hours)	Daily Water Use (Gallons)
Boiler based	7.3	407
Boilerless	4.7	13.9

Normalizing these data for a daily use of 7.3 hours and for a yearly use of 365 days, the following water use / savings numbers are obtained:

Table 22. Food Steamers Annual Water Savings

Boiler Based Annual Water Use (gallons)	Connectionless Annual Water Used (gallons)	Annual Savings (gallons)
148,555	7,880	140,675

Cost

Cost varies based on various factors. The following table provides a quick look at the possible cost of the different types of food steamers.

Table 23. Representative Costs for Boilerless Steamers

Model	Price
Cleveland 1SCMCS Countertop 5 Pan - Electric	\$4,899 (1) (Webstaurantstore)
Stellar Steam (Altair II-6) - 6-Pan Boilerless Electric	\$7,624 (2) (Foodservicewarehouse)

5.3.4. PRE-RINSE SPRAY VALVES

Description

The dishwashing process (spray valves and dishwashers) is the largest consumer of water in the commercial food service industry. Pre-Rinse Spray Valves are used to rinse dishes and cookware before dishwashing. These fixtures can use up to 5 gpm of water, which could consume 328,500 gallons of water in a year if operated for three hours a day (Food Service Technology Center (FSTC), 2010). FSTC recommends a Pre-Rinse Spray valve of 1.6 gpm or less. Currently, there are valves in the market that operate at 0.65 gpm flow, reducing water consumption by as much as 87 percent.

Savings

Based on 3 hour per day use, replacing a 5 gpm valve with a 1.6 gpm valve would result in annual water savings of 212,380 gallons. These devices have an immediate payback, due to their very low cost.

Cost

FSTC has verified a number of Pre-Rinse Spray valves as meeting both water consumption of 1.6 gpm or less and of having a cleanability performance of 26 seconds per plate or less. The FSTC web site lists these valves. A representative cost for some of these valves is shown below:

Table 24. Pre-Rinse Spray Valves Representative Costs

Model	Water Use in gpm	Cleanability in Seconds	Cost
Niagara N2180	1.28	17	\$40 (Waterwisetech)
Fisher Ultra-Spray 2949	1.15	22	\$45 (Plumbersurplus)
T&S JetSpray B-0108-C	0.64	21	\$75 (Katom.com)

5.4. INDOOR - RECYCLED WATER

The term recycling is usually referred to the reuse of materials such as glass, aluminum and newspaper, but water can be recycled as well. Recycling water is the reuse of treated water for agricultural processes, landscape irrigation, toilet flushing, clothes washing, and various industrial processes. This section provides some examples of smaller scale water recycling practices that can be applied to small businesses or residential uses (Bastian, 2006).

Recycled water in this discussion is for non potable uses only. In a household and in commercial structures the non potable uses include flushing toilets and outdoor irrigations. These uses can be fully supported through rain harvesting systems.

Regulations

In the United States, the U.S. Environmental Protection Agency (EPA) regulates the standards for recycling water. In its document, "Guidelines for Water Reuse" published in 2004, the EPA lists and explains all of the state and national standards for water reuse. Generally, most of the recycled water uses in the United States are for non potable applications such as industrial processes, landscape irrigation, and public parks and golf course irrigation. The EPA has determined various standards for recycled water based on the intended use of the recycled water. The standards regulate the quality of the water based on several factors such as salinity, hardness, nutrients, chlorine, microorganisms, and sodium content (United States Environmental Protection Agency, 2004).

The regulations outlined in the EPA's Guidelines for Water Reuse apply entirely to commercial, industrial, and urban large scale uses in which the water supply agency is responsible for meeting those regulations if the public is likely to come into contact with the recycled water. This Background Report focuses on smaller scale applications that a homeowner or business owner can implement on their own, in which case these regulations do not necessarily apply since the public would not be exposed to the reused water.

5.4.1. BATHROOM

Description

In the United States, flushing toilets represents about 30 percent of indoor water use (California Department of Water Resources, 2010). This is a large amount of water that can be reduced by reusing water in the bathroom. Reusing bathroom sink water is possible with technology that works by storing water from the bathroom sink which is then used to fill the toilet for flushing. This system can be used in single and multi-family housing, business and commercial property, office buildings, and anywhere with a sink and a toilet in close proximity.

Savings

An average bathroom for two uses 9-12 gallons of water for sink activities throughout the day. The water reuse system can retain up to 5.5 gallons in its tank at a time to use for flushing. If the bathroom is operating a low flow toilet of 1.6 gpf, then the 9-12 gallons of water saved from the sink can provide 7.5 flushes a day without using fresh water.

Cost

This technology is manufactured by Water Saver Technologies and is known as AQUUS Greywater Recycling system. It currently sells for \$295.95

5.5. OUTDOOR WATER USE

Outdoor water use varies throughout the state but is generally the single largest water use in single family residences. According to the California Department of Water Resources, in the Central Coast 39 percent of total water consumption is used for outdoor purposes. Of this percentage, 60 percent is consumed by residential housing. This is a considerable amount of water consumption that is being used strictly to maintain lawns, public parks, and landscaping in general (California Department of Water Resources, 2010). This water consumption can be dramatically reduced through water efficiency regulation, education, behavior change, and the utilization of current water conserving technologies. The following section describes some of the regulations that aim to reduce water use and specific technologies that can save water and reduce storm water runoff.

Regulations

In California, there are two important regulations that directly affect the use of water for irrigation and landscape purposes. They are the Water Conservation Act of 2009 and the State of California's Model Water Efficient Landscape Ordinance, AB 1881 (CADWR). Both regulations are intended to promote water efficiency and conservation throughout the state of California through education, best practices, and the use of state of the art technology.

The Water Conservation Act of 2009 was enacted in 2009 which requires that the state of California achieve a 20 percent reduction in urban per capita water use by December 31, 2020. It also established an intermittent goal of a 10 percent reduction by December 31, 2015. In order to meet these goals, the bill created a task force to develop best management practices for statewide water savings, required agricultural water suppliers to develop and file agriculture water management plans as determined by DWR, and established a process for urban water suppliers to meet per capita based conservation targets.

Another regulation that directly affects urban water use for landscape irrigation is the Model Water Efficient Landscape Ordinance AB 1881. The ordinance was adopted in

2006 and requires cities, counties, charter cities, and charter counties to adopt landscape water conservation ordinances by January 1, 2010 (California Department of Water Resources, 2009).

The ordinance is a model ordinance developed by the state to increase water efficiency for landscape irrigation. The ordinance may be adopted as is in local jurisdictions or act as a model for the jurisdiction to develop their own landscape ordinance. The ordinance includes requirements for establishing water budgets, irrigation design, landscape design, grading design, irrigation scheduling, maintenance schedules, irrigation efficiency, and dealing with recycled water and storm water (California Department of Water Resources, 2009).

5.6. OUTDOOR - LANDSCAPE

5.6.1. SMART IRRIGATION

Description

The term “smart irrigation” refers to the use of irrigation controllers that adjust irrigation run times based on changes in certain environmental factors such as precipitation and soil moisture. They use sensors and weather information to manage watering times. Smart controllers have the ability to turn sprinklers off during rain, high wind, or low temperatures (Stryker, 2009). Several types of controllers exist that all use different methods for adjusting watering schedules. The types are listed below:

Historical: uses historical weather data for the specific geographic region. The downside of this type is that it doesn’t adjust to current weather conditions, so in an unusually hot or cold month the system would need to be manually adjusted.

Historical with sensor: combines the use of historical weather data for the region and a sensor that detects the current weather. This type will adjust watering by comparing daily temperature to historic data.

Off-Site Data: Uses weather data provided by a remote provider. The controller uses a radio, Internet, or phone connection to obtain the data from either a central data provider, or from a local weather station. Generally there is a subscription charge for the data service and there may also be charges for the telephone, Internet, or radio link. Accuracy is dependent on where the data is obtained from.

Weather Station: This controller has its own weather station installed on it. It uses real-time data from the weather station to adjust the watering times. It is very accurate if it uses a good weather station.

Moisture Sensor: This system uses several sensors placed throughout the landscape to measure the moisture of the soil. This method provides the most accurate watering schedule but maintenance and set-up require more work. It may

not be ideal for commercial use because the moisture sensors must be placed throughout a large area.

Savings

Sprinkler systems are generally 40-50 percent efficient (Stryker, 2009). This means that only half of the water that they consume actually gets to the root of the plants they are watering. Typical irrigation systems use automatic timers to create watering schedules for lawns and other vegetation. This approach ensures that water is turned on and off at appropriate times but it does not account for temperature change, soil moisture, and plant type. Smart irrigation systems can reduce water use on gardens and landscaping by up to 25 percent. They can accomplish this by watering only when necessary and by using different amounts of water for plants that have different water requirements (State of Michigan, 2006). The following section explains the specific benefits that smart irrigation systems provide:

Less Water- smart controllers use less water than regular automatic sprinkler systems because they adjust their water output based on the weather and the moisture of the soil. In hot/dry weather plants need more water and in cool/wet months they need less or no water. The smart irrigation systems will adjust based on the weather and they will water accordingly.

Plant Specific Watering- Smart controllers have the ability to control water output by regions within a landscape. To maximize efficiency, plants should be arranged in a landscape based on their water requirements. The smart system can then water high water requiring plants more frequently than low water requiring plants. Without this capability, all plants are watered equally and water is wasted.

Table 25. Smart Irrigation Summary Table

Type	Accuracy	Cost
Historical	Moderate	\$300 (Smart Rain)
Historical with sensor	Very	\$300 (Cyber-Rain)
Off-Site Data	Least-Very	\$400 (Smart Rain)
Weather Station	Very	\$300 (Smart Rain)

Moisture Sensor	Very	\$50-300(Cyber-Rain)
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5.6.2. DRIP IRRIGATION

Description

Drip irrigation is a method of plant irrigation that slowly applies water to the soil at very specific spots. This results in a more efficient use of water because the water is directly applied where needed, at the plant's base, and permeates the soil to reach the plant's roots without having much time to evaporate or runoff. This design results in 90 percent water use efficiency. Drip irrigation use is ideal for garden beds, trees, shrubs, vegetables, and bushes.

Savings

- High water efficiency (90 percent)
- Can irrigate irregular fields or areas
- Allows safe use of recycled water
- Minimized soil erosion
- Foliage remains dry so disease risk is lower
- Operates at lower pressure than sprinklers so less energy use

Cost

Drip irrigation systems are relatively inexpensive. Drip lines can be purchased in rolls for approximately \$0.15 per foot. An entire system can be put together for under \$200 dollars for a typical residential property. For fields of row crops, kits can be found for around \$70 including 200 feet of drip tape and all the necessary parts to get the system running. The cost for larger systems will vary depending on how large the irrigating surface is.

Table 26. Summary Table for Drip Irrigation

Uses	Benefits	Cost
Shrubs, bushes, vegetables, trees, row crops	High water efficiency, low soil erosion, simple to install	\$0.15 per foot (HomeDepot)

5.6.3. PERVIOUS PAVEMENT

Description

Pervious pavement can be used to reduce on-site runoff and help to recharge groundwater. Water that falls to the ground in a natural setting would be filtered through the soil and recharge the groundwater. Due to the large amounts of impervious surface in our built environment, the water flows through the engineered drainage systems and flows directly to the storm water drain thus reducing groundwater recharge (Pennsylvania Department of Environmental Protection, 2005). The use of pervious or porous paving materials simulates the natural functions of soil, filtering water and allowing it to infiltrate past the surface and recharge groundwater. Some of the common materials used are:

Porous Concrete: Larger pea gravel and a lower water-to-cement ratio are used to achieve a pebbled, open surface that is roller compacted. Fine aggregate typically is eliminated entirely, and the size distribution (grading) of the coarse aggregate is kept narrow, allowing for relatively little particle packing. This provides the useful hardened properties, but also results in a mix that requires special considerations in mixing, placing, compaction, and curing (Pennsylvania Department of Environmental Protection, 2005).

Block Pavers: Block pavers can be made out of various materials including brick, stone, and pebbles. They are porous by design and allow water to drain through the surface. Their primary use is for walk ways, plazas, and courtyards.

Porous Asphalt: Conventional asphalt consists of a combination of plant-dried coarse and fine aggregates coated with hot asphalt cement to bind them together. In porous asphalt, the fines have been screened and reduced which allows water to pass through the small voids that are created (State of Michigan, 2006).

Plastic Grid Systems: High strength plastic grids are placed in roadway areas. Some are designed to be filled with gravel on top of an engineered aggregate material, while others are filled with a sand/soil mixture on top of an

aggregate/topsoil mix that allow grass to be planted on the surface. The grids provide a support structure for heavy vehicles, and prevent erosion. After heavy rains, the grids act as mini holding-ponds, and allow water to gradually absorb into the soil below (Pennsylvania Department of Environmental Protection, 2005).

The following table summarizes the pavement types with their uses.

Table 27. Pavement Types and Uses

Type	Picture	Use
Porous Concrete		Patios, sidewalks
Porous Asphalt		Parking lots, sidewalks, tennis courts, playgrounds
Block Pavers		Walk ways, sidewalks, plazas, courtyards
Plastic Grid		Grass, walk ways, sidewalks, gardens

Savings

The Savings/Benefits of the above pavements are:

- Reduce storm water runoff
- Recharge groundwater
- Improve water quality by filtering properties of pervious pavement
- Reduce erosion from reduced runoff
- Reduce siltation in surface water from reduced runoff
- Reduce flooding

Cost

Current estimates are that pervious paving materials and installation are 2-3 times more expensive than conventional concrete and asphalt material. However, overall project cost may be less because of the reduced need for retention ponds and connective materials to the drainage system (Texas Water Development Board, 2005).

5.6.4. MULCH

Description

Mulch is a variety of different materials that is used in agriculture and gardens to maintain soil moisture and encourage micro-organisms to generate nutrients into the soil. The moisture maintained in the soil reduces the amount of water necessary through irrigation and thus saves water in the long run. The use of mulch mimics natural leaf cover in forests. There are two distinct categories of mulch: organic and inorganic. The organic mulch decomposes in typically one growing season, providing nutrients to the soil, and needs to be replaced. Inorganic mulch is more permanent but does not provide the excess nutrients from decomposition (California Urban Water Conservation Council, 2009). There are several types of materials used for mulch described below:

Organic residues (organic): a variety of sources exist for this. Bark can be purchased or the use of grass and leaf clipping, wood chips, or straw.

Compost (organic): fully composted material which can be purchased or produced from a composting bin.

Rubber (inorganic): pieces of rubber from recycled tires.

Plastic (inorganic): thin plastic sheets with holes that allow the plants to grow through. Predominately used in large scale vegetable growing.

Rock and gravel (inorganic): In cooler climates the heat retained by rocks may extend the growing season.

Savings

The Savings/Benefits of the various mulch types are:

- Extend growing season
- Reduce watering requirements
- Maintain soil moisture by reducing evaporation
- Improve soil nutrients by providing habitat for micro-organisms
- Protect against weed growth
- Protect against erosion

- Prevent weed growth

Cost

The cost of mulch will vary depending on the type of mulch, the source of the mulch, and the size of the area to be applied to. If using organic type mulch, the cost can be zero by recycling garden and landscape waste to be used as mulch. If mulch is to be purchased, then the following table can be referenced to determine the approximate cost.

Table 28. Mulch Types and Cost

Mulch	Cost
Bark (Scotts Brand)	\$1.95 per cubic foot (HomeDepot,Lowes)
Rubber (Vigoro Brand)	\$4.48 per cubic foot (HomeDepot,Lowes)
Gravel (Vigoro Brand)	\$7.98 per cubic foot (HomeDepot,Lowes)
Plastic(Harris Seeds Brand)	\$159.95 5ftx2000ft (HomeDepot,Lowes)

5.6.5. WATER WISE PLANTS

Description

Xeriscaping is landscape with the use of low water requiring plants which are generally native to the local area. Native plants are adapted to the local climate and therefore thrive with less use of water, fertilizer, and pesticides than non-native plant species. Most importantly, native plants use much less water than exotic and tropical plants. The wise use of these types of species can dramatically improve the water consumption of a garden or landscape (California Urban Water Conservation Council, 2009).

In order to have a successful water-wise landscape, the appropriate local plant species must be selected. There are a few main factors to consider when choosing these plants. These factors include:

Climate: the climate refers to the average weather of the region throughout the year. The climate zones for the United States are provided by the Sunset Western Garden Book. San Luis Obispo falls within Sunset climate 16. Details for each zone are provided on the Sunset website.

Microclimate: The microclimate refers to the specific characteristics of the area to be landscaped. Large structures or trees that create shade or areas of extreme sun exposure can both affect the plant. Plants should be chosen based on these elements.

Water needs: Plants should be chosen and placed according to their water needs. Low and medium water requiring plants should be chosen and plants with similar water needs should be planted in the same area of the landscape to allow for more efficient irrigation.

Soil: Soil quality and composition can vary greatly. Some species prefer clayey soil while others prefer sandy or more organic conditions. Soil pH can also affect how plants grow. All of these factors should be considered and determined before choosing plants.

Placement in the landscape: know the mature size of the plant and make sure there is adequate space in the design for the fully grown plant.

Savings

The Savings/Benefits of this type of landscape are:

- Minimal to no water requirements
- Reduced fertilizer need
- Reduced pesticide need
- Enhanced local biodiversity by providing native habitat and species
- Certain jurisdictions give incentives for xeriscaping

Cost

There is no extra cost in choosing to create a xeriscape with native plants over a non xeriscape area. The water-wise landscape will only save money in the long run because of less water and maintenance requirements. A water-wise landscape should be irrigated with a multi zone irrigation controller to maximize water efficiency.

5.6.6. LANDSCAPE TECHNOLOGY SUMMARY TABLETable 29. Landscape Technology Summary Table

Technology	Saving/Benefit	Avg. Cost
Smart Controllers	25% water reduction	\$300-\$500
Drip Irrigation	90% irrigation efficiency	\$0.15 per foot
Pervious Pavement	Ground water recharge	\$2-\$3 per ft ²
Mulch (Bark)	Reduce evaporation	\$1.95 per cubic foot
Plants	Minimal to zero water requirement	NA

5.7. OUTDOOR - RECYCLED WATER

The term recycling is usually referred to the reuse of materials such as glass, aluminum and newspaper, but water can be recycled as well. Recycling water is the reuse of treated water for agricultural processes, landscape irrigation, toilet flushing, clothes washing, and various industrial processes. This section provides some examples of smaller scale water recycling practices that can be applied to small businesses or residential uses (Bastian, 2006).

Recycled water in this discussion is for non potable uses only. In a household and commercial structure the non potable uses include flushing toilets and outdoor irrigation. These uses can be fully supported through rain harvesting systems.

Regulations

In the United States, the U.S. Environmental Protection agency regulates the standards for recycling water. In their document, “Guidelines for Water Reuse” published in 2004, all of the state and national standards for water reuse are listed and explained.

Generally, most of the recycled water uses in the U.S. are for non potable applications such as industrial processes, landscape irrigation, and public parks and golf course irrigation. The EPA has determined various standards for recycled water based on the intended use of the recycled water. The standards regulate the quality of the water based on several factors such as salinity, hardness, nutrients, chlorine, microorganisms, and sodium content (United States Environmental Protection Agency, 2004).

The regulations outlined in the EPA’s Guidelines for Water Reuse, apply entirely to commercial, industrial, and urban large scale uses in which the water supply agency is responsible for meeting those regulations if the public is likely to come into contact with the recycled water. This guidebook on water conservation focuses on smaller scale applications that a homeowner or business owner can implement on their own, in which case these regulations do not necessarily apply since the public would not be exposed to the reused water.

5.7.1. RAIN HARVEST

Description

Rain Harvesting is a process in which rain water is collected, stored, and then used for drinking, irrigation, or to refill aquifers. Rain harvesting for drinking purposes is primarily used in regions where rain water is the only source of available drinking water (Texas Water Development Board, 2005). In San Luis Obispo, this is not the case, and therefore rain harvesting would best be used for residential and small commercial uses. Households can collect rainwater to irrigate their gardens, flush toilets, and wash dishes and clothes. Commercial operations such as restaurants or other small businesses can use rain harvesting to irrigate landscapes, flush toilets, and wash dishes. There are two main types of rain harvesting systems which are described below.

Roof Catchment: A roof catchment system collects rain that falls onto a rooftop and is collected through a gutter and pipe system. This system is the most common since residential and commercial uses are the primary focus of rain harvesting in most U.S. communities.

Ground Catchment: A ground catchment system captures rain runoff from the ground into a storage area (Texas Water Development Board, 2005).

Focus will be given to roof catchment systems since they are the easiest to install and more applicable for small scale uses for individual commercial or residential applications. The roof catchment system consists of a collection tank, referred to as a cistern, which is available in various sizes, roof gutters, a downspout filter, a water diverter, an overflow assembly, and a pump for distributing water throughout the landscape.

These systems are capable of collecting hundreds of gallons of water depending on how large the roof is and how many cisterns are utilized. Generally, after one inch of rain, 1 square foot of roof will yield 0.623 gallons of collectable water. On a mid size house with a collectable roof area of 1,000 square feet, 623 gallons of water can be

collected in a one inch rain spell (Rain Harvest Co., 2009). Cisterns are available in many different sizes and therefore systems can be created with different capacities ranging from 400 gallon to 5,000 gallon. At the most basic level, only a cistern is required to be connected to a water diverter from the roof to collect rain water. The tank will begin to collect water which can then be connected to a garden hose. A more advanced system will have a separate pump which can be used to irrigate the entire landscape (Rain Harvest Co., 2009).

Savings

Savings directly depend on how large the rain harvest system is, how large the collection area is, and the average rainfall in the region. With a complete system (as described below) 350 gallons of water can be collected at one time. The system is easily expandable by adding more cisterns. Along with the water savings, rain harvesting has several other benefits including:

- Storm water runoff collection
- Reduced reliance on city water
- Reduced water and wastewater bills
- “Free” water
- Naturally soft water, which is ideal for irrigation

Cost

Cost will vary greatly depending on the capacity of the system and the type of system. A cost estimate of two separate systems is provided in the table below. The first is a basic system without a pump and the second is a complete system with a pump.

Table 30. Rain Harvest Systems Costs

Basic System (Cistern Only)	
Components	Description
350 Gallon Cistern	Collection tank holds 350 gallons of water
TOTAL	\$489.95 (RainHarvestSystems)

Complete System (Cistern and Pump)	
Components	Description
350 Gallon Cistern	Collection tank holds 350 gallons of water
Downspout Filter	Filters incoming water to system
Water Pump	Supplies water at 50 psi for household irrigation and uses
Hardware	All necessary hardware to connect and use the water pump
TOTAL	\$997.95 (RainHarvestSystems)

6.0 POTENTIAL ISSUES WITH WATER CONSERVATION TECHNOLOGY

Water Conservation approaches need to be comprehensive and include human behavior change, smart practices, and updated technology. This study presents technology that can aid in a larger water conservation approach. However, without the educational element to change people's behaviors and awareness of water use, reducing water use will be difficult.

After looking at various approaches to water conservation in California and other parts of the United States, it is clear that education and awareness is the key factor in achieving water conservation. Requiring certain low flow fixtures and high efficient washing machines can limit the water that the appliance uses, but it will not change human behavior. When people fail to maintain their appliances or neglect to fix leaks, then 1000's of gallons of water can be wasted annually. Programs such as the United States WaterSense and the Phoenix, Arizona WET, are focused on educating people about the effects that their water use has on the environment and the surrounding community. These programs have been very effective in changing people's behavior in an effort to reduce water use (Brock, 2007).

In some instances, educational efforts are not enough. Some cities have started to force changes in peoples' wasteful behavior, such as Los Angeles, California. Los Angeles has implemented regulations on water use, including increasing water prices and mandating landscape watering hours. Despite the new laws in Los Angeles, there are still many people who have not adapted to the new changes. Los Angeles has responded with a team of water enforcers known as Water Cops (Shankman, 2009). This team of people employed by the city patrols the neighborhoods of Los Angeles looking for water leaks and wasteful water practices, such as watering lawns in the middle of the afternoon or cleaning the driveway with the garden hose. Water Cops issue warnings and fines to violators. These efforts combined with city ordinances have proven successful. Soon after the implementation of these programs, water use

dropped by 12.7 percent in June of 2009 compared to June of 2008, accomplishing the lowest overall level of consumption in 32 years (Shankman, 2009).

Examples like this and many others show that water conservation must address many issues in a community. When people become more informed and aware of their water use they tend to make wise decisions on their own. Every approach to water conservation is different based on location and circumstances, as seen in the Los Angeles example. However, every approach must be comprehensive and address all of the elements of water conservation.

7.0 CONCLUSIONS

7.1. ADDITIONAL PROGRAM RECOMMENDATIONS

Countywide Water Conservation Program

The County of San Luis Obispo has made some efforts to conserve water but, there is no countywide program that involves all of the residents and various jurisdictions within the county. The county should consider a large scale program similar to what Phoenix, Arizona has done. Another example of such a program can be seen in the County of Santa Barbara just south of San Luis Obispo.

The program should include a dedicated web page for the program with links, interactive tools, rebate programs, educational materials, water savings tips, and any other information that is related to the water conservation efforts. A website like this will provide residents with all the information they need so that the county can work together on reaching its larger water conservation goals.

Community Involvement

A large part of water conservation is education and human behavior. Water use is learned behavior and can properly be taught and influenced. The County of San Luis Obispo can focus on promoting water use and conservation education to the community so that people can learn how to best use water, thereby limiting overall use and waste.

Involving the community will also help the county to accomplish more with less opposition from the residents. If the community members feel that they have been included in major decisions and that their input is being received, it will likely be easier for the county to achieve its water conservation goals. The county can also explore various community events to educate and involve the public. For example, educational seminars on landscaping best practices and countywide rebate programs for people who reduce their water consumption or install low water using appliances and fixtures.

Recycle Water

The County of San Luis Obispo should explore the possibilities of recycling water. Currently, the City of San Luis Obispo within the county has its own water recycling program. The city collects wastewater from the residents' sewers that it directs into a tertiary treatment process where it is disinfected and distributed throughout the city for irrigating landscapes and public parks. Recycled water can also be used for irrigation of farmland and crops. This would save the county a tremendous amount of water since currently, 58 percent of the county's water supply is used for agriculture purposes (PMC, 2009). Such a program requires the construction of new distribution pipes commonly referred to as purple pipes to send the recycled water to its desired location. The possibilities should be explored through a feasibility study to determine the cost and benefits from such a project.

7.2. LIMITATIONS OF THIS STUDY

Expand Study

This Handbook is limited and does not cover all of the technologies available for conserving water. Because the Handbook focuses on residential and commercial applications, it does not include agricultural and other industrial processes. Agriculture is the single largest use of water in the County of San Luis Obispo at 58 percent (PMC, 2009). A similar study such as this one could be completed to focus on the water use of agriculture practices within the county.

Law

This Handbook and water saving guide will only be used as a tool to help people decide what fixtures and appliances to put in their homes or businesses on a voluntary basis. The next step for the County of San Luis Obispo is to require such retrofits and water conserving appliances for everyone throughout the county. This can be accomplished through new ordinances and by supplying the resources and materials to residents at no or minimal charge, much like the City of Phoenix did in its water conservation program.

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Product 2:

**A HANDBOOK OF WATER CONSERVATION
TECHNOLOGIES AND PRACTICES**

A Handbook of Water Conservation Technologies And Practices

San Luis Obispo County
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A Handbook of Water Conservation Technologies and Practices

For:
The County of San Luis Obispo

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INTRODUCTION

This Handbook is part of a Professional thesis project for the completion of a Master's of City and Regional Planning at Cal Poly, San Luis Obispo. The Handbook consists of various water conserving technologies and practices to aid developers and residents of the County of San Luis Obispo meet a 20% per capita water use reduction goal by 2020.

The Handbook is organized in two main sections: Indoor Water Use, and Outdoor Water Use. Each section contains various water using appliances and fixtures with a brief description of the technology, a savings comparison to their non water conserving counterpart, and a cost example.

This Handbook is a supplemental document to The Background Report for the Water Conservation Handbook (Background Report) and contains summarized information from the Background Report for presentation purposes and reader's ease. For more information on any of the technologies or references mentioned in this Handbook, the Background Report should be referenced.

Note to Reader

The reader should note that the cost examples are included to provide samples of what the technology might cost. The prices are to be taken with discretion as many factors may influence the actual cost, such as geographic location, sales, quality, etc...In many instances a particular appliance model is used to provide an actual price. These models are by no means recommendations or endorsements by the author. All technologies mentioned in this book should be further researched by the reader to obtain a more accurate price.

INDOOR WATER USE

- Washing machines
- Point of use tankless water heaters
- Sink aerators
- Low flow showerheads
- Low flow toilets and urinals
- Automatic faucets
- Automatic toilets and urinals
- Bathroom water recycling
- Commercial dishwashers
- Commercial pre-rinse spray valves
- Commercial ice makers
- Commercial food steamers

INDOOR WATER USE

Water use can be categorized into Indoor and Outdoor water use. This section provides information on indoor water using appliances and presents alternative technologies that can be chosen to reduce water consumption inside a home or a business. In the United States, residential uses consume the most water. The average American family can consume 400 gallons of water in one day.

Indoor water use data is used to determine what areas of a building consume the most water. In general, indoor water use consists of showers, toilets, faucets, dishwashers, clothes washers, leaks, and other. Often times the information is presented based on the type of room in a building that consumes water. For example in a residential unit, the bathroom use represents the largest indoor water use at almost 30%. In a restaurant, the dishwashing process (spray valves and dishwashers) represent the largest water consumption. This information is valuable so that people can identify what area of their home or business is consuming the most water and make changes appropriately to reduce water consumption. The following chart shows an example of residential indoor water use in the United States by water use category.

Water can be conserved through a combination of education, behavioral adjustment, and implementation of water conserving technology. Advances have been made in technology to conserve water in bathrooms, kitchens, and laundry rooms.

For example:

- **Old toilets used 3.5-7 gallons per flush. New ones use less than 1.6 gallons per flush**
- **New clothes washers use as low as 10 gallons per cycle. Old ones used 40 gallons per cycle**
- **Sink aerators and Pre-Rinse Spray valves are available at 0.5 gallons per minute**

The following section presents technologies in the various indoor water use categories that conserve water compared to older technology. The information is intended to serve as a quick guide for readers to learn about various ways of reducing water use by purchasing the appropriate fixture or appliance for their home or business.

WASHING MACHINES

Important Features:

Look for front load, Energy Star approved washing machines with the lowest water factor possible.

Technology

Non efficient washing machines can use up to 40 gallons of water per load (gpl). Energy Star approved, efficient washing machines can use as low as 10 gpl. Efficient models exist in top load and front load technology. The front load models are generally more efficient than the top loading ones.

Water Factor

The Water Factor (WF) is a unit of measurement used to measure the water efficiency of washing machines.

The lower the WF the less water the machine uses. It can be calculated by dividing the capacity in cubic feet of the machine into the total water used per cycle (gpc).

Savings

Savings from washing machines come from a decrease in water and energy use. The following table shows a comparison of the water used by an old washing machine and an average priced high efficient machine available today.

Water Use Comparison	Water Factor	Gallons/Cycle
Standard Top Load	11.4	40
Average High Efficient Front Load	3.6	14.4

Cost

Water efficient washing machines can be purchased from the same suppliers that carry traditional washing machines. The following table is an example of the cost of water efficient machines, one being top load and the other front load.

Machine Type	Price
Standard Top Load	\$480.00
Average High Efficient Front Load	\$750.00

POINT OF USE TANKLESS WATER HEATERS

Important Features:

Reduces wait time for hot water which in turn reduces water waste.

Technology

Point of Use Tankless Water Heaters, or on demand water heaters, save water by eliminating the wait period for hot water to reach the demand. A shower with a flow rate of 2 gallons per minute (gpm), that requires two minutes to get hot, will waste 4 gallons of water. A point of use heater will not waste this water since the hot water comes out as soon as the hot water faucet is turned on.

Savings

The on demand water heater saves water by eliminating the wait period for hot water to reach the demand. A shower with a flow rate of 2 gpm taking two minutes to get hot will waste 4 gallons of water. A point of use heater will not waste this water since hot water comes out as soon as the hot water is turned on.

Cost

Point of use heaters can be purchased from the same suppliers that carry traditional tank heaters. The following table is an example of Energy Star water efficient tankless point of use heaters.

Heater	Price
Ariston Point of Use Water Heater (6 Gal)	\$200.00
Ariston Point of Use Water Heater (2.5 Gal)	\$160.00

DISHWASHERS

Important Features:

Look for Energy Star ratings that are lower than 9 gallons per cycle (gpc).

Technology

Dishwashers consume water on a daily basis and average about 9.3 gallons per cycle. More efficient technology is available under the Energy Star program that consume less than 3 gpc.

Savings

Energy Star rated dishwashers provide the greatest water and energy savings. The federal government provides manufacturing standards and Energy Star has even more strict specifications. The following table shows the potential water savings from an Energy Star, low WF machine.

Dishwasher Type	Gallons/Cycle	Savings
Standard Kitchen Aid KUDD03ST	>9	NA
Energy Star Frigidaire FGHD2433	3.68	144%

Cost

Dishwasher Type	Water Factor	Price
Compact Kitchen Aid KUDD03ST	2.7	\$594.00
Standard Frigidaire FGHD2433	3.68	\$467.00

SINK AERATORS

Important Features:

Lower flow is recommended for bathrooms and higher flow for kitchens. Look for aerators below 1.6 gpm.

Technology

Faucet water use represents almost 16 % of total indoor residential water use in the United States. Water can be saved by using an aerator. An aerator is a small metal device with a screen that screws onto the faucet spigot. They reduce water flow to as low as 0.375 gpm, reduce splashing from water, and increase spray coverage. Many different aerators exist. The Aerator Type table shows some of the most common ones with their intended use and a short description.

Savings

Regulations on plumbing fixtures have influenced aerator technology. Currently, 1.6 gpm is the most common aerator available. This reduced flow rate can provide water savings in households and commercial buildings. The table below shows the percent difference of water use from available aerator types compared to a sink faucet without an aerator.

Aerator	Gallons/Minute	Savings
No Aerator	3.5	NA
Flip Aerator	2.2	59%
Standard Aerator	1.6	118%
Vacuum Aerator	0.5	600%

Aerator Type

Type	Example	Use
Standard Aerator		Bathroom or Kitchen. Least expensive and comes in various flow rates.
Flip Aerator		Ideal for Kitchens because it has an on/off switch and higher flow rate.
Swivel Aerator		Ideal for Kitchens because it has an on/off switch, higher flow rate and a swivel to clean dishes easier.
Vacuum Aerator		Ideal for Bathrooms because it has the lowest flow rate. Most expensive type.

Cost

Aerator Type	Gallons/Minute	Price
Standard Aerator	0.5-2.2	\$1.95
Flip Aerator	2.2	\$7.00
Swivel Aerator	2.2	\$7.00
Vacuum Aerator	>0.5	\$25.00

LOW FLOW SHOWERHEADS

Important Features:

Water usage during a shower depends on showerhead flow rate and duration of shower. Try reducing shower time and installing a low flow showerhead with an on/off switch.

Technology

Low flow showerheads range in flow rate from 0.5 to 2.5 gpm. There are a few different technologies currently being used in order to achieve this lower flow rate compared to the older 5-8 gpm showerheads. Some showerheads have self pressurizing technology that adjusts flow rate based on water pressure and others use the infusion of air, much like faucet aerators to reduce water flow. The Showerhead Type table shows some of the more common shower heads available today with a short description of the technology.

Savings

The average shower time is approximately 8 minutes per person. One shower could consume up to 64 gallons of water. Improvements and innovations in showerhead technology have led to a much greater reduction in water use from showers. Installing a low flow showerhead of 1.5 gallons per minute will use 12 gallons of water in an 8 minute shower saving 52 gallons of water per shower. The following table gives more examples of savings compared to a showerhead with a 7 gpm flow rate.

Showerhead	Gallons/Minute	Savings
No Low Flow	7	NA
Massaging	1.75	300%
Standard	1.5	366%
Vacuum Flow	0.5	1300%

Showerhead Type

Type	Example	Description
Standard Low Flow		The simplest and most inexpensive showerhead operates at 1.5 gpm. Mixes water with air to reduce flow.
Non-Aerated Massaging		Non-aerated so the flow rate is higher at 1.75 gpm. A little more expensive because of the massage spray feature.
Self Pressurizing Aerated		This type adjusts flow rate based on water pressure and also has a water velocity control valve. It also uses air to reduce flow. Maximum flow rate is 1.5 gpm.
Vacuum Flow Restriction		Water enters a vacuum chamber and is mixed with air which allows the lowest flow rate of all technologies at as low as 0.5 gpm. This is also the most expensive.

Cost

Showerhead Type	Gallons/Minute	Price
Standard Low Flow	1.5	\$8.00
Messaging	1.75	\$20.00
Self Pressurizing	1.5	\$20.00-\$35.00
Vacuum Flow	0.5	\$60.00-\$80.00

LOW FLOW TOILETS AND URINALS

Important Features:

Current toilet technology has reduced flush volumes to below 1.6 gallon per flush (gpf). Urinals can use as low as 0.125 gpf but waterless urinals exist which use no water and are easy to install.

Technology

Toilets are the highest residential indoor water consuming appliances in the United States. Almost 30 % of household water consumption is from flushing the toilet. The average person flushes their toilet 5 times per day. Depending on the amount of water per flush, many people could consume approximately 20 gallons of water a day just from flushing the toilet. The use of low flush toilets and urinals in households and commercial buildings can significantly reduce the water use per person by choosing the appropriate toilet / urinal for its intended use. The table Toilet / Urinal Type describes the different technologies and intended uses.

Savings

Savings from toilet and urinal use vary based on the flush volume of the existing fixture and the different types of technologies available today to replace old ones. Low flow toilets, dual flush toilets, compost toilets, low flow urinals, and waterless urinals all use different amounts of water per flush. The savings for each of these are shown below compared to a toilet of 3.5 gpf and a urinal of 1.6 gpf.

Toilets

Toilet Type	Gallons/ Flush	Savings
Standard Toilet	3.5	NA
Low Flow Toilet	1.6	118%
Dual Flush Toilet	0.8 / 1.6	337% / 118%
Compost Toilet	Zero	No Water Use

Urinals

Urinal Type	Gallons/ Flush	Savings
Standard Urinal	1.6	NA
Low Flow Urinal	0.125	1180%
Waterless Urinal	Zero	No Water Use

Toilet / Urinal Type

Type	Description	Use
Low Flow Toilet	Two technologies: gravity fed or pressure assist. Gravity are common in homes and pressure assist in commercial buildings.	Applicable in any bathroom. Ideal for home, office, or commercial bathrooms.
Dual Flush Toilet	Dual Flush Toilets give users two different flush volume options. Low volume for liquid and large volume for solid waste.	Applicable in any bathroom. Ideal for home, office, or commercial bathrooms.
Compost Toilet	Toilets which use little or no water and treat toilet wastes on-site for reuse as valuable compost.	Ideal for houses in rural areas or cabins that are not connected to a sewage system. Also a good alternative to septic tanks.
Low Flow Urinal	These incorporate a flushing system that utilizes water for the sanitizing rinse and odor removal.	Ideal for high use commercial bathrooms. Also applicable in homes.
Waterless Urinal	Urinals that use a cartridge insert filled with a chemical sealant that allows urine to pass through, but then traps it below.	Ideal for high use commercial bathrooms. Also applicable in homes.

Cost

Toilet Type	Gallons/Flush	Price
Low Flow Toilet	1.6	\$200.00-\$600.00
Dual Flush Toilet	0.8 small flush / 1.6 big flush	\$200.00-\$600.00
Compost Toilet	Zero	>\$800.00
Low Flow Urinal	0.125	\$250.00
Waterless Urinal	Zero	\$250.00

AUTOMATIC FAUCETS

Important Features:

Automatic faucets combine aerators with automatic shut off technology to achieve maximum water savings and also reduce spread of bacteria because there is no handle for people to touch.

Technology

Several different technologies exist for automatic faucets. The most commonly used is an infrared sensor powered by a single battery or connected to an electrical line. The touchless faucets combine aerator technology with low flow rates to provide the most water saving capabilities in faucets available today.

Savings

Automatic faucets have a motion sensor and are equipped with aerator with a flow of 0.5 gpm. Flow rates can range from 0.5 to 1.6gpm. Low flow rate and automatic on/off provides maximum water saving ability. They can save up to 70% compared to standard faucets.

Cost

Faucet Type	Gallons/Minute	Price
Standard Faucet	0.5-2.2	\$170.00
SLOAN Automatic Faucet	0.5	\$225.00

AUTOMATIC TOILETS AND URINALS

Important Features:

Automatic Toilet and Urinal flush valves can be used with low flow fixtures to help reduce unnecessary flushes.

Technology

Several different technologies exist for automatic toilet valves. The most commonly used is an infrared sensor powered by a single battery or connected to an electrical line. The touchless toilets are combined with low flush volume technologies to provide the most water saving capabilities in toilets/urinals available today.

Savings

The main benefits from these toilets are the reduction of a flush handle which helps reduce the spread of germs. The toilet can also save water by preventing people from over flushing.

Cost

Toilet Type	Gallons/Flush	Price
No Auto Flush	3.5	\$150.00
AutoFlush Chrome Toilet	Any Flush Volume	\$140.00
AutoFlush Chrome Urinal	Any Flush Volume	\$140.00

BATHROOM RECYCLED WATER

Important Features:

The reuse of water is an easy way to help conserve water and reduce usage. Systems are available for bathrooms and entire houses.

Technology

In the United States, flushing toilets represents about 30 % of indoor residential water use. This is a large amount of water that can be reduced by reusing water in the bathroom. Reusing bathroom sink water is possible with technology that works by storing water from the bathroom sink which is then used to fill the toilet for flushing. This system can be used in single and multi-family housing, business and commercial property, office buildings, and anywhere with a sink and a toilet in close proximity.

Savings

An average bathroom for two uses 9-12 gallons of water for sink activities throughout the day. The water reuse system can retain up to 5.5 gallons of this water in its tank at a time to be used for flushing. If the bathroom is operating a low flow toilet of 1.6 gpf, then the 9-12 gallons of water saved from the sink can provide 7.5 flushes a day without using fresh water.

Cost

This technology is manufactured by Water Saver Technologies and is known as AQUUS Greywater Recycling system. The system is only for recycling sink water for toilet use. Larger systems are more expensive.

System	Tank Capacity (Gallons)	Price
AQUOS	5.5	\$295.00

COMMERCIAL PRE-RINSE SPRAY VALVES

Important Features:

Pre-Rinse Spray Valves and Dishwashers consume the most water in restaurants. The Food Service Technology Center recommends a Pre-Rinse Spray Valve of less than 1.6 gpm.

Technology

The dishwashing process (spray valves and dishwashers) is the largest consumer of water in the commercial food service industry. Pre-Rinse Spray Valves are used to rinse dishes and cookware before dishwashing. These fixtures can use up to 5 gpm of water, which could consume 328,500 gallons of water in a year if operated for three hours a day. The California Food Service Technology Center recommends a Pre-Rinse Spray valve of 1.6 gpm or less. Currently, valves are available operating at as low as 0.65 gpm.

Savings

Savings are based on a 3 hour per day use and compared to a Spray Valve with a 5 gpm flow rate.

Pre-Rinse Spray Valves	Gallons/Minute	Savings
Standard	5	NA
Niagara N2180	1.28	290%
T&S JetSpray B-0108-C	0.65	669%

Cost

Pre-Rinse Spray Valves	Gallons/Minute	Price
Niagara N2180	1.28	\$40.00
Fisher Ultra-Spray 2949	1.15	\$45.00
T&S JetSpray B-0108-C	0.65	\$75.00

COMMERCIAL DISHWASHERS

Important Features:

Dishwashers should be chosen based on restaurant size and water consumption. Look for models that use less than 1.0 gallon per rack (gpr).

Technology

The dishwashing process (spray valves and dishwashers) is one of the largest water consumption processes in the commercial food service industry. Dishwashers are categorized into “Under Counter,” Door-type,” and “Conveyor.” Conveyor type uses the most volume of water and Under Counter uses the smallest volume. The water used by all types is measured in gallons per rack. There has been much improvement in the efficiency of commercial dishwashers. In the 1990s, the most efficient dishwashers used 1.5 gpr compared to machines today that use below 1.0 gpr.

Savings

The United States Energy Star Program provides many resources on commercial appliances. The savings listed in the table below are based on different model types provided by the Energy Star website.

	Conventional	Energy Star	
Washer Type	Gallons/Rack	Gallons/Rack	Savings
Under Counter	1.98	1.00	98%
Door Type	1.44	0.95	51%
Conveyor	1.13	0.70	61%

Cost

The following table gives some cost examples of the different types of commercial dishwashers.

Washer Type	Gallons/Rack	Price
Under Counter, Hobart LXIH-3	0.74	\$4,000
Under Counter, Hobart AM15-6	0.74	\$8,000
Conveyor, Jackson AJX-44	0.68	\$11,000

COMMERCIAL ICE MAKERS

Important Features:

Every restaurant needs an Ice Maker. Makers with water-cooled condensers can use 150 more gallons than air-cooled ones to produce the same amount of ice. Look for Energy Star, air-cooled systems.

Technology

Every restaurant requires an Ice Machine to produce ice. Ice machines work with either an air-cooled or water-cooled system. The air-cooled system is recommended by the California Food Service Technology Center because it uses less water than water-cooled systems due to the absence of a water condenser. A condenser uses around 150 gallons of water to produce 100 pounds of ice. The water needed to make the ice ranges from 16-25 gallons. Therefore a condenser type machine uses an extra 150 gallons of water to produce the same amount of ice.

Savings

The biggest savings from Ice Makers can be achieved by using an Energy Star, Air-Cooled Machines. The following table shows the savings based on the production of 450 pounds of ice.

Ice Makers	Gallons/Day	Savings (Gallons)
Water Cooled	783	NA
Air-Cooled	126	657
Energy Star Air-Cooled	90	693

Cost

Ice Makers	Water/100 lbs Ice	Price
Water Cooled Ice-O-Matic ICE1806HW_B100Ps	161 gallons	\$6,610.00
Air Cooled Ice-O-Matic ICE1406FA_B100PS	36 gallons	\$5,417.00

COMMERCIAL FOOD STEAMERS

Important Features:

Food Steamers are the most energy efficient restaurant appliances. Choose connectionless steamers because they use as low as 2 gallons of water per hour compared to 40 gallons per hour for a boiler based system.

Technology

Food Steamers are amongst the most energy efficient kitchen appliances. There are two types of Food Steamers, ones that have boilers and ones that do not (connectionless). Connectionless steamers use less water than the boiler based ones, and thus they are recommended by the California Food Service Technology Center. A boiler based steamer can consume up to 40 gallons of water per hour while the connectionless steamer consumes as little as 2 gallons per hour.

Savings

According to a study sponsored by the Metropolitan Water District (MWD) and the East Bay Municipal Utility (EBMUD), water savings can be achieved by replacing boiler based systems with connectionless ones.

Food Steamer Type	Gallons/Day	Savings (Gallons)
Boiler Based	407	NA
Connectionless	22	385

Cost

Connectionless Steamers	Price
Cleveland 1SCMCS Countertop 5 Pan	\$4,899
Stellar Steam (Altair II-6) - 6-Pan Boilerless	\$7,624

OUTDOOR WATER USE

- Smart irrigation controllers
- Drip irrigation
- Mulch
- Pervious pavement
- Water wise plants
- Rain harvest systems

OUTDOOR WATER USE

Outdoor water use primarily consists of maintaining gardens, irrigating landscapes, outdoor cleaning, and car washing. In the United States, in an average home the outdoor water use represents 59% of the total household water use. This water is being used primarily for watering lawns and gardens. The chart represents total residential water use in the United States. The indoor component on the chart represents all of the various water uses described in the Indoor Water Use section of this Handbook.

Outdoor water use can be reduced through a combination of education, behavioral adjustment, and implementation of water conserving technologies. There are many strategies and technologies available today to help people reduce their water use from irrigation and still maintain a beautiful and healthy looking garden. Examples include:

- **Drip irrigation systems that are 90% efficient**
- **Smart irrigation controllers which adjust watering based on local weather**
- **Use of native plants can significantly reduce water, pesticide, and fertilizer needs**
- **Recycled rain water and grey water to irrigate gardens**

The following section provides information on outdoor water usage. It gives examples of technologies available that can conserve water and recycle water. It also provides some guidelines and recommendations for certain practices and landscaping ideas that if followed will help to reduce outdoor water use. The information is intended to serve as a quick guide for readers to learn about various ways of reducing water use by purchasing the appropriate technology and doing all that they can to use less water.

SMART IRRIGATION CONTROLLERS

Important Features:

Automatic sprinkler systems are only 40-50% efficient. Smart controllers adjust their watering based on weather data or actual weather conditions, reducing water use by 25%.

Technology

The term “smart irrigation” refers to the use of irrigation controllers that adjust irrigation run times based on changes in certain environmental factors such as precipitation and soil moisture. They use sensors and weather information to manage watering times. Smart controllers have the ability to turn sprinklers off during rain, high wind, or low temperatures. Several types of controllers exist that all use different methods for adjusting watering schedules. They are described in the Controller Type table.

Savings

Sprinkler systems are generally 40-50% efficient. This means that only half of the water that they spray actually gets to the root of the plants that they are watering. Typical irrigation systems use automatic timers to create watering schedules for lawns and other vegetation. This approach ensures that water is turned on and off at appropriate times but it does not account for temperature changes, soil moisture, and plant type. Smart irrigation systems can reduce water use on gardens and landscaping by up to 25% by watering only when necessary and by providing different amounts of water for plants that have different water requirements. The savings are summarized below.

- **Reduces water use by 25%**
- **Changes water use based on current weather**
- **Waters different areas of the landscape based on plants’ water need**
- **Reduces water runoff by only watering when necessary**

Controller Type

Type	Accuracy	Description
Historical Weather Data	Does not adjust in real time thus, on days that do not represent historical averages the controller would still water based on the historical average temperatures.	Uses historical weather data for the specific geographic region. Does not adjust in real time.
Off-Site Weather Data	This type obtains its data from a separate provider so accuracy depends on the provider.	Uses weather data provided by a radio, Internet, or phone connection to obtain the data from either a central data provider, or from a local weather station
Weather Station	Most accurate because the weather station attached to the controller automatically updates based on current conditions.	Has a weather station attached to the unit. Uses real time data to adjust watering.
Moisture Sensor	Also very accurate because the moisture sensors allow the controller to water only when the soil needs to be watered.	Uses several sensors placed throughout the ground to measure soil moisture.

Cost

Cost varies greatly in these systems based on features and quality. But in general the prices are similar for all of the various technologies.

Controller Type	Price
Historical	\$300.00
Off-Site	\$400.00
Weather Station	\$300.00
Moisture Sensor	\$300.00

DRIP IRRIGATION

Important Features:

Drip irrigation is 90 % water efficient. This means that 90 % of the water used actually gets consumed by the plant. Drip irrigation is inexpensive, efficient, and versatile.

Technology

Drip irrigation is a method of plant irrigation that slowly applies water to the soil at very specific spots. This results in a more efficient use of water because the water is directly applied where needed, at the plants base, and permeates the soil to reach the plants roots without having much time to evaporate or runoff. This design results in 90 % water use efficiency. Drip irrigation use is ideal for garden beds, trees, shrubs, vegetables, and bushes.

Savings/Benefits

- **High water efficiency (90 %)**
- **Can irrigate irregular fields or areas**
- **Allows safe use of recycled water**
- **Minimizes soil erosion**
- **Foliage remains dry so disease risk is lower**
- **Operates at lower pressure than sprinklers so less energy use**

Cost

Drip irrigation systems are relatively inexpensive. Drip lines can be purchased in rolls for approximately \$0.15 per foot. An entire system can be put together for under \$200 dollars for a typical residential property. For fields of row crops, kits can be found for around \$70 including 200 feet of drip tape and all the necessary parts to get the system running. The cost for larger systems will vary depending on how large the irrigating surface is.

MULCH

Important Features:

Mulch helps maintain soil moisture which reduces water needs and extends the growing season. Organic mulch adds nutrients to the soil through decomposition but inorganic mulch is more permanent.

Technology

Mulch is used in agriculture and gardens to maintain soil moisture and encourage micro-organisms to generate nutrients into the soil. The moisture maintained in the soil reduces the amount of water necessary from irrigation and saves water in the long run. Mulch can be organic or inorganic. Organic mulch includes bark, garden clippings, and compost. Inorganic mulch includes rubber, gravel, and plastic sheets. Organic mulch decomposes in typically one growing season, adding nutrients to the soil. Inorganic mulch is more permanent but does not provide nutrients from decomposition.

Savings/Benefits

- **Extends growing season**
- **Reduces watering requirements**
- **Maintains soil moisture by reducing evaporation**
- **Improves soil nutrients by providing habitat for micro-organisms**
- **Protects against erosion**
- **Prevents weed growth**

Cost

The cost of mulch varies depending on type and size of area to be applied to. Organic mulch can cost nothing by recycling garden waste. The following table gives some price examples for different mulch.

Mulch Type	Price (square feet)
Bark	\$1.95
Rubber	\$4.48
Gravel	\$7.98
Plastic	\$0.030

PERVIOUS PAVEMENT

Important Features:

Pervious pavement is made of a variety of materials and can be used anywhere. Pervious pavement helps to reduce water runoff, improve water quality by filtering water, and helps to replenish ground water supply.

Technology

Pervious pavement can be used to reduce on-site runoff and help to recharge groundwater. Water that falls to the ground in a natural setting would be filtered through the soil and recharge the groundwater. Due to the large amounts of impervious surface in our built environment, the water flows through the engineered drainage systems and flows directly to the storm water drain thus reducing groundwater recharge. The use of pervious or porous paving materials simulates the natural functions of soil, filtering water and allowing it to infiltrate past the surface and recharge groundwater. The table Pervious Pavement Type explains the different materials used for pervious pavement.

Savings/Benefits

The savings and benefits from using pervious pavement materials includes the following:

- **Reduces stormwater runoff**
- **Recharges groundwater supply**
- **Improves water quality because of filtering properties**
- **Reduces erosion from reduced runoff**
- **Reduces siltation in surface water from reduced runoff**
- **Reduces flooding**

Pervious Pavement Type

Type	Example	Use/Description
Porous Concrete		Concrete with large particles that create pores. Used for patios and sidewalks.
Porous Asphalt		Coarser particles allow water to pass through voids. Used in parking lots, tennis courts, playgrounds, sidewalks.
Block Pavers		Made out of brick, stone, or pebbles. Used for walkways, sidewalks, and plazas.
Plastic Grid		High grade plastic grids filled with various materials such as soil or gravel. Used in grass gardens, sidewalks, and walkways.

Cost

Current estimates are that pervious paving materials and installation are 2-3 times more expensive than conventional concrete and asphalt material. However, overall project cost may be less because of the reduced need for retention ponds and connective structures to the drainage system.

WATER WISE PLANTS

Important Features:

Choosing native plants can help reduce water use because native species have adapted to the local climate and therefore thrive with less water, fertilizer, and pesticides.

Technology

Xeriscaping is landscape with the use of low water requiring plants which are generally native to the local area. Native plants are adapted to the local climate and therefore thrive with less use of water, fertilizer, and pesticides than non-native plant species. Most importantly, native plants use much less water than exotic and tropical plants. The wise use of these types of species can dramatically improve the water consumption of a garden or landscape. There are certain consideration to keep in mind when choosing plants. Refer to the Plant Factors section on the following page for these.

Savings/Benefits

The savings and benefits from using water wise plants include:

- **Minimal to no water requirements**
- **Reduced fertilizer need**
- **Reduced pesticide need**
- **Enhanced local biodiversity by providing native habitat and species**
- **Certain jurisdictions give incentives for xeriscaping**

Plant Factors

In order to have a successful water-wise landscape, the appropriate local plant species must be selected.

There are a few main factors to consider when choosing these plants. These factors include:

Factors	Description
Climate	The climate refers to the average whether of the region throughout the year. The climate zones for the United States are provided by the Sunset Western Garden Book. San Luis Obispo falls within Sunset climate 16. Details for each zone are provided on the Sunset website.
Microclimate	The microclimate refers to the specific characteristics of the area to be landscaped. Large structures or trees that create shade or areas of extreme sun exposure can both affect the plant. Plants should be chosen based on these elements.
Water Needs	Plants should be chosen and placed according to their water needs. Low and medium water requiring plants should be chosen and plants with similar water needs should be planted in the same area of the landscape to allow for more efficient irrigation.
Soil	Soil quality and composition can vary greatly. Some species prefer clayey soil while others prefer sandy or more organic conditions. Soil pH can also affect how plants grow. All of these factors should be considered and determined before choosing plants.

Cost

There is no extra cost in choosing to create a xeriscape with native plants over a non xeriscape area. The water-wise landscape will only save money in the long run because of less water and maintenance requirements. A water-wise landscape should be irrigated with a multi zone irrigation controller to maximize water efficiency.

RAIN HARVEST SYSTEMS

Important Features:

Rain harvesting can supply water for irrigation and cleaning needs around the home or in a business. They can collect over 600 gallons with 1 inch of rain.

Technology

Rain harvesting is a process in which rain water is collected, stored, and then reused around the house or in a small business for cleaning and irrigation. The system is installed on the building's roof and water is collected into a cistern through a pipe and filter system. The water can then be redirected for its intended use. These systems are capable of collecting hundreds of gallons of water depending on how large the roof is and how many cisterns are utilized. Generally, for one inch of rain, 1 square foot of roof will yield 0.623 gallons of collectable water. On a mid size house with a collectable roof area of 1,000 square feet, 623 gallons of water can be collected in a one inch of rain fall.

Savings/Benefits

Savings directly depend on how large the rain harvest system is, how large the collection area is, and the average rainfall in the region. With a complete system, 350 gallons of water can be collected at one time. The system is easily expandable by adding more cisterns. Along with the water savings, rain harvesting has several other benefits including:

- **Storm water runoff collection**
- **Reduced reliance on city water**
- **Reduced water and wastewater bill**
- **“Free” water**

Cost

Cost will vary greatly depending on the capacity of the system and the type of system. A cost estimate of two separate systems is provided below. The first is a basic system without a pump and the second is a complete system with a pump.

Basic System (Cistern Only)

Components	Description
350 Gallon Tank	Collection tank, 350 gallon capacity
TOTAL	\$490.00

Complete System (Cistern and Pump)

Components	Description
350 Gallon Tank	Collection tank, 350 gallon capacity
Downspout Filter	Filters incoming water to system
Water Pump	Supplies water at 50 psi for household irrigation and uses
Hardware	All necessary hardware to connect and use the water pump
TOTAL	\$998.00