Facility Manager's Guide to Water Management

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This guidebook was prepared by the
Arizona Municipal Water Users Association
Regional Water Conservation Committee
with assistance from Black and Veatch.

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The AMWUA Regional Water Conservation Committee developed this guidebook as a resource to assist in identifying areas where commercial, industrial, and institutional facilities can improve their water use efficiency within reasonable economic parameters. Many water providers offer additional resources such as workshops, printed materials, and individual assistance. Please call your city water conservation office listed on the next page for additional information.

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The *Facility Manager's Guide to Water Management* can be found at www.amwua.org/business_library.html.

Other sources of information include:

American Water Works Association's Water Wiser Web site, http://www.waterwiser.org/
U.S. Environmental Protection Agency, John Flowers, 202-564-0624, email: flowers.john@epa.gov
The Arizona Department of Environmental Quality, Phoenix, 602-771-2300, or 1-800-234-5677
The Arizona Department of Water Resources, Phoenix, 602-771-8500 or 1-800-352-8488
The University of Arizona Water Resources Research Center, http://ag.arizona.edu/AZWATER
Your municipal pollution prevention department.

FACILITY MANAGER'S GUIDE TO WATER MANAGEMENT

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SECTION I: INTRODUCTION TO WATER MANAGEMENT

The Purpose of the Facility Manager's Guide to Water Management:

Our cities are committed to helping our industrial, commercial, and institutional customers improve their water use efficiency. This workbook was developed to provide guidance to customers wishing to design their own water management programs and provides specific step-by-step instructions and suggestions on how best todevelop and implement a program for your facility. Not all material in this guidebook will pertain to your particular business. You may move those sections to the back of the book or just skip them.

Do Business and Industry Really Use Significant Volumes of Water?

In the Phoenix metropolitan area, 30 percent of the water delivered is used by industrial and commercial customers. This translates to 44.6 trillion gallons of water each year. A 10 percent reduction in commercial and industrial water use would provide enough water for more than 137,000 families for one year.

Why Should We Conserve Water?

The rising costs of water, wastewater treatment, and the energy used to heat water all play major roles in our continuing use of this precious resource. More importantly, an endless supply of water is never a guarantee, especially in the arid Southwest. In an age where business may be seen as an excessive user of water supplies, a successful water conservation program can demonstrate to the public your willingness to become an active community partner in environmental responsibility.

- **To save money.** The water-conserving technologies that the cities are suggesting are cost-effective; they pay for themselves and deliver lasting cost savings. Conservation can help cut costs in the following areas:

  - Water
  - Wastewater
  - Environmental Fees
  - Pretreatment
  - Chemicals
  - Energy
  - Maintenance

- **To keep rates low.** Maximizing the life of our current water supplies helps defer the need to develop new, more expensive sources of water and water treatment facilities and therefore helps keep water rates from increasing.

- **To comply with regulations.** The Arizona Department of Water Resources (ADWR), some federal agencies, and the Valley cities have established some requirements and/or guidelines for efficient water use in water-intensive non-residential applications.

- **To prepare for drought.** Droughts are an inevitable part of the Valley's weather pattern. Conserving water now helps you prepare to operate efficiently in dry times.

- **To preserve a resource for the benefit of all.** All water users must help conserve our water resources. It simply is a matter of doing something for the common good and projects a good public image for your company.

Who Should Use This Guidebook?

This workbook can be used by the facility manager, general manager, public information officer, and all personnel involved in resource conservation and employee communication.

This book will lead you through the basics of plan development and provide some materials for employee outreach as well as data sheets to use for planning and consumption tracking. Because of the variations in processes, equipment, and water situations at different sites, further technical questions should be addressed to your vendors and consultants.

Principles of Water Management

Developing a water management plan is a logical, step-by-step process. It involves more than just conducting a cost-benefit analysis and preparing a report. To be successful, a water management plan should not only consider the technical side, such as installing efficient plumbing fixtures, but also the human side, such as changing employees' long-standing operating procedures and water-using habits. Facility managers also need to look at managing water use so that they comply with the law, make cost-effective decisions, and can document their savings.

The following tips will help you develop a comprehensive and effective water management program.

- Water management techniques generally fall into three categories:

    1. Reducing losses (for example, fixing leaky faucets and pipes)
    2. Reducing the amount of water used by equipment or processes (for example, using ultra low-flow toilets and automatic shut-off faucets)
    3. Reusing water that would otherwise be discarded (for example, treating water from sinks for use on landscaped areas)

- An effective plan is one that fully outlines not just how much water is being used, but how it is used and by whom.

- Water use does not exist in a vacuum. Conserving water within a building also affects the other building systems. For example:

  - Reducing the amount of hot water used in a dishwasher would also reduce the amount of electricity needed to heat that water.
  - Reductions in hot water use reduce energy use.
  - Reductions in heating and air conditioning requirements, through energy conservation, reduce cooling and boiler water use.
  - Water conservation reduces wastewater flows.
  - Reductions in water use and waste management can reduce pretreatment requirements.

- Your water management plan, to a great degree, will only be as good as the information you collect to develop it.

- Implementation can be done in phases, starting with the easiest and lowest-cost.

- Evaluate your actions based on a basic economic analysis, not just by considering the initial investment.

- Match the quality of the water used to the application. You may not have to use potable water for all applications. Each use can be examined to determine where water of less-than-drinking-water quality can be reused or recycled at the facility. For example, cooling water or process water could be reused for landscape irrigation or other purposes.

- Company management must be committed to efficient water use if they want to convince employees that their actions make a positive difference.

NOTE: *At all facilities, water conservation measures must be consistent with public health, Americans with Disabilities Act (ADA), and other requirements and/or guidelines and must be accepted by regulatory authorities.*

The forms in this guide are provided as masters.
Please copy these and use them freely in the development of your water management plan.

FACILITY MANAGER'S GUIDE TO WATER MANAGEMENT

SECTION II: HOW TO DEVELOP A WATER MANAGEMENT PLAN

The following is a general outline of the suggested approach to developing a water management plan. The steps involved in the development of the plan are not complex, but will require some time and participation from all levels of personnel at the facility. Given a working knowledge of the facility, the facility manager should not have a difficult time in gathering the information necessary. The result of this effort will be a better understanding of where and how much water is used throughout the facility, where best to implement conservation efforts, and what benefits can be expected from implementation of the management actions.

PLAN OUTLINE

Goals. The initial goals set for water use reduction should be as specific and measurable as possible. As more information is gathered and the water management plan develops, these goals may be revised to reflect achievable management actions. Prior to implementing the chosen actions, the goals should be expressed in terms of gallons or percentage saved and include dates for when the goals will be achieved.

1. **DEVELOP A WATER USE INVENTORY.** This is where the majority of your effort will be focused. Initially, however, this step can begin with generating a very basic list of water uses at the facility. You might start by listing the most significant water uses at the site, or those uses that are believed to be most in need of conservation measures (noticeably inefficient water use). This will be a good starting point for the more detailed facility survey discussed later in this guide.

2. **IDENTIFY WATER MANAGEMENT ACTIONS.** A plan should be developed that outlines and determines the feasibility of each management action by presenting simple cost/benefit analyses and the projected payback periods where applicable. Current or proposed water/wastewater rates should be used when determining the costs and benefits of the actions. The plan should include actions that are no-cost or low-cost, actions that require capital expenditure, and actions that require changes in water use procedures by facility personnel. Details of possible water management actions are presented in Section III of this guide.

3. **IMPLEMENT THE WATER MANAGEMENT PLAN.** Implementation of the water management actions selected in the previous step should begin with the prioritization and scheduling of the actions. Thought should be given to scheduling the actions in a logical manner. For example, it may make more sense to postpone retrofitting of plumbing fixtures if a remodel of the facility is planned for the near future.

   This step also includes the communication of water management actions to all levels of personnel. This can help foster a facility-wide awareness that management is dedicated to the concept of water conservation. Communication is especially important if the water management actions include changes in the staff's work procedures or habits.

Implementation of the management actions should be followed by some form of monitoring to determine if the actions achieved the desired effect. Long term dedication to monitoring the water consumption of the facility can also help in identifying future problems with water use such as system leaks.

THE IMPORTANCE OF TOP MANAGEMENT SUPPORT

It is crucial that the top management at the facility support the water conservation plan in a material way. This requires not only dedication to a written policy statement, but also willingness to provide the money, staff, time, and other resources necessary to implement the water management plan. Water conservation must be seen as a long term investment rather than a short term budget enhancement.

Large corporations are frequently seen as environmentally wasteful and as if they are not held accountable for their use of natural resources. Many companies, however, have had the forethought to start energy and water conservation programs and have made water conservation one of their decision filters and management policies.

DEVELOPING A POLICY STATEMENT

For a company plan to have the impact of a directive, a company policy statement is necessary. This statement will reflect the intentions of management and therefore will be different for every company. We offer one example here:

> "Water conservation as a way of life is encouraged not only at work, but also at home for our employees. To that end, the company is committed to developing and maintaining a comprehensive water-saving and management program that will help ensure our continued ability to grow as well as to provide an increased dollar-saving potential."

Without support from management, it is much more difficult to implement an effective plan. The genuine desire to conserve water must be present -- from the top and on down the line.

STEPS FOR DEVELOPING A WATER MANAGEMENT PLAN

The following discussion provides a more detailed examination of the steps involved in the development of the water management plan.

STEP 1: DEVELOP A WATER USE INVENTORY

A. Gather Information. Before starting your survey, collect the information that already exists. This will save time during the facility survey. The people who are familiar with daily operations, especially operating and maintenance personnel, can be very helpful in this step. Some information will be readily available; other data may take some time to collect.

Examples of data collection forms are included in this guide to assist personnel in gathering necessary information. It may be helpful to copy some of these sheets and use them directly for recording information. In some cases, such as consumption history data, it may be more helpful to use the provided form as a template for recording the data in a computer spreadsheet. By using a computer, statistics such as total annual water consumption or average gallons per day may be easier to compile and maintain.

Specifically, gather the following:

- Building floorplan and list of water meters serving the building. When multiple water meters serve multiple buildings at the facility, it is recommended to group meters serving each building. Worksheet II-1 provides a table for recording the meter account information. It is recommended that the local water utility be contacted to get a complete list of all meters serving the facility. The utility may also be able to provide information regarding the type of use that each meter serves (landscape, fireline, etc.). By recording both the billing account number and the meter number (usually stamped on the dial cover for the meter), you may be able to determine which meter(s) serve a particular building or area of the facility.

- Water and sewer bills for the last two years. Worksheet II-2 presents an example data collection table for this purpose. However, for multiple meters at a facility, it may be easier to record the two years of billing data on a computer spreadsheet.

- List of outdoor water uses and two years of consumption data, if available. Outdoor water use may include make-up water for pools and spas, supply water for evaporative misting systems, as well as landscape irrigation. As noted previously, the local water utility may know which meters are solely for landscape use. If possible, the landscape water use data should be separated from the indoor or process water use data on the Water Consumption History sheet (Worksheet II-2). However, many older facilities will have meters with combined landscape and indoor service. In these cases it may not be possible to separate the water uses. Installing separate meters for irrigation can sometimes save on sewer use fees.

- Submeter consumption data for two years. Your facility may submeter process water use or make-up water for cooling towers. If possible, the submeter data should be collected to separate these consumptions from the other water uses recorded on the city meters. The results of any water submeter calibration tests should be reviewed so that meter reading can be adjusted to reflect actual water use. Any submeters used should be American Water Works Association (AWWA) approved.

- Typical facility operating schedules, number of employees and visitors, and maintenance and janitorial work schedules. This information can be recorded on the Building Water Survey Form presented as Worksheet II-3.

- Lists of all water using equipment with manufacturers' recommended or specified flow rates, where available.

- A complete inventory of plumbing fixtures.

- Any prior water and energy surveys.

B. Conduct a Comprehensive Facility Survey. After you have collected the available existing information, you are ready to begin the survey. The exact extent of a water survey will depend upon the size of the building, the complexity of its systems, and the survey budget (if any). The more comprehensive the survey, the greater the value of the resulting water management options and cost savings. An inventory form for Existing Plumbing Equipment is provided in Worksheet II-4. Details associated with the assignment of responsibilities for the survey are discussed in Section IV – Participation.

A Water Use Inventory table is provided in Worksheet II-5. Copy this form and use it to record information while performing the detailed facility survey. The following steps should be performed while recording information on the Inventory forms.

- Walk through your facility, and through direct observation and measurements, identify and list any equipment that uses water: faucets, toilets, showerheads, drinking fountains, kitchen equipment, water-using process equipment, cooling towers, boilers, ice machines, etc.

- Determine the amount of water used by each type of plumbing fixture or device within the facility. Log or record the consumption data for each device. When field-testing the flow of water through fixtures, it is usually sufficient to take sample readings at a few representative fixtures located throughout the facility. When measuring the flow rate of fixtures such as faucets, adjust the fixture to an average or typical flow rate. Keep in mind that measured flows may vary on different floors because of pressure losses at higher elevations.

- Where possible, install temporary water meters to gauge water use by large water-using equipment. Compare the equipment water use measurements with the manufacturers' rated flow amounts; some equipment may be operating at higher water consumption rates than necessary. If there is a significant difference, consider having qualified personnel review equipment operation and make adjustments to lower water consumption.

- Record hours of operation for plumbing fixtures, devices, and all water-using processes or pieces of equipment. Note any particular fixture, device, or piece of equipment that uses water for more than one operation. Ice makers, for example, can use water for both making ice and for cooling. When possible, determine actual schedules of plumbing fixture use by talking to operating personnel familiar with the fixture use.

- Verify operating schedules and the number of building occupants during different times of the day.

- Determine daily facility consumption rates from water meter and submeter readings and other sources. This step will also help to prepare for monitoring water use reductions after beginning the water management program. After the survey is completed, continue to take meter readings on a monthly basis.

- As you list the water using equipment and fixtures during the survey, note any issues that have an impact on water consumption. Leaking faucets and valves, single-pass cooling flows, and outdated fixtures are examples of some of the observations that should be recorded. These issues should be addressed when developing the Water Management Actions.

C. Prepare the Estimated Water Balance. After completing the inventory of water uses around the facility, you should take the time to group the uses by category. Categories that might apply to your facility could include:

- Domestic Plumbing (restroom consumption such as toilets, urinals, showers, and faucets)
- Heating and Cooling (evaporative cooler and/or cooling tower make-up, boiler blow-down, etc.)
- Kitchen Plumbing (ice machines, food preparation, dishwashers, etc.)
- Process Water (process cooling, rinsing operations, chemical dilution, etc.)
- Water Features (pools, spas, fountains, etc.)
- Landscape Irrigation

As you group the various water consumptions of your facility, you will be able to generate an estimated water balance. This water balance will provide you with an estimate of the total amount of water that your facility consumes on a daily and annual basis. Figure II-6 provides an Estimated Water Balance table that you may use to summarize and total the consumptions of your applicable categories. At the bottom of the table, you can compare the estimated total water consumption with the total metered water consumption. This is an excellent way to check the accuracy of your water use inventory. It will probably be easiest to compare these consumption numbers based on a gallons per day (gpd) basis. If the difference of the estimated and metered consumptions is greater than 15 percent, you may have forgotten to include some water uses in the inventory or your water use assumptions for some items may not be accurate. You may need to revise your water use inventory and the associated water use assumptions.

Note that in the Estimated Water Balance table (Worksheet II-6), there are columns for listing average gpd for three separate time periods; May to October, November to April, and Annual (January through December). This allows you to recognize that some water uses will be seasonal. For example, the occupancy of your facility may vary from winter to summer (like a hotel or resort); this will have an effect on the average daily domestic plumbing water consumption. Alternatively, water use items such as cooling towers, evaporative coolers, and landscaping irrigation will have significantly greater average daily consumption in the summer compared to the winter season. The seasonal uses should also be compared to the corresponding seasonal metered consumption. If your water provider charges seasonal rates, it may be helpful to group your months to correspond to those seasons.

STEP 2: IDENTIFY WATER MANAGEMENT ACTIONS

A. Examine Possible Management Actions. By grouping the various uses in the water balance into categories, you will be able to verify which categories use the largest amounts of water. This information should guide your efforts in determining the most effective water management actions. For example, if the cooling system accounts for half of your facility's total water consumption, this could be a good area on which to focus conservation efforts.

Your approach to evaluating the water management options for each water use category should be comprehensive. Complete replacement is typically not an option for most facilities and may not necessarily be the best solution. Often, simple procedural changes in maintenance or operation can produce substantial water savings. A constantly running toilet, for example, can waste 4,000 gallons of water per day. Checking and replacing valves and ballcocks regularly can save this otherwise wasted water.

A checklist of conservation measures is provided in Worksheet II-7 at the end of this section. This checklist will provide you with an excellent starting point for determining possible water management actions at your facility. The checklist will allow you to note which conservation actions you have already implemented, which actions you can implement without further evaluation (such as actions that require little or no cost to implement), and which actions need to be investigated to determine cost effectiveness. Some of the actions listed may not apply to your facility.

As you weigh your fixture and equipment options, consider federal legislation and state water conservation and plumbing regulations. Some states and municipalities that have experienced water shortages in the past and those concerned about water use and conservation in general have passed stringent legislation.

While reviewing and selecting the possible water management options, you will want to determine how much water will be conserved by implementing this action (gallons per day) and how much it will cost to implement this action. This information will be critical to performing the economic analysis.

Section III provides detailed discussions of a variety of Water Management Options that you may consider for your facility.

B. Perform an Economic Analysis of Actions. After you have examined and selected a number of Water Management Actions, you must then determine which actions will be economically feasible.

Since some water efficiency options can be expensive and budgets are usually limited, it is critical that you choose those options most appropriate and cost-effective to your facility. At the same time, initial cost should not be the only reason for deciding which option is best. For example, replacing an existing frequently used or older toilet with a low-flow model will require a larger initial investment than simply installing a retrofit device. However, the device will require regular observation and maintenance and eventual replacement. The labor costs

may quickly offset the initial low cost of the device. Replacing the toilets that get the greatest mount of use will have a quicker pay-back than less frequently used toilets.

At this point you will have information pertaining to the amount of water each action will conserve. However, this conservation information needs to be translated into a cost (dollar) savings. The savings that a particular action will provide can then be compared to the initial cost of implementing the action.

Total Cost of Water. The basic cost of water can be determined from your utility bills or by calling your local water utility. Water utility bills usually contain two components: fixed charges and charges based on the amount of water used (unit costs). The fixed charges should not be included as a part of the total unit cost, since these amounts do not change relative to the amount of water used. Unit costs on your utility bill may include:

- Basic water unit cost (and associated consumption charges)
- Environmental costs
- Seasonal costs
- Wastewater fees
- Additional discharge fees

The units used for billing these costs may vary from city to city. You should determine whether the billing units are in gallons, thousands of gallons, or ccf (100 cubic feet = 748 gallons).

The total unit cost of water at your facility may include more than just the water and wastewater billing rates provided by your local utilities. A number of expenses may be added together to form the total water/wastewater unit cost. These might include:

- Energy cost of pumping water from wells
- Cost of pre-treating and on-site pumping
- Cost of water heating and cooling
- Chemical and/or other treatment costs, including treating cooling tower or boiler feed and reuse water
- Sewer costs, which can be based on the amount of water, biochemical oxygen demand, dissolved solids, and suspended solids

When combining these costs, you can use current prices. However, if possible, use prices that you expect will be in effect at the time any water efficiency and conservation changes are actually made. In that way, you can assess more accurately the savings realized by reducing water use. You may already have some of these expenses in the form of unit costs (such as dollars per gallon). However, your energy related expenses, such as pumping and heating, may need to be converted into unit costs. This can be done by estimating the costs associated with these expenses over a given time period and dividing these by the estimated volume of water used over this time period. Knowing the total cost per unit of water used is important because it will be used to determine savings realized by conservation actions.

Economic Analysis. The "simple payback" economic analysis compares the total initial cost of a water management action with the annual dollar savings that the action will provide to determine the length of time required before the action will pay for itself. Economic analyses that include the "time value of money" are available. These more detailed approaches may be necessary in situations where long term operating costs of an action will be significant. However, the simple payback method is easy to calculate and generally sufficient for most cases.

Simple payback is calculated by dividing the capital cost of the water management action by the net annual savings that the action will provide:

$$\text{Simple Payback Period} = \frac{\text{Capital cost (\$)}}{\text{Net annual savings (\$/year)}}$$

The following page illustrates an economic analysis for a cooling tower conservation action. For the details involved in the consumption calculations, refer to Section III: Water Management Actions. The provided example calculations indicate that the $5,000 initial cost of implementing the water management action will be paid back in approximately 11 months. Actions with payback periods of three years or less should be considered.

Worksheet II-8 presents a table that can be used in the economic evaluation of the proposed water management actions. The table below summarizes the sample calculations for the cooling tower.

Action	Annual Water Savings		Other Savings ($/yr)	Total Savings ($/yr)	Annual Costs ($/yr)	Net Savings ($/yr)	Capital Costs ($)	Payback Period (yr)
	Gal/yr	$/yr						
Cooling Tower Acid Addition	1,350,000	4,050	1,350	5,400	0	5,400	5,000	0.9

SAMPLE ECONOMIC CALCULATION
COOLING TOWER WATER CONSUMPTION

Note: See the Cooling Tower discussion in Section III: Water Management Actions for details of the consumption calculations.

- **Assumptions:**

Capacity:	300 tons of refrigeration
Operation time:	250 days per year
Efficiency:	2.5 cycles of concentration before conservation
Water/Wastewater rate:	$3.00 per 1000 gallons

- **Conservation Actions:** Conductivity controller, pH controller, treat with sulfuric acid to increase cycles to 5.0

- **Consumption Before Actions:**

Evaporation:	(300 tons) x (3 gpm/100 tons) x (1440 min/day) =	12,960 gpd
Bleed:	(12,960 gpd) ÷ (2.5 CR – 1) =	8,640 gpd
Total Make-Up:	(12,960 gpd) + (8,640 gpd) =	21,600 gpd

21,600 gpd for 250 days/yr = **5,400,000 gal/yr**

- **Consumption After Actions:**

Evaporation:	(300 tons) x (3 gpm/100 tons) x (1440 min/day) =	12,960 gpd
Bleed:	(12,960 gpd) ÷ (5.0 CR – 1) =	3,240 gpd
Total Make-Up:	(12,960 gpd) + (3,240 gpd) =	16,200 gpd

16,200 gpd for 250 days/yr = **4,050,000 gal/yr**

- **Annual Water Savings:** **1,350,000 gal/yr**

- **Cost Savings:**

Water & Sewer:	(1,350,000 gal/yr) x ($3.00/1000gallons) =	$4,050/yr
Chemical:	(1,350,000 gal/yr) x ($0.10/100 gallons) =	$1,350/yr

$4,050/yr + $1,350/yr = **$5,400/yr**

- **Capital Cost:** $5,000

- **Payback Period:** $5,000 ÷ $5,400/yr = 0.9 years = 11 months

STEP 3: IMPLEMENT THE WATER MANAGEMENT PLAN

A. Develop a Water Management Plan and Schedule. Once you have decided to take action to conserve water, choose the specific actions based on the previous examination of current water use, occupant needs, and the results of the economic analysis. Prioritizing the selected water management options in this way will maximize water, energy, and financial savings while maintaining or improving occupant comfort and increasing facility efficiency. Because individual facilities vary, no one plan is right for all facilities. After choosing water efficiency options, you should then develop a comprehensive water management plan work schedule. Determine what funding is available for what improvements, when the funding is available, and the time required to complete the entire water management project. Examine large retrofit or replacement options or high-priority jobs to determine the time necessary to complete each. While many can be implemented in a few hours or days, others may require up to several months and the services of a professional contractor.

When preparing the schedule, do not plan so closely that a delay in implementing one option throws the entire schedule off balance. If a water management program is expected to take 18 months, the first six months should be planned in detail, and progress and savings should be closely monitored. As you develop a sense of your progress in the first six months, you will be better able to plan the next phase (the next six months) with equal detail. In this way, remaining options are continually reviewed, helping to ensure that the plan is as realistic as possible and reflects the realities of actual progress compared to the initial plan.

Note: If you have an energy efficiency plan in place, a "piggy-backed" water conservation plan maximizes the effectiveness.

B. Communicate the Water Management Plan. Before implementing your water management plan, be sure that your employees know what is going on and why. Most water efficiency measures will only yield the savings you expect when *users* are part of the solution. Begin by sending all employees a letter from management expressing support for the water efficiency program and urging employees to participate on all levels. The letter should explain why changes are being made, what difference they will make, and finally, why water management is necessary. Signs should be posted near equipment, particularly in restrooms, so visitors are aware that water-savings initiatives are in place.

Since many water efficiency measures produce savings only when used properly, you must teach employees how to operate them. Additional signage may be necessary concerning low-flow toilets and urinals and automatic faucets.

Bulletin boards, newsletters, and staff meetings should regularly discuss the progress of the water management program and might also attempt to change occupant water use overall. As part of your program you may wish to incorporate some of the following suggestions:

- Set up a "hotline" to report leaks or other wastes of water to facility managers or maintenance personnel.

- Start a suggestion and incentives system to recognize water-saving ideas.

- Distribute flyers or pamphlets to promote the facility's water management plan or to educate occupants about good water use habits.

- Organize a slogan or poster competition.

- Start a water column in your regular employee newsletter featuring how much water has been saved through the water management program.

- Prepare a water conservation display covering different aspects of water use affected by the water management program (landscaping, low-flow plumbing products, water use habits, process changes, etc.), and place it in an appropriate location such as the facility lobby or employee cafeteria. Include ideas for home water conservation so your employees can lower their personal expenses. Contact your water supplier to see if it can contribute literature and/or other items for this display.

C. Implement The Water Management Plan. Now you are ready to start installing retrofits or replacements and to introduce maintenance or operational changes. Once work begins, closely monitor your program to ensure that it runs smoothly. This part of your plan should include at least the following items:

- Call contractors to verify that their work is progressing as promised.

- Follow up regularly with operating and maintenance personnel to make sure that their equipment is regularly checked and serviced.

- Listen to your facility's water users and keep communication lines open. Those who regularly use the equipment and fixtures will be able to provide the best feedback if something is not working as planned. Let them know that their input is important, so repairs or modifications can be made quickly.

- Check your water and sewer bills for decreases in your consumption and billing.

D. Monitor the Water Management Plan. Once implementation of your water management program has begun, you will want to carefully monitor water use to see what types of savings you are actually realizing. In addition to checking equipment, facility managers should maintain regular contact with operating and maintenance staff to verify that their work continues to produce water savings.

After verifying that your conservation efforts have produced positive results, share this information with others. Not only should you let your employees and management know about how much water they are saving, you may also want to share the news with your customers and community. This may encourage other groups and facilities to develop a similar water management program. Consider graphing or visually displaying water savings to emphasize successes.

Worksheet II-1

LIST OF WATER METERS			
Water Account Numbers (for billing)	**Meter Numbers**	**Size/Type of Meter**	**Meter Locations**

Worksheet II-2

WATER CONSUMPTION HISTORY											
Year 20___	Monthly consumption by Billing Units: Thousands of gallons OR ccf[1] (by water account number)										
	Indoor Uses						Landscape Uses				
Month	Account # _____	Account # _____	Account # _____	Account # _____	Billed Days	Average Gpwd[2]	Account # _____	Account # _____	Account # _____	Billed Days	Average Gpwd[2]
January											
February											
March											
April											
May											
June											
July											
August											
September											
October											
November											
December											
TOTAL											
Average											

[1] ccf = 100 cubic feet = 748 gallons [2] gpwd = gallons per workday, assuming 5 days per week

Worksheet II-3

BUILDING WATER SURVEY FORM				
Surveyed by:				
Date:				
General Information				
Name of Building:	**Address:**			
Building Contact:	**Phone:**			
Building dimensions: **Width** **Length**	**Building wastewater is currently:** ❑ **Treated on site** ❑ **Connected to city water system** ❑ **Other**		**Is recycled water currently used in any of the following areas?** ❑ **Toilets** ❑ **Urinals** ❑ **Cooling Towers** ❑ **Irrigation**	
Number of Floors (height):				
Building Occupancy Data				
Average number of occupants:	**Number of women:**		**Number of men:**	
Occupancy Schedule				
Weekdays	**From**	**a.m.**	**From**	**p.m.**
Saturdays	**From**	**a.m.**	**From**	**p.m.**
Sundays	**From**	**a.m.**	**From**	**p.m.**
Holidays	**From**	**a.m.**	**From**	**p.m.**

Worksheet II-4

EXISTING PLUMBING EQUIPMENT									
Use Area	**Location**	**Equipment**	**# of Units**	**Type**	**Mounting (Floor/Wall)**	**Make / Model**	**Average Flow Rate or Consumption (gpf)**	**Average Uses per Week per Unit**	**Comments (leaks, control, etc.)**

gpf = gallons per flush

Worksheet II-5

WATER USE INVENTORY					
ITEM	**LOCATION**	**FLOW, gpm**	**OPERATING TIME minutes / day**	**FLOW / DAY gpd**	**REMARKS**

Worksheet II-6

ESTIMATED WATER BALANCE YEAR _____			
Use	Average Gallons Per Day		
	May to October	November to April	Annual Average
TOTAL			
Metered Consumption			
Percent Difference			

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
BUILDING OPERATIONS				
✓ Read water meters on a regular basis				
✓ Make water use figures known to employees				
✓ Shut off water to unused areas				
✓ Install pressure reducing valves if pressure is high				
✓ Regularly check building for leaks and water waste				
✓ To the extent possible, quantify water use by each operation				
✓ Where feasible, investigate recycling and re-using water				
✓ Install water fountains that are self-closing and use air-cooling for chilled water				
✓ Eliminate unnecessary wash-downs				
RESTROOMS				
✓ Repair leaks and plumbing problems				
✓ Use water conserving plumbing fixtures: • Install low-flow showers, faucets, toilets, and urinals • Install metering or spring-loaded faucets, or faucets with censors				
✓ Adjust plumbing to use the minimum amount of water that is functional				

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
✓ Retrofit old fixtures				
✓ Remind users to conserve				
KITCHENS/CAFETERIAS				
✓ Look for water waste				
✓ Install separate water meters for large operations				
✓ Don't use running water to melt unwanted ice				
✓ Dish washing • Operate equipment only when needed • Wash only full loads • Use final rinse water for pre-washes and garbage disposers • Hand scrape dishes • Install an automatic shutoff so water does not run when garbage disposer is not in use				
✓ Ice making machines • Control bleed-off from clear ice machines • Ice flake machines usually use less water than ice cube machines • Use air-cooled machines where possible • Use bleed-off water for condenser cooling				

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
CLEANING AND SANITIZATION				
✓ Sweep when you don't have to mop or wash down				
✓ Establish a monthly budget based on plant water needs				
✓ Make sure that automatic irrigation equipment is operating properly • Inspect system regularly to ensure that there are no leaks and that heads are not broken or misaligned • Adjust pressures to the specifications for the equipment used				
✓ Water only when needed: • Determine water needs based on evapotranspiration needs or soil moisture • Water infrequently, but deeply, not everyday for a few minutes • Turn off the system controller if it has rained • Adjust controller times seasonally				
✓ Install timers, soil moisture sensors, and rainfall shutoffs				
✓ Use drip irrigation wherever possible				
✓ Do not over-fertilize or over-prune				
✓ Use heat resistant, drought tolerant plants				
✓ Limit turf areas				

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
✓ Be sure that hoses have shutoff nozzles				
✓ Use mulch around groundcovers, trees, and shrubs				
✓ Use a faucet timer if watering by hand				
✓ Avoid winter lawns				
✓ Mow regularly and avoid scalping grass				
LAUNDRIES				
✓ Consider and investigate water use when purchasing equipment				
✓ Use continuous-batch tunnel washers where volume of laundry justifies them				
✓ Use hot water reuse systems and other water conserving technology where feasible				
✓ Evaluate wash cycles and detergent/chemical formulation for maximum efficiency				
✓ Avoid excess filter and softener backflush				
✓ Wash only full loads				
POOLS AND SPAS				
✓ Do not use fill and draw pools				
✓ Use filter backwash for lawn watering				
✓ Cover pools and spas when not in use				
✓ Adjust pool levels to minimize splash-out				

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
COOLING SYSTEMS AND COOLING TOWERS				
✓ Meter and record water use				
✓ Never use once-through cooling, or reuse the water elsewhere in the facility				
✓ Use air cooling where feasible				
✓ Maximize cycles of concentration for cooling towers by providing efficient water treatment				
✓ Establish performance-based specifications when contracting with a cooling tower vendor				
✓ Investigate side-stream treatment				
✓ Reuse cooling tower effluent where possible				
✓ Investigate wet-dry cooling towers				
✓ Reuse treated wastewater or other sources of water for cooling tower make-up				
BOILERS AND HEATING				
✓ Establish performance-based specifications when contracting with a boiler vendor-operator				
✓ Check stream traps regularly				
✓ Reuse stream condensate water and boiler blow-down water where feasible				
✓ Avoid once-through operations				
✓ Record water use and check for leaks				

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
VEHICLE WASHING				
✓ Keep records of water used per vehicle washed				
✓ Install equipment that recycles water				
✓ Adjust solenoids, valves, nozzles, and equipment to minimize water use				
✓ Inspect and replace worn jets and parts				
✓ Reduce "show foam" to reduce need for rinse water				
✓ Use high-pressure rinses instead of flood arches				
✓ Use chemically compatible washing solutions/waxes to recycle together				
OTHER WATER USING EQUIPMENT AND OPERATIONS				
✓ Examine ways to modify existing processes & use alternative processes when replacing units				
✓ Use automatic valves that shut off water when equipment is off				
✓ Consider water use when purchasing equipment				
✓ Use mechanical/oil seals instead of water packing glands on pumps where possible				
✓ Regenerate water softeners only when needed				
✓ Capture reject water from reverse osmosis units and reuse it where feasible				

Worksheet II-8

SUMMARY OF POTENTIAL WATER CONSERVATION ACTIONS								
Action	Annual Water Savings		Other Saving	Total Savings	Annual Costs	Net Savings	Capital Cost	Payback Period
	gal/year	$ / year	$ / year	$ / year	$ / year	$ / year	$ / year	(year)
TOTAL								

FACILITY MANAGER'S GUIDE TO WATER MANAGEMENT

SECTION III: WATER MANAGEMENT OPTIONS

For virtually every use of water in a building, facility managers can choose from a wide variety of water management options. Some options simply involve altering the water use of building occupants. Other options involve changing the way fixtures and equipment are operated and maintained. The most significant long-term savings, however, will probably require the retrofitting or replacement of fixtures and equipment.

In some instances, one option alone might achieve the desired savings (such as replacing showerheads with low-flow models). In others, a combination of options may be needed (for example, inserting flow restrictors and providing automatic sensor controls for bathroom faucets).

A comprehensive water management plan should explore all water management options. This plan should recognize that a building's water system, and changes to it, will have an impact on other systems in the building, such as heating. For example, installing a flow restrictor on a faucet not only will reduce the amount of water consumed, but also will lower energy costs associated with heating this water for use and lower sewerage costs based on consumption.

Some ways to reduce your current water consumption will be immediately apparent, such as fixing a leaky faucet. Others, such as determining how many and what types of toilets to install, will require some product research.

It is important to evaluate each option not only on its ability to conserve water, but also on its practicality. For example, replacing a high-consumption fixture with a low-consumption fixture will enable you to realize the greatest amount of water savings over time, but where limited budgets prevent the initial high price of replacement, other interim measures, such as retrofitting toilets with displacement devices, may help save significant volumes of water.

CONSERVATION ACTIONS

Indoor uses of water will vary greatly from facility to facility. As discussed in Section II, the person charged with the responsibility of implementing the water conservation plan should perform a detailed audit of each major water use, process, machine, and position. Water management actions will then be chosen and evaluated to determine which are most cost-effective. The following discussion offers specific actions that you may want to evaluate to improve indoor water use at your facility. Generally these indoor uses of water fall into four major categories:

1. Domestic Plumbing
2. Cooling and Heating Systems
3. Kitchen and Cafeteria
4. Process Water Uses

Outdoor water use (specifically, landscape water use) is often an area with significant conservation potential. Landscape conservation actions, such as irrigation and Xeriscaping, are discussed in Section III, Number 3. Additional efforts should be discussed with a landscaping consultant.

1. DOMESTIC WATER USES

Domestic water use can include toilets, urinals, sinks, showers, and other appliances used for human health and sanitation. Domestic water conservation opportunities in new and existing facilities are evaluated below.

Code Requirements

Most local plumbing codes require water-conserving toilets, faucets, and showerheads in new construction. Federal requirements for water efficient plumbing took effect in 1992. The current state Construction Code requirements for toilets, urinals, lavatory faucets and showerheads are presented in the table below. All new fixtures sold must meet these requirements; however, replacement of existing fixtures is not generally required.

Federal Plumbing Fixture Standards

Toilets, gpf*	1.6
Urinals, gpf*	1.0
Lavatory Faucets, gpm^{+}	2.5
Showerheads, gpm^{+}	2.5

*gpf (gallons per flush)
$^{+}$gpm (gallons per minute)

Several different approaches enable plumbing fixtures to be both effective and water-saving.

Toilets and Urinals

- ✓ Flush valves for toilets and urinals can be adjusted to reduce flow without reducing flushing effectiveness. Flow reducing devices can also be installed.
- ✓ Toilets with individual tanks can be retrofitted by placing a dam or a water-filled plastic container in the tank to conserve a portion of the volume used by each flush.
- ✓ Retrofit devices of various types, such as toilet dams, displacement devices, or early closing flappers, are available to reduce the volume of flushing.
- ✓ Toilets and urinals are now only available in ultra-low volume versions with improved bowl designs and flushing procedures. The models with the lowest water use typically incorporate either a siphon action or air or vacuum assistance.
- ✓ Check timing cycles and volumes for automatic water flushing systems in urinals and toilets. All automatic systems should be tied to operating hours and should not run 24 hours a day, 7 days a week.
- ✓ For tank-type toilets with 3.5 gallon or greater flush volumes, complete replacement of the fixture should have an economically feasible payback period, depending on usage. At the very least, toilet dams or low-flow flapper valves should be installed to decrease consumption per flush.

Faucets and Showerheads

- ✓ Faucets and shower heads can be retrofitted with aerators that add air to the flow stream, resulting in a spray-like flow and reducing water usage.

- ✓ Another approach is to replace the faucets and showerheads with reduced-flow models.

- ✓ Metering faucets deliver a measured quantity of water on demand.

- ✓ Spring-loaded faucets shut off immediately after use.

- ✓ An automatic sensor controlled system for faucets has been available for several years. It uses a beam of infrared light to detect the presence of the user and thereby starts and/or stops faucet flow. These devices deliver metered flows, only on demand, preventing running of water at faucets not in use. The controls are designed to prevent activation by passers-by and to reset after use to accommodate the next person.

Preventive Maintenance. A scheduled program of leak detection and repair can provide considerable savings in water and energy costs for a small increase in maintenance effort. All tank toilets should be "dye-tested" to check for leaks. This simply involves placing a small tablet of dye in the tank, waiting 15 minutes, and checking the bowl to see if any water from the tank, colored by the dye, has leaked into the bowl. Dye tablets are inexpensive. Alternatively, several drops of food coloring can be added to the tank instead of the dye. Metering faucets should be periodically checked to ensure that they do not run for excessive periods of time.

Down With the Clog

One of the major causes of clogged toilets and plumbing maintenance headaches is the misuse of toilets as trash cans. In traditional, high-volume flush gravity toilets, this practice did not seem to seriously impair the toilet's performance or harm the pipes, since the high volume of water made virtually any object flushable. With the 1.6 gpf models, however, even if waste appears to flush, there is less water to propel the waste through the pipes, and clogs can form down the line if there isn't supplemental water from other sources.

2. COOLING AND HEATING SYSTEMS

Cooling and heating may be used for both ambient climate control and cooling of equipment. Uses include, but are not limited to, cooling towers, boilers, chillers, air scrubbers, refrigeration equipment, and evaporative coolers. For equipment such as cooling towers that use large volumes of water, install submeters for both influent and bleed-off water. Small changes in operation can lead to great savings in water, energy, and chemicals. Increase cooling tower cycles of concentration as equipment allows. Eliminate all single-pass water use. Investigate all possibilities of water reclamation and reuse.

Heating, ventilating, and air-conditioning (HVAC) equipment can use a great deal of water to meet a facility's heating and cooling needs. This equipment often uses water inefficiently, either by not recycling it or by recycling fewer times than possible. For these reasons, improving the efficiency of HVAC equipment can produce considerable water savings in your facility.

Cooling Towers

Cooling towers are the site of significant water consumption in most large cooling systems. In the Phoenix area, most cooling towers are used as the mechanism for rejecting heat from air conditioning systems. Some serve the cooling needs for plant equipment with large heat loads. The thermal efficiency, proper operation, and longevity of the water cooling system all depend on the quality of water and its reuse or recycling potential.

A free Cooling Tower Maintenance training video and workbook produced by the ADWR are available for on-site use. For a more detailed discussion of cooling tower water treatment and conservation or to obtain the video, contact your city's water conservation office.

In a cooling tower, a circulating stream of warm water contacts an air flow, causing evaporation of a portion of the water. When this water evaporates, the water that remains behind is cooled. The rate of evaporation from a typical cooling tower is approximately one percent of the rate of flow of the recirculating water passing through the tower for every 10°F decrease in recirculating water temperature achieved by the tower. The loss of heat by evaporation (latent heat) cools the remaining water. A small amount of cooling also takes place when the remaining water transfers heat (sensible heat) to the air. The water that passes through a cooling tower then circulates through a cooling system, warms, and returns to the tower.

A cooling tower consumes water in the following ways:

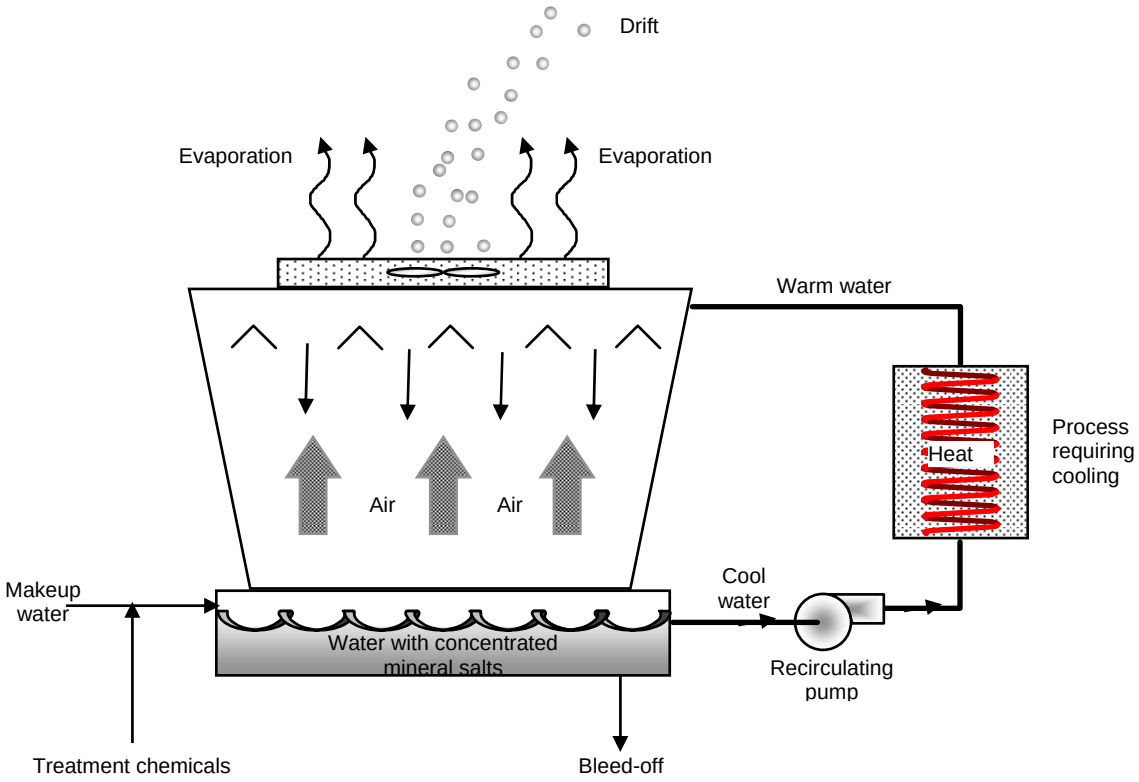
- **Evaporation.** As noted above, cooling of the water stream is accomplished through the evaporation of a portion of that input water flow. The amount of evaporation that occurs is a function of the amount of cooling performed and the weather conditions. For these reasons, the amount of evaporation cannot be reduced without an unacceptable reduction in the performance of the cooling tower. A general guideline for estimating the rate of evaporation from a cooling tower is 3 gallons per minute (gpm) per 100 tons of cooling load.

- **Blow-Down.** In addition to evaporation, water is lost from the cooling tower through "blow-down" or "bleed-off." Blow-down is the intentional release of some of the circulating water from the tower to remove suspended and dissolved solids left behind during the evaporation process. Without blow-down, dissolved minerals would continually increase in concentration and result in scale buildup in the system components.

- **Drift and Other Losses.** Drift is the loss of water in the form of mist, driven by the air draft of the tower. Drift droplets contain suspended and dissolved solids, so this loss can be considered a part of blow-down. A typical rate of drift is 0.05 to 0.2 percent of the total water circulation rate. Other system losses, such as valve leaks or drawoff for other uses, can also be considered as part of total blow-down.

- **Make-Up Water.** Water must be added ("made up") to the cooling tower to replace evaporation, blow-down, and drift losses. The relationship of the quantities of make-up water and blow-down can be expressed in terms of the concentration ratio (CR), also known as the number of cycles of concentration. This value is the ratio of total dissolved solids (TDS) in the blow-down water to their concentration in the make-up water. Figure III-1 illustrates a typical cooling tower schematic.

Figure III-1
Cooling Tower Schematic



As the concentration ratio increases, the amount of blow-down decreases. This means that less water is discarded and the tower is more water efficient. Significant volumes of water can be conserved by reducing blow-down to the minimum level consistent with good operating practice. Reducing the amount of water lost as blow-down is usually accomplished by treating the cooling water by physical or chemical means.

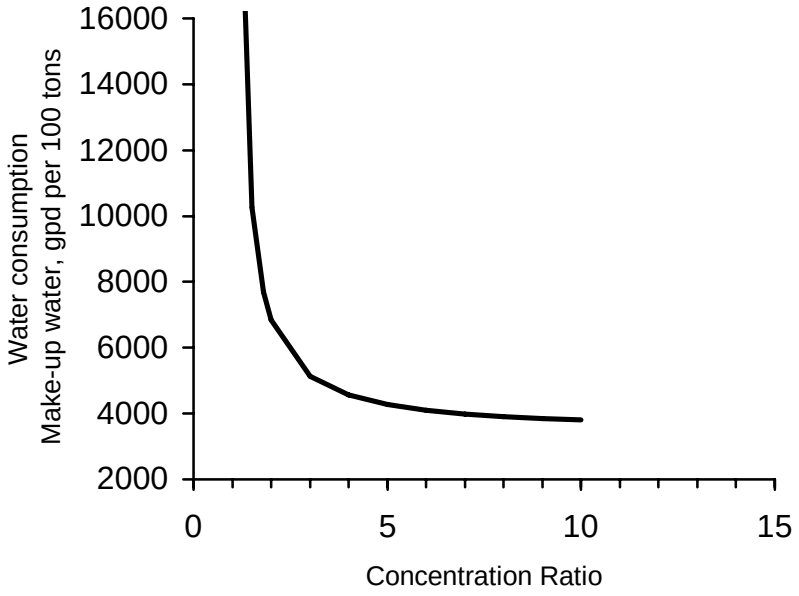
The following equations express the relationships between the make-up water volume (M), evaporation volume (E), blow-down volume (B), and the concentration ratio (CR). Assume that drift, leaks, and other losses are a part of the blow-down value.

$$M = B + E$$
$$CR = M \div B$$

By substitution, $CR = (B + E) \div B$
Solve for B, $B = E \div (CR - 1)$

If you assume that evaporation is constant for a given set of conditions, then the following Figure III-2 illustrates the relationship between concentration ratio and total make-up water consumption.

Figure III-2
Cooling Tower Water Consumption vs. Concentration Ratio



Water quality management issues. The principal areas of concern with respect to the water circulating through the cooling tower are the prevention of scale, corrosion, and biological fouling. Effective control of these potential problems prevents system failure, maintains energy efficiency, and minimizes system maintenance.

- **Scale.** Scale is formed when minerals in the water precipitate and collect on the surfaces in contact with the water. The formation of scale is affected by pH, temperature, and mineral concentration. Scale acts as an insulator, thereby reducing the heat transfer efficiency of equipment. Scale can also become an obstruction in piping, resulting in increased pumping costs. Scale can be controlled by several methods including addition of scale inhibiting chemicals, control of pH, make-up water softening, and blow-down to reduce mineral concentrations.

- **Corrosion.** The most common causes of corrosion are acid, oxygen, galvanic action, and impingement. Aside from poorly controlled chemical feed systems, the primary source of acidity in cooling tower water is polluted air. Galvanic action can occur when dissimilar metals are in contact in the presence of water containing minerals (cooling tower water). Corrosion inhibiting chemicals can be added to the water to form protective films on the metal or otherwise stop corrosion.

- **Biofouling.** Biofouling is the result of algae, bacteria, and fungi growth. Biofouling causes plugging of tower water distribution systems, assists in scale and corrosion formation, decreases heat transfer efficiency, and rots wooden tower components. Biofouling can be controlled by a number of chemical treatments including oxidizing biocides such as chlorine.

State of Arizona Requirements. Water conservation requirements for cooling towers have been established by the Arizona Department of Water Resources for the Phoenix area since 1990. The Second Management Plan (1990 to 2000) affected all facilities defined as "new large cooling users," referring to industrial facilities whose aggregate cooling capacity exceeded 250 tons after the effective date of the plan. This plan required the affected facilities to achieve a minimum total dissolved solids concentration of 2,000 mg/l in their tower water before blow-down. In its Third Management Plan, for the period 2000 to 2010, the requirements affect all facilities whose aggregate cooling tower capacity exceeds 1,000 tons (regardless of start date of operation). These users are required by the ADWR to achieve either a total hardness concentration of 1,200 mg/l or a silica concentration of 120 mg/l in the tower water prior to blow-down (whichever occurs first). The facilities are also required to use non-groundwater for make-up water "where available and of suitable quality." Make-up and blow-down water volumes, as well as hardness and silica concentrations, must be measured and reported. These requirements may be waived if the facility reuses all of its blow-down water in a beneficial manner, such as landscape watering. These requirements mean that facilities have to manage their cooling towers more water-efficiently than is currently achieved by many cooling tower users in the Valley.

Managing Your Cooling Tower System

- ✓ Prepare an inventory of each cooling tower you have, its cooling capacity, and the equipment or processes that it serves. A Cooling Tower Water Survey Checklist is provided in Worksheet III-1 to record this information.

- ✓ You may be able to have a credit for evaporation deducted from your sewerage bill, if you properly meter your cooling tower's water losses as previously described and if your provider offers this credit. If you wish to receive this deduction, be sure to set up your metering program in accordance with your city's water services requirements.

  Note: If you are a permitted Significant Industrial User (SIU), evaporation credits are <u>not</u> an option.

- ✓ If you purchase chemicals for the treatment of the recirculating cooling tower water, have the chemical vendor explain the purpose and action of each chemical.

- ✓ Have your chemical vendor provide a written report of each service call, and be sure that the vendor explains the meaning of each analysis performed as well as the test results.

- ✓ Tell your chemical vendor that water conservation is a priority at your facility. Ask your vendor to tell you about alternative programs that could reduce the amount of water that is bled off from the towers. A performance contract for services is recommended.

Operation Modifications

- ✓ Improve the method of releasing the tower bleed-off. Most cooling towers are bled off automatically, when the conductivity of the water reaches a preset level. Try to operate the bleed-off on a more continuous basis, maintaining the conductivity of the tower closer to the limits, without wide fluctuations.

- ✓ Install flow submeters on the make-up and bleed-off lines. This practice enables the operator to verify the volume of water being used in the tower. Submeters should, at a minimum, be capable of totaling the flow. There are also submeters that display instantaneous flow. It is also important to read and record submeter data regularly. Submeters can be installed by your plumber and must meet AWWA specifications if you wish to obtain a deduction from your wastewater bill for evaporative losses (if this option is available to you). Worksheet III-2 presents a Cooling Tower Water Consumption Logsheet which you may use to record the submeter data and estimate the tower's concentration ratio.

- ✓ Use sulfuric acid treatment for adjustment of alkalinity. When added to recirculating water, sulfuric acid can improve water efficiency by reducing scale buildup created from mineral deposits. This makes it possible to operate the tower at a higher concentration ratio. Sulfuric acid lowers the pH of the water and is effective in converting a portion of the calcium bicarbonate, typically the primary cause of scale, to the more readily soluble calcium sulfate.

Sulfuric acid treatment, however, is not for installations where the additive may be vulnerable to vandalism, such as schools or prisons, and workers must be well trained in the handling and operation safety of this treatment. Contact your chemical vendor for further information.

✓ All water treatment, no matter what kind, must be strictly monitored and performed by qualified workers.

Retrofit Options

- If suspended materials are degrading the quality of your cooling tower water, use a sidestream filtration system composed of a rapid sand filter or a high-efficiency cartridge filter to cleanse the water. These systems draw water from the basin, filter out sediment, and return the filtered water to the tower, enabling the system to operate more efficiently with less water. This system is particularly effective where the water is cloudy, airborne contaminants are common, or cooling water passages are small and susceptible to clogging. Removing particles or suspended solids in the recirculating water enables the system to operate more efficiently and with less maintenance.

- Consider an ozonation system for biological control. An ozonation system consists of an air compressor, ozone generator, diffuser or contractor, and a control system. While it is a powerful oxidizing agent, ozone (a gas) has an effective life of less than an hour to a few minutes. Therefore, it must be generated at the site by passing cool, dry air (or pure oxygen gas) through a high voltage field between two electrodes (known as the corona discharge method).

A list of water management options for cooling towers, along with each option's advantages and disadvantages, are listed in Table III-1.

Evaporative Coolers

The function of evaporative coolers is to decrease the temperature of incoming air being drawn into a building by increasing its humidity. Most evaporative cooling equipment is used to cool air flow for space cooling. The air's ambient, or "dry bulb" temperature is lowered when the air absorbs water vapor. The saturation, "wet bulb", temperature remains constant. After a short period of operation, recirculating water in an evaporative cooler assumes the wet bulb temperature of the entering air. This temperature is theoretically the lowest temperature to which the entering air may be cooled.

Most evaporative coolers are equipped with recirculation pumps, and most coolers have a bleed-off to control concentrations of contaminants in the recirculating water and prevent damage to the cooler's pads. Water is used in some evaporative coolers in "single-pass" fashion. This is not good practice for two reasons. Water consumption is unnecessarily high, and the cooler does not cool as effectively because the water does not cool to the wet bulb temperature. Evaporative coolers usually do require either a small amount of bleed-off or cleaning to operate effectively. Worksheet III-3 presents an Evaporative Cooler Checklist to help you evaluate the condition and operation of your coolers.

- ✓ Replace the pads at the beginning of the season. Old pads will reduce the cooling efficiency and may thereby increase the water consumption.

- ✓ Be sure your coolers have pumps to recirculate the water through them.

- ✓ Check to make sure you are not bleeding off an excessive amount of water. For a typical small cooler, anything more than a few gallons per hour may be excessive.

- ✓ Pipe the bleed-off from your coolers to help water a landscaped area.

- ✓ Consider installation of thermostats to control the operation of coolers.

- ✓ Consider the use of chemical additives to allow the cooler to efficiently operate with reduced bleed-off volume.

Once-Through Cooling

Many facilities in Arizona have equipment cooled by a single-pass flow of water. After passing through and cooling the equipment, the water is discarded. This is prohibited by many city codes. Equipment that might be cooled by once-through water includes: ice-making machines, air conditioners, air compressors, degreasers, rectifiers, hydraulic equipment, x-ray machines, condensers, hydraulic presses, welders, and vacuum pumps. The ADWR prohibits the use of once-through cooling water by industrial users supplied by their own wells. The discharge of this uncontaminated water to the sanitary sewer may be prohibited by your city's municipal sewerage ordinance.

More efficient water use can be achieved through alternatives to single-pass cooling, including:

- ✓ Replace the existing water-cooled equipment with new air-cooled equipment.
- ✓ Remote air-cool the condenser fluid (applicable to air conditioners, ice machines, etc.).
- ✓ Connect the water cooled equipment to chilled water or cooling tower piping.
- ✓ Reuse the single-pass cooling water as make-up water for other process needs or for landscape irrigation.

Boilers/Steam Generators

Boilers and steam generators are commonly used in large heating systems, in cooling, or in facilities where large amounts of processed steam are used. This equipment consumes varying amounts of water depending on the size of the system and the amount of water that has not evaporated (called condensate return).

Maintenance Modifications

- ✓ Check steam traps and lines for leaks, which should be repaired as soon as possible. These are very costly energy-wasters as well as water-wasters.
- ✓ Provide proper insulation on piping and on the central storage tank.

Retrofit Options

- ✓ Install a condensate return system. By recycling condensate for reuse, water supply and operating costs for this equipment can be reduced up to 70 percent. A condensate return system also helps to lower energy costs since the condensate water is already hot.

3. LANDSCAPE WATER USES

Value of Landscaping

Landscaping provides many benefits to industrial, commercial, and institutional properties. These include enhanced aesthetics, shading and climate mitigation, pleasant outdoor spaces for employees and clientele, as well as greater property value.

More than half of the water provided by Valley cities is used outdoors to water lawns and landscape plants. For this reason, it is very important to plan and install landscapes carefully and to plan for proper maintenance. With good planning we can have beautiful, colorful landscapes that are water efficient and easy to maintain.

A good design will include desert-adapted plants that are thoughtfully placed for attractive and functional landscapes and ease of maintenance. The ADWR has established a list of recommended low-water-use plants, which is included in the appendix and is available on ADWR's website, http://water.az.gov/. The irrigation design should segregate the site into zones based on exposure, provide the most efficient types of irrigation system components for different plant needs, and include products that minimize water waste.

A well-planned, well-installed design will avoid future maintenance problems and expense. Watering costs alone can be cut by one-half to two-thirds by installing a Xeriscape instead of turf or other types of water-thirsty landscapes.

The term "Xeriscape" comes from the Greek word "xeros," meaning dry, but should not be confused with barren "zero-scapes." Xeriscape describes a philosophy that includes sound horticultural practices and a common-sense approach to landscaping. The following seven Xeriscape principles serve as guidelines to successful landscaping.

1. **Good landscape planning and design.** Selecting the right size and type of plant for the location, grouping plants with similar needs together, and creating attractive, functional areas will help ensure a long-lasting and enjoyable landscape.

2. **Appropriate turf areas.** Grass lawns should be placed where they can be used and enjoyed. Wall-to-wall turf is unnecessary. Small, irregular areas may be inefficient and hard to maintain. High-foot traffic areas may be better served with hardscape instead of turf.

3. **Efficient irrigation.** Good water management practices, along with an efficient system, help maintain a healthy landscape without wasting water.

4. **Soil improvements.** Some soil may need to be aerated or amended to improve water absorption and the water-holding capacity of the soil.

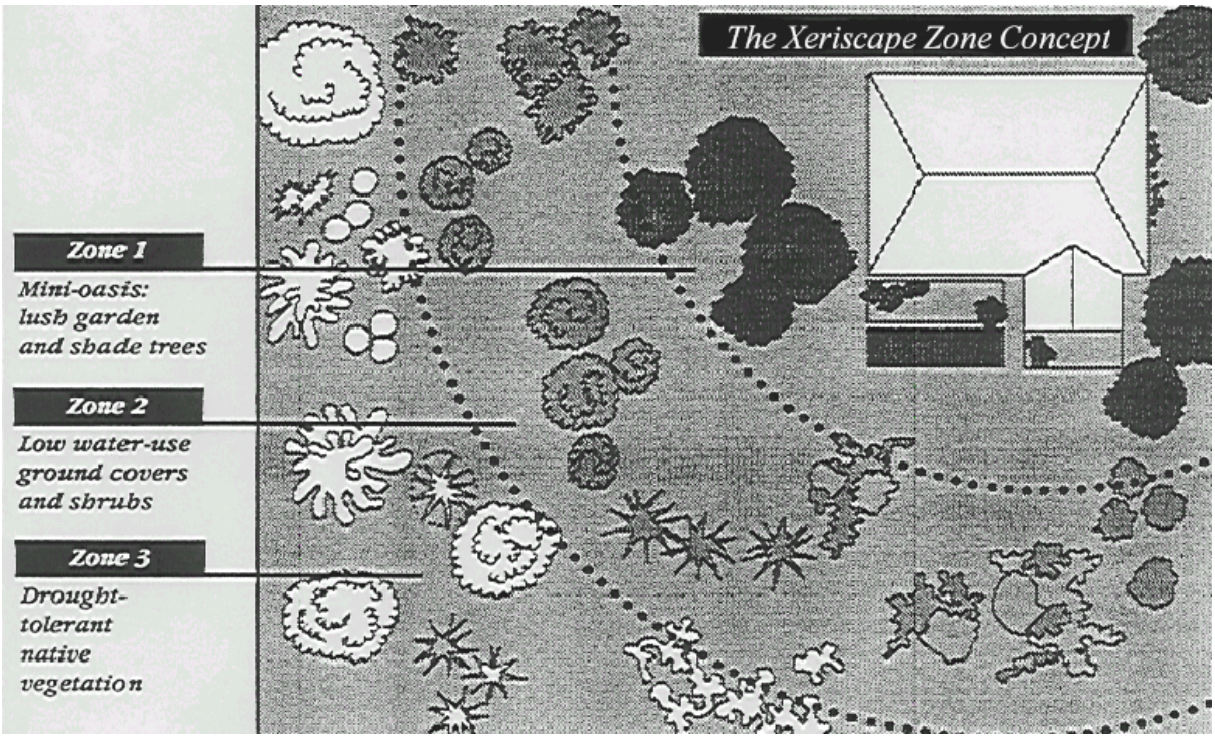
5. **Use of mulches.** Organic or inorganic mulches protect the soil from being baked in direct sun; help retain water; and control weeds, dust, and mud.

6. **Use of low-water-use plants.** The wide variety of plants available provide year-round color in many forms and functions. They can create almost any look and help reduce energy costs when placed for shade and insulation. Desert-adapted plants usually require less maintenance.

7. **Proper maintenance of plants and irrigation systems.** The natural look of many plants is enhanced with occasional pruning, fertilizing, weeding, and pest control. Proper maintenance means less waste going to the landfills; healthy, long-lasting landscapes; and protection of your investment. Checking your irrigation system regularly can prevent costly repairs.

Proper plant selection and placement reduces water use. Low-water-use, drought-tolerant plants can be used to create a variety of looks, from Sonoran to tropical, formal or casual. Many other groundcovers, flowers, shrubs, and grasses can be used instead of turf. Trees and shrubs in planters can provide shade, privacy screening, noise reduction, area definition, as well as attractive foliage, colorful flowers, and pleasant fragrances.

Low- and high-water use plants should not be planted together in the same area to avoid over-watering the low-water-use plants. High-water-use plants can be planted in low-lying areas or swales to intercept runoff from hardscape or pavement and decrease the need for supplemental watering. Group high-water-use plants together in a mini-oasis near the building for energy savings or in areas where they can be enjoyed up close, such as a courtyard. The lowest-water-using plants should be placed farthest away from the building in the arid zone. Desert-adapted trees are more tolerant of the harsh conditions of parking lots. The area in between the arid zone and the mini-oasis or turf area is called the transition zone. This zone has low- to moderate-water use plants that blend the lush areas with the more arid ones. For an example of the Xeriscape zone concept, see the following diagram.



Proper Landscape Water Management Saves Money

Potential financial impacts of landscape water management include water cost, maintenance cost, plant loss and replacement cost, and property value. Recent local studies show that many landscapes are over-watered by as much as 100%, while others are deficit watered. Over-watering encourages excessive growth, disease, and other maintenance problems. Other common problems are shallow watering or poorly applied water. Deep, periodic watering encourages strong, healthy root systems that can better tolerate periods of drought.

There are a number of ways to conserve water used for landscape irrigation. Proper irrigation system design, installation, and maintenance are important. Be sure to hire contractors who have experience and knowledge with water management. You may wish to hire a company to provide water management training to your current staff or contractors.

Irrigation systems should be designed to avoid unnecessary sprinklers and blockage of the spray stream by obstacles. Sprinklers should serve only the required turf areas and not spray on buildings or non-landscaped areas. Excess water on sidewalks and pavement causes damage, increases liability, and wastes water. The irrigation system should have a timer and/or moisture sensors to activate the system, and watering should be done before sunrise or after sunset to reduce evaporation losses. Turf areas, planters, trees, and shrubs should be watered separately to meet differing needs. The amount of solar exposure, wind, and soil types also affect irrigation needs. Take into consideration the surrounding plantings that may have overlapping watering schedules. Always irrigate the entire depth and width of the root zone regardless of the time of year. Once or twice a year, water twice as long to leach out salts that build up.

WATERING SCHEDULE GUIDELINES

Plant Type		Spring (Mar. - May)	Summer (May - Oct.)	Fall (Oct. - Dec.)	Winter (Dec. - Mar.)	Watering Depth
Trees	Desert-adapted	14-30 days	7-21 days	14-30 days	30-60 days	3-4 feet
	High-water-use	7-12 days	7-10 days	7-12 days	14-30 days	3-4 feet
Shrubs	Desert-adapted	14-30 days	7-21 days	14-30 days	30-45 days	2-3 feet
	High-water-use	7-10 days	5-7 days	7-10 days	10-14 days	2-3 feet
Groundcovers and Vines	Desert-adapted	14-30 days	7-21 days	14-30 days	21-45 days	1 foot
	High-water-use	7-10 days	2-5 days	7-10 days	10-14 days	1 foot
Cacti and Succulents		21-45 days	14-30 days	21-45 days	if needed	1 foot
Annuals		3-7 days	2-5 days	3-7 days	5-10 days	1 foot
Warm Season Grass		7-10 days	3-5 days	7-10 days	30 days	6-8 inches
Cool Season Grass		3-5 days	none	3-5 days	5-10 days	8-10 inches

Guidelines for established plants (2 years for shrubs, 5 years for trees). More water is required for new plantings, sandy soils, and extremely hot, dry weather. Water as deep as the root zone and 1 1/2 times the canopy width.

Proper system maintenance is essential to irrigation water conservation. Sprinkler heads should be inspected regularly; and damaged, worn, or broken heads should be replaced promptly. Sprinkler heads should be cleaned periodically to remove mineral deposits and maintain hydraulic efficiency. The system should be inspected for leaks in pipes, couplings, and faucets and should be repaired as necessary. All irrigation timing cycles should be adjusted monthly to meet varying seasonal demands. Large turf areas should be watered according to the evapotranspiration (ET) rate, which can be found in the weather section of your daily newspaper.

Proper Landscape Practices Checklist

- ✓ Adjust irrigation program frequency monthly. This requires effort and persistence, but results in healthier, more attractive landscapes and lower water bills.

- ✓ Automate landscape irrigation systems.

- ✓ Schedule irrigation for early morning or late evening.

- ✓ Water only as frequently as necessary. In the Phoenix area, turf should be watered no more than every third day in summer and less frequently in fall and spring. Dormant Bermuda grass needs no supplemental winter watering.

- ✓ Drip irrigation should run for two to three hours to provide deep watering. Frequency of operation should vary according to plant needs. Variables are based on temperature, solar exposure, rainfall, soil conditions, plant type and maturity, density of plantings, number and placement of emitters, and emitter application rate. Use the watering guide in your local newspaper or the watering recommendations using the ET rate found on the Internet at http://ag.arizona.edu/azmet.

- ✓ Segregate valves by plant needs and exposure. For example: water turf and seasonal flowers separately. Solar exposure is more significant to water needs than temperature. The north side of a building has the least sun exposure.

- ✓ Place enough drip emitters around the root zone (at the canopy edge) of trees to encourage roots to spread farther from the trunk.

- ✓ Add or move drip emitters as plants mature. Cap emitters if no longer needed.

- ✓ Install rain or moisture sensors to reduce scheduling requirements.

- ✓ Decrease or eliminate turf areas. Keep only those that are used for active recreation. Myoporum uses only $^{1}/_{10}$ the amount of water required for turf. Groundcovers reduce maintenance requirements, too.

- ✓ Landscape with drought-tolerant Xeriscape plants. A list of these plants is included in the Appendix.

- ✓ Use mulches, such as decomposed granite, around plants to help retain moisture.

- ✓ Keep turf at the proper height. Grass that is too short uses more water. Keep at ¾ to 1 inch for warm season grass, 1½ to 2 inches for cool season grass.

- ✓ Dethatch or aerate lawns annually to improve water infiltration.

- ✓ Remove weeds that compete with desired plants for water.

- ✓ Follow the principles of Xeriscape to ensure a long-lasting, water and energy efficient landscape.

- ✓ Only prune as needed. Heavily sheared spheres and cubes are less healthy and much more wasteful of resources than plants with a natural form.

- ✓ Keep your irrigation system running as efficiently as possible (see Irrigation System Tune-Up Checklist below).

Irrigation System Tune-Up Checklist

1. Identify Equipment

- ✓ Make an irrigation system map that shows the location of all water lines, sprinklers, bubblers, emitters, and valves.

2. Check for leaks

- ✓ Turn off all water and read the meter. After 15 minutes, read it again. If the meter hand has moved, you may have a leak inside or outside the building.
- ✓ Leaks outdoors can often be located by looking for overly green or muddy areas, but sometimes they are undetectable without special eqiupment.

3. Check Controllers

- ✓ Make sure that all valves are turning on. If the controller has a battery backup, check the charge on the battery.
- ✓ Replace electro-mechanical clocks with electronic models, which are much more accurate and allow more flexible watering schedules.
- ✓ Make a list of where all of the stations water. Place the list in the controller box.

4. Irrigation System

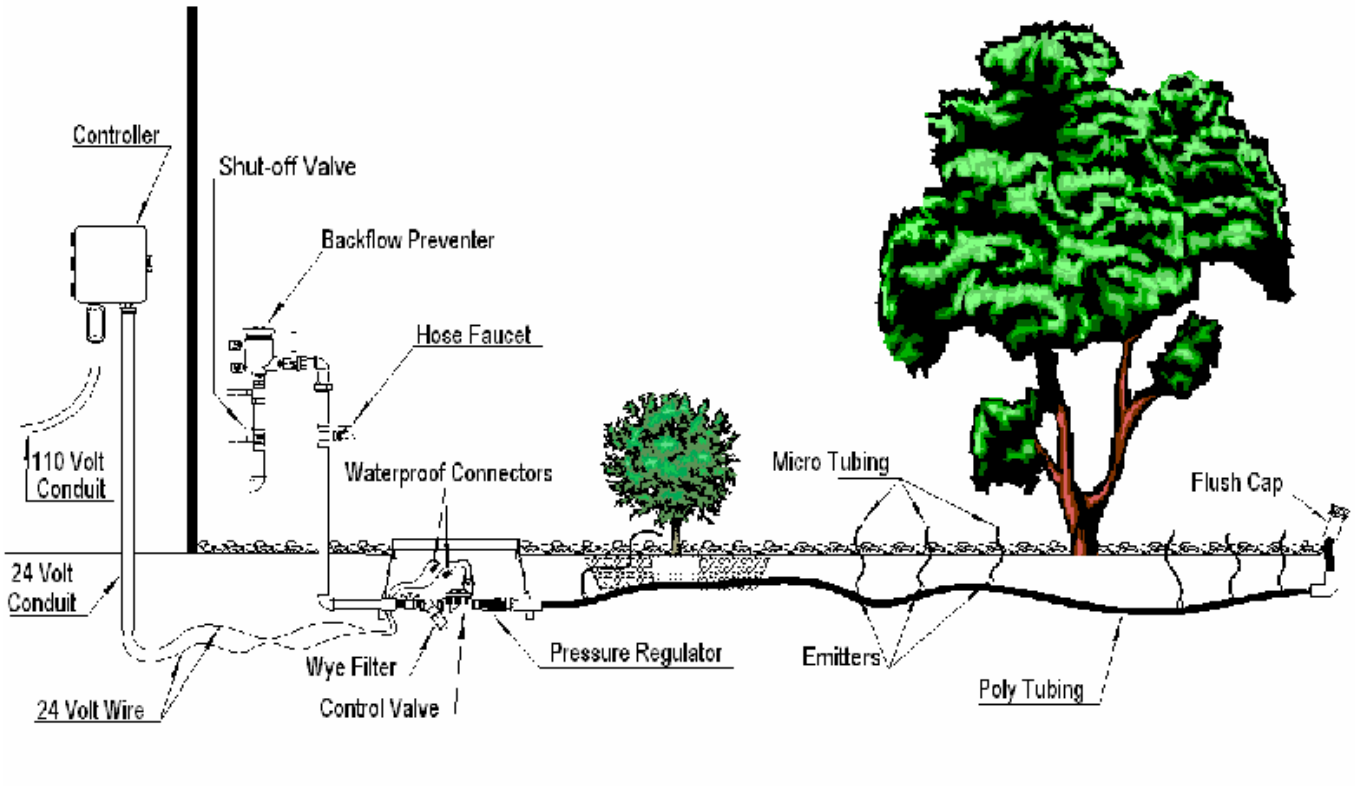
- ✓ Repair or replace broken or missing sprinkler heads, bubblers, and drip emitters.
- ✓ Check seals between the neck and base of the sprinkler heads. Water will squirt out of the base if worn. Make sure all heads pop up all the way and fully retract when water is turned off.
- ✓ Check for sprinkler spray blocked by weeds or grass. If the spray is blocked, lower the mowing height or raise the sprinkler level.

- ✓ Make sure sprinklers are vertical and flush with soil grade. Soil should be tightly compacted around the sprinklers.
- ✓ Check for low system pressure. Water will stream out of the sprinkler instead of forming a spray. Consult an irrigation supplier for advice.
- ✓ Clean or replace clogged nozzles. Clean the sprinkler's trash screen, if it has one.
- ✓ Check the rotation and direction of spray. Adjust the radius and arc to avoid spraying sidewalks and buildings.

5. Irrigation Scheduling

- ✓ Water at night or in the early morning. Between 2 a.m. and 6 a.m. is best.
- ✓ Do not water turf more than once every three days. Sandy soils and hybrid (Tiff) Bermuda grass may need to be watered more often.
- ✓ If water runoff is a problem, irrigate two or three times per night at $^1/_2$ to $^1/_3$ the normal watering times, respectively. Wait an hour between waterings.
- ✓ Change the watering schedule about once a month according to prevailing conditions. Use ET as a guide.

The following schematic shows the basic components and general layout of a drip irrigation system. Backflow prevention devices must be installed in compliance with local ordinances.



Components of a Drip Irrigation System
(Not to scale)

Proper Maintenance Protects Landscape Investment

Good maintenance practices will help increase property value and attract clientel. Poor maintenance practices detract from the building's appearance and become costly to repair.

If a tree is pruned improperly, or staked so long that the bark has grown around the support wires, you can probably consider the tree a loss. Remember the investment you have in that tree: the initial cost of the tree, planting cost, watering cost, and any other maintenance time. With a chainsaw, a landscaper without the proper pruning knowledge can destroy a tree in minutes. A tree that has been topped often becomes a liability, as well as an eyesore. Proper pruning is done for three reasons: the health of the plant, safety, and aesthetics. Excessive pruning increases water needs, contributes to landfill waste, is hard on the plant, and is costly in terms of maintenance. With proper plant selection (the right plant for the right place), much of the need for pruning can be eliminated. Many plants have attractive natural forms that need little or no pruning.

Turf should be kept to the proper height: ¾ to 1 inch for warm season grasses such as Bermuda, and 1½ to 2 inches for cool season grasses such as rye. Dethatching turf annually in April or October increases aeration and water infiltration, which leads to healthier turf and decreased water consumption. Drought resistance is assisted by decreasing nitrogen fertilizers and increasing potassium levels. Weeds should be removed regularly so they don't compete with desired plants for water and nutrients.

Landscape maintenance can be one of the most difficult areas to manage on your property, especially if you are unfamiliar with proper maintenance techniques. Like many other services that are contracted out, it is important to hire a company that employs highly trained, skilled individuals.

When choosing a landscape or lawn care contractor, there are many important questions to consider. The checklist below will help guide you in selecting a contractor.

Contractor Selection Checklist

- ✓ **References:** Call them and look at quality and condition of projects.
- ✓ **Education:** Owner or crew supervisor should have some training. There are several local training and certification programs. See the following list.
- ✓ **Licensed and Bonded:** Check registrar of contractors for status and type of license.
- ✓ **Customer Service:** Do they return phone calls promptly? Are they friendly and courteous? Is someone available at all times? Will they provide records or plan-of-work reports tailored to your project? Are they willing to have meetings or inspections with you?
- ✓ **Water Management Philosophy:** Do they practice seasonal scheduling and watering to promote deep roots? Can they develop water budgets?

- ✓ **Irrigation System Maintenance:** What is their frequency of inspection and how do they handle repairs?

- ✓ **Pruning Philosophy:** Have they had special training in pruning? Do they believe in minimal or heavy pruning? Do they prefer natural or formal pruning? If plants require pruning constantly because of location, would they prefer to replace them with something more appropriate? Do they have knowledge of plant material and understand its natural form? Is equipment sharp, in good condition, and appropriate for the job?

- ✓ **Weed and Pest Control Philosophy:** Do they have an Arizona Structural Pest Control Certification Card? What is their philosophy on weed control in turf and/or in desert landscape areas?

- ✓ **Fertilizer Regime:** How often do they recommend fertilizing desert plants and/or tropical plants? How often for turf?

- ✓ **Turf Management Philosophy:** At what height do they cut the grass? How often do they dethatch and aerate the soil? What is their over-seeding philosophy?

Titles or Certifications in the Landscape Industry

The list below includes a description of titles or certifications that are common in the landscape industry. Don't hesitate to ask your landscape contractor about his or her training and level of expertise. Anyone who has had the training will be proud to show you his or her credentials.

Arizona Certified Landscape Professional: A landscaper who has received certification by the Arizona Landscape Contractors Association. Testing required.

Certified Arborist: An arborist who has received certification by the International Society of Arboriculture. An exam on tree identification and care is required. Thirty hours of continuing education is required every three years.

Certified Landscape Irrigation Auditor, Contractor, Designer or Manager: An irrigation specialist who has received certification by The Irrigation Association. The four certifications listed above represent different levels of certification. A Landscape Irrigation Auditor is at the beginning level, and an Irrigation Manager is the advanced level.

Certified Tree Worker: A tree worker trained to prune and climb properly and certified by the International Society of Arboriculture. Requires an oral test on tree care and practical exam covering climbing skills. Requires eighteen (18) months of experience. Continuing education is required.

Consulting Arborist: No license or certification is required. Typically it is a person who offers advice on tree selection and care.

Desert Landscaper Certification: A program administered by the Desert Botanical Garden consisting of thirty (30) workshops over a ten (10) month period that include basic training, hands on experience, and a final comprehensive landscaping project.

Horticulturist: Anyone with a two-year, four-year or advanced degree in horticulture.

Landscape Contractor: The Arizona Landscape Contractors Association certifies a landscape installation and maintenance contractor. Testing and insurance are required.

Master Gardener: A volunteer who has gone through sixteen (16) weeks of specialized horticultural training from the University of Arizona Cooperative Extension.

Pesticide Applicator Certification: A pesticide applicator who has been tested and certified by the Arizona Structural Pest Control Commission. Anyone spraying chemicals on commercial property must have this certification.

***Smartscape* Certified:** *Smartscape* is a training program for nursery and landscape professionals designed to encourage consistent horticultural practices compatible with the Sonoran Desert. Participants must complete a series of eight (8) two-and-a-half (2½) hour workshops.

If you oversee a landscape maintenance contractor, and especially if you are responsible for the landscape maintenance directly, it is advisable to get some basic landscape maintenance training. The Arizona Municipal Water Users Association offers a four-week landscape program two times a year called *Smartscape*. Call (602) 248-8482 for more information.

The Irrigation/Pruning Connection

Irrigation affects pruning and vice versa. When landscape plants are given excessive water, they grow much more rapidly. More plant growth means more pruning, increasing maintenance time and expense. This is a good example of why water management is one of the most important components of your maintenance program. Not only can water management save a great deal of money on water budgets, but it also saves on maintenance, overall plant health, and landscape longevity.

Pruning can also affect how much water landscape plants use. Poor pruning removes shade protection on the branches, trunks, and roots. It also removes leaves, buds, and stored energy, which are needed for healthy growth. Removing too many branches also increases susceptibility to pests, slows growth, undermines health, and stimulates excessive sprouting. Plant stress, higher temperature, open wounds, and excessive sprouting can cause a plant to require more water than normal.

Tree Pruning

Pruning is both a skill and an art. The skill is in making cuts that heal and callus properly and minimize the chance for decay. The art is in making cuts in the right places so that the plant takes on an attractive, natural form.

Reasons for Pruning

- To remove dead, weakened, diseased or insect-damaged branches.
- To improve safety by eliminating hazards such as branches in walkways or paths.
- To remove crowded or crossing limbs.
- To direct growth of the tree.
- To improve stability by reducing wind resistance.

Trees allowed to grow to their natural form and with the most of their lower branches intact are stronger and less likely to be wind damaged. Some thinning of top-heavy trees may be necessary. Pruning should rarely drastically change the height or shape of the plant but should enhance its natural form and character.

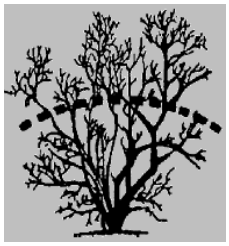
For The Healthiest Trees

- Do not top trees.
- Do not remove tree branches unless necessary.
- Always cut back to a branch; do not tip back.
- Leave lower branches on as long as possible.
- Tree workers should be highly skilled.

DO NOT TOP TREES

Shrub Pruning

Shrubs and ground covers used in landscapes should be permitted to grow and develop into their natural shapes. They may require pruning periodically to control size, remove die-back or for rejuvenation. Designing and selecting a plant with the mature size in mind reduces the need for frequent or heavy pruning. You can prune shrubs to stay within limited bounds without shearing into contrived shapes that increase maintenance costs and shorten the life of the plant.
"Remember that pruning is a dwarfing process because it removes food producing leaves. Pruning is also a wounding process, allowing dessication of the plant and openings to insects and disease."



DO NOT SHEAR BACK SHRUBS

- Do not shear back shrubs.
- Do not cut back cold-damaged branches until new growth emerges.
- Use thinning cuts to reduce size.
- Remove shrubs that are too big for the area and replace with more appropriate plants.

Make sure that your landscape maintenance contractor is knowledgeable about pruning. You may want to consider hiring a Certified Arborist under a separate contract for your tree care.

For further information on Xeriscape, appropriate plant materials, proper irrigation, and water management, contact your city water conservation office or read some of the publications listed below. The "Low Water Using Plant List" for the Phoenix Active Management Area is in the Appendix. Updated versions and an extensive bibliography are available from the Arizona Department of Water Resources and on its website, http://water.az.gov/.

RECOMMENDED READING LIST FOR WATER-CONSERVING LANDSCAPES

Arizona Municipal Water Users Association (AMWUA). **Converting to Xeriscape: Renovate Your Landscape with Style**. Phoenix, AZ: AMWUA. 1997. 16 pp.

AMWUA. Xeriscape Gardens: Plants for the Desert Southwest. Phoenix, AZ: AMWUA. 1998. 32 pp.

AMWUA. **Xeriscape: A New Look for Arizona Gardens**. Phoenix, AZ: AMWUA. 1997. 16 pp.

AMWUA. **Visions of Xeriscape**. Phoenix, AZ: AMWUA. 1997. 24 pp.

Brookbank, George. **Desert Landscaping.** Tucson, AZ: University of Arizona Press. 1992. 253 pp.

Duffield, M. and Warren D. Jones. **Plants for Dry Climates**. 2nd Edition. Tucson, AZ: H.P. Books. 1992. 192 pp.

Johnson, Eric A. **Pruning, Planting and Care**. Tucson, AZ: Ironwood Press. 1997. 160 pp.

Johnson, Eric A. and Scott Millard. **The Low-Water Flower Gardener**. Tucson, AZ: Ironwood Press. 1993. 144 pp.

McPherson, E. Gregory and Charles Sacamano. **Southwestern Landscaping that Saves Energy and Water**. Tucson, AZ: College of Agriculture, University of Arizona. 1989. 64 pp.

McPherson, E. Gregory and Gary C. Woodard. "Cooling the Urban Heat Island with Water-and-Energy Efficient Landscapes" in **Arizona Review**. Tucson, AZ: College of Business and Public Administration, University of Arizona. Spring 1990.

Mielke, Judy. **Native Plants for Southwestern Landscapes**. Austin, TX: University of Texas Press. 1993. 310 pp.

Miller, George 0. **Landscaping with Native Plants of Texas and the Southwest**. Stillwater, MN: Voyageur Press. 1991. 128 pp.

Perry, Robert. **Landscape Plants for Western Regions**. Claremont, CA: Land Design Publishing Co. 1992. 318 pp.

Perry, Robert. **Trees and Shrubs for Dry California Landscapes**. San Dimas, CA: Land Design Publishing Co. 1981. 180 pp.
Phillips, Judith. **Southwestern Landscaping with Native Plants**. Santa Fe, NM: Museum of New Mexico Press. 1987. 140 pp.

Shuler, Carol. **Low Water Use Plants for California and the Southwest**. Tucson, AZ: Fisher Books. 1993. 138 pp.

Sunset Magazine and Books. **Waterwise Gardening**. Menlo Park, CA: Lane Publishing. 1989. 96 pp.

Sunset Magazine and Books. **Sunset Western Garden Book**. 6th Edition. Menlo Park, CA: Lane Publishing Co. 1995. 624 pp.

Sunset Magazine and Books. **Sunset Western Landscaping**. Menlo Park, CA: Sunset Books, Inc. 1997. 416 pp.

Walters, J.E. and Balbir Backhaus. **Shade and Color with Water Conserving Plants**. Portland, OR:

3. KITCHEN AND CAFETERIA WATER USES

Many facilities have kitchens and cafeterias. Most of these kitchens are equipped with dishwashing machines, garbage disposers, and ice makers. These typically are the major water-using items in kitchens.

Dishwashers

Commercial spray-type dishwashers are designed to clean dishes, flatware, and glassware by washing with detergent and water and to sanitize the dishes by the application of hot water or chemical solutions. There are several types of commercial dishwashers for different volumes of dishes and utensils to be cleaned. In a stationary rack machine, dishes are loaded into a rack that fits inside the machine; complete wash and rinse cycles average from 1 to 3 minutes. In a conveyor-type machine, dishes are loaded onto a conveyor belt that travels through the machine. The final dishwashing rinse is accomplished with either hot fresh water or with a chemical sanitizing agent that is mixed with water. Dishwashing machines that use chemical sanitizing agents for the final rinse use approximately the same amount of water as machines using only hot water for the final rinse.

Water Use Requirements. Minimum wash and rinse requirements for dishwashers are established by the National Sanitation Foundation (NSF). Typical water use requirements are 4.5 to 6.0 gallons per cycle of wash and rinse for stationary rack machines using water for the final rinse and 2 to 6 gallons per cycle for conveyor-type machines. Commercial dishwashing machines typically reuse the final rinse water in wash steps for the succeeding racks of dishes.

Water Conservation Opportunities. The way in which a dishwasher is operated affects its water efficiency. Higher efficiency can be achieved by operating the equipment properly, washing full loads, and limiting water flow rates to those specified by the manufacturer. Pressure and flow regulators are available to maintain the desired flow during periods of high water supply pressure.

- ✓ Check your dishwasher to be sure that it is not using an excessive flow of water. Experiment with a modest reduction (about ten percent) in the flow rate of water to your dishwasher to see if any problems result. If no problems occur, continue to operate at the reduced flow rate. Consult with the equipment manufacturer or your service contractor before making major changes.

- ✓ Reuse wastewater from your dishwasher for a low-grade purpose such as prewashing and garbage disposers. Final rinse water may be reused in the following wash cycle.

- ✓ Be sure that the flow of water through the dishwasher stops when the flow of items being washed stops. Conveyor-type dishwashers should be equipped with an automatic shutdown device to deactivate the rinse water when dishes are not passing through the system.

- ✓ Reduce or eliminate the amount of fresh water used for prewashing before the dishwasher.

Garbage Disposers

Commercial garbage disposers grind solid wastes into small particles so that they can be disposed of and conveyed through a sewer system. The ground garbage is passed into a mixing chamber where it is mixed with water for disposal. In larger systems, the garbage disposer is often preceded by a scrapping and preflushing system that uses water to carry garbage to the disposer. For some larger systems, a conveyor can be used instead of a scrapper to transport waste to the disposer using less water.

Water Use. Typical water consumption rates for various garbage disposers and disposers combined with scrapers or conveyors equipment are as follows:

Equipment	Typical flow rate, gallons per minute (gpm)
Disposer	4 to 8
Scrapper/disposer	7
Conveyor/disposer	10

Water Conservation Opportunities. Because it is not necessary to dispose of food wastes to a sewer, the use of garbage disposers could be eliminated entirely. In fact, some facilities do not use garbage disposers because they frequently require repair or replacement. Consider eliminating garbage disposers and disposing of wastes by other means.

Garbage Strainers. One method of eliminating garbage disposers is installation of a garbage strainer. A strainer-type waste collector passes a recirculating stream of water over food waste held in a basket, reducing the waste volume by as much as 40 percent by washing soluble materials and small particles to the sewer. The holding basket is periodically emptied. The water consumption rate for these units is approximately 2 gpm, considerably less than the 5 to 8 gpm requirement of garbage disposers. This water could be provided by wastewater from the dishwasher, eliminating any additional fresh water consumption by the strainer.

If use of the disposer is deemed necessary, there are still opportunities for conservation.

- ✓ Use wastewater from other kitchen operations (such as the dishwasher) for garbage disposer and trash trough flushing.

- ✓ Be sure that the flow of water through the garbage disposer stops when the disposer motor stops.

- ✓ Many disposers have two water supply lines, one to the bowl and one to the grinding chamber. Be sure to check both.

- ✓ Experiment by gradually reducing the flow rate of water through the disposer. If no problems arise, continue to operate at the reduced flow rate.

Ice-Making Machines

Ice-Making Equipment. Ice-making equipment can be divided into two different groups: ice cube machines and ice flake machines. The methods used to produce ice cubes and flaked ice are different. Descriptions of the machines and their use of water are presented below.

Ice Cube Machines. Ice cube making usually is a batch process. The goal of ice cube machines is to produce clear ice cubes. Cloudy ice cubes can be caused by minerals or other substances frozen in the ice. Most ice cube machines are designed to wash the frozen surface of the cube as it forms. The dissolved contaminants are more soluble in the slightly warmer run-off water (which does not freeze) and are therefore carried off by the run-off water. The frozen water in cube ice, therefore, typically is purer than the source water.

Ice Flake Machines. Flake ice production is a continuous process, operated with less concern for the quality of the ice. The flakes are thin, randomly shaped, and mostly white or cloudy. Flake ice is typically produced on a rotating evaporation drum. Ice is broken off the drum by an ice cutter and scraped to produce the flakes.

Uses of Water. There are uses of water in ice-making machines other than the water that is frozen as ice. As noted above, in cube ice makers, where the frozen water quality is important, a continuous water bleed-off is used to remove dissolved contaminants. In batch processes, a batch dump may be used instead. According to information from manufacturers of cube ice-making equipment, approximately 20 to 25 gallons of water is required to produce 100 pounds of clear ice cubes. Because 100 pounds of ice is equal to approximately 12 gallons of water, it is evident that approximately half of the water used to produce ice is not frozen, but is drained from the ice cube maker. There also is wide variation in the amount of water required for ice production because of the different ways that cube ice can be made. Some manufacturers require up to 90 gallons of water to produce 100 pounds of cube ice.

Water is also used by some ice makers to cool the refrigeration condenser. Other condenser cooling options are air cooling, cooling by the plant's chilled water system, or remote air-cooled condensers. Water-cooled ice makers are popular because they are less expensive than remote-cooled units and do not generate heat in the kitchen, as air-cooled units do.

Water-cooled ice makers also generally use slightly less electricity than the other two types. Most water-cooled ice makers do not recirculate the cooling water. For typical ice makers, ranging in capacity from 400 to 1,200 pounds of ice per day, approximately 130 to 180 gallons of cooling water is required per 100 pounds of ice produced.

Water Conservation Opportunities. There are two sources of water consumption for ice makers: the ice-making process itself and the cooling of the refrigerant condenser (for water-cooled models).

- **Ice-Making Water.** Conservation potential for water used in ice making depends on the bleed rate. Ice makers that produce ice flakes generally use the potable water source with no bleed-off. Ice cube makers have a large variation in the amount of water bled off per unit of ice

produced. Some units recirculate the water until it is frozen, with a set bleed rate. Other units use once-through water flow. Pretreatment of the ice-making water to remove hardness could be used as a way to reduce water consumption without sacrificing the quality of the ice.

- **Condenser Water.** Most water-cooled ice makers use cooling water on a once-through basis. Possible conservation technologies and practices for once-through cooling water are discussed in the once-through cooling section of this report. Another water-conserving option is replacement of water-cooled units with air-cooled ones. These units require slightly more electricity for operation and do not produce as much ice as water-cooled units. Requiring the installation of only air-cooled ice makers in new facilities is technologically and economically feasible. Under some conditions, ice makers often have a useful life of only about five years. This implies that replacement of existing water-cooled ice makers with air-cooled models is also feasible and could be done when the water-cooled units require replacement.

  Eliminate the use of once-through ("single-pass") cooling of ice-making machines. Consider replacing water-cooled units with air-cooled models, or supply cooling water for the ice maker from the plant's recirculating chilled water system. Otherwise, reuse the cooling water for some other purpose, such as landscape watering.

Other Kitchen Uses

Additional kitchen water uses can include food preparation, thawing frozen food, rinsing vegetables, steam tables, and leaking faucets.

- ✓ Repair leaks in steam, hot water, and cold water lines.

- ✓ Do not thaw frozen foods with a running stream of water unless absolutely necessary; plan ahead and thaw in a refrigerator. If water-thawing is necessary, a running stream of water should be used for health reasons, but use a slow flow.

4. LAUNDRY WATER USES

Some facilities operate large laundry operations for linens, uniforms, and other washable items. Water conservation for laundries can involve simple options using existing equipment or more sophisticated approaches requiring new or additional equipment. The easiest, operational-oriented conservation approach is to consistently load the washing equipment to its maximum capacity.

Water reclamation equipment may be added and used in conjunction with existing equipment. Although water reclamation equipment is now commercially available for laundries, most laundries in Arizona have not installed it. If new or replacement washing equipment is to be purchased, the equipment now available is more water-efficient than those used in the past.

Reuse Systems. Some existing laundry equipment can be set up to recycle water used in the rinse cycle into water used in subsequent wash cycles. This requires the installation of a holding tank for the rinse water. Ideally, the washing machine will have two separate drain ports; one for draining the wash water to the sewer, and one for draining the rinse water to the holding tank. Likewise, two supply ports may be used to separate the freshwater and recycle water supply. Some machines will already be equipped with the additional piping required for this approach. However, a machine that does not already have this built-in capability may be retrofitted with actuated valves on the supply and drain piping.

Reclamation Systems. Several different systems have been developed to reclaim wastewater from commercial laundries. These systems can be cost-effective due to savings in water, laundry chemicals, energy for heating, and sewerage fees.

One system specifically designed to require little maintenance consists of a mixed media filter containing plastic beads, anthracite coal, and silica; an activated carbon column; and an ion exchange unit. The ion exchange unit requires frequent regeneration and the activated carbon must be replaced monthly. The system provides approximately 75 percent reuse and is available as a packaged unit.

Another reclamation system uses settling, high-rate ultrafiltration, and fixed bed carbon adsorption processes. Pretreatment with hydrated lime in dry powder form is used to assist the ultrafiltration treatment.

Additionally, a commercially available package treatment system claims savings in water costs of 70 percent; in water heating, 50 percent; in softening chemicals, 70 percent; and in alkali-chemicals, 35 percent. The system is patented and includes dissolved air flotation (DAF), flow equalization, filtration (macro and micro), and flocculation.

These systems can include one or more of various treatment processes including filters, ion exchange, settling tanks, ultrafiltration, and dissolved air flotation.

Continuous-batch Washers. The continuous-batch washer, or "tunnel" washer, has been in use for a number of years in Europe and is now being installed in many large U.S. laundries. The conventional washer-extractor found at most laundries has a chamber which is filled and emptied

each time a new step in the wash cycle begins. In contrast, a continuous-batch washer has one or more modules for each process step and the laundry items pass automatically from one module to the next. Significant water conservation is achieved by these tunnel washers due to the use of counter-current flows. Properly operated installations can save 60 to 70 percent of the volume of water and steam required by washer-extractors. Additional benefits include energy savings due to recovery of heat from the laundry itself during the rinse cycles, savings in labor costs because the process is automated, and reduced maintenance costs. Chemical usage can also be reduced in some cases. Disadvantages of continuous-batch machines include the need to carefully schedule loads to minimize the need for resetting of equipment controls.

Additional Water-Conserving Ideas for Laundry Water Users

- ✓ Be sure to launder full loads only.
- ✓ Work with your laundry chemical supplier to reduce water consumption. Inform your chemical supplier that water conservation is a priority in your laundry operations.
- ✓ Consider recycling rinse water for use in wash cycle.
- ✓ Investigate laundry water reclamation systems for applicability to your facility.
- ✓ Consider the use of continuous-batch washers for new laundries or major expansions of existing laundry operations.

5. X-RAY AND PHOTO PROCESSING

Many facilities utilize X-ray or photo processing equipment. Processing is done using automated equipment. Water-conserving technologies related to X-ray processing have been researched and developed due in part to regulatory requirements pertaining to silver in wastewater discharges. Water savings may be realized through modifications in operation and equipment and use of reclamation and recovery systems.

X-ray processing is a series of complex chemical transformations. In general, these processes must develop, stop, fix, harden, wash, bleach and dry the film. Some of these steps are repeated, omitted, or combined in the various specific types of processing that are performed. Automatic processing equipment contains tanks and dryers that operate in series to provide the necessary process steps. A transport system is responsible for moving the film from one tank to the next.

Most modern automatic processing equipment has solenoid valves that open to feed water for wash purposes only when film is being processed. This is a water-saving feature, but these valves must be properly maintained to perform as designed. Regulating valves are also available to limit the flow rate of the wash water to a set quantity. The most advanced machines offer automatic control of flows, chemicals and other process variables that are adjusted as the equipment monitors the product passing through the processing sequence. This type of control may provide the highest quality product for the least water consumption.

Proper Operation. The first step for water conservation in X-ray processing operations is to ensure that the facilities and equipment in place are being operated as water-efficiently as possible. Many hospitals have the flow rates through X-ray film processors set higher than necessary. In many cases, a flow rate of 2 gallons per minute (gpm) or less is sufficient for effective processing, but the actual rates being used are 3 to 4 gpm or even higher. This can be corrected by simply adjusting a valve to reduce the flow rate to the minimum rate that still provides for quality processing results. One approach to this would be to install an inexpensive flow rate meter on the water line feeding each processor. This would enable staff to verify that the appropriate flow rate of rinse water is being received by the processor.

Squeegees. One water-saving feature available is the squeegee. This device physically removes the liquid from the product surface as it travels from one tank to the next. This serves to reduce carryover of processing solutions and thus washwater requirements. The degree of carryover reduction depends on squeegee type, product area, and the speed with which the product travels through the machine. Carryover reduction due to squeegee typically ranges up to 95 percent.

Worksheet III-1

COOLING TOWER WATER SURVEY CHECKLIST								
Tower Number	**Serving**	**Capacity**	**Manufacturer and Model #**	**Type**	**Average Make-up Water (gpm/day)**	**Type of Chemical Treatment**	**Current pH level**	**Comments (leaks, valve problems, etc.)**

gpm = gallons per minute

Worksheet III-2

COOLING TOWER WATER CONSUMPTION LOGSHEET							
Tower_____				Location_____			
		Make-up Water		**Bleed-off Water**			
Date	Cooling Load (tons)	Meter Reading	Consumption M[1]	Meter Reading	Consumption B[1]	Evaporation E = M – B	Concentration Ratio M/B

[1] Equals current meter reading minus previous meter reading

Worksheet III-3

EVAPORATIVE COOLER CHECKLIST

TYPE OF COOLER:

Drip Cooler
Rotary Drum
Air Washer
Two-Stage

CONDITION OF COOLER PARTS:

PART:	GOOD	FAIR	REPLACE
Fan			
Motor			
Pads			
Emitters and Piping			
Recirculation Pump			
Water Make-up Valve			
Collector Pan			
Reservoir Level Control			

_____ **Bleed-off valve checked for excessive water loss**

_____ **Pan checked for corrosion and leakage**

_____ **Check for torn pads**

_____ **Check recirculation pump, reservoir level control, emitters, and piping for proper operation**

FACILITY MANAGER'S GUIDE TO WATER MANAGEMENT

SECTION IV: EMPLOYEE PARTICIPATION

ESTABLISH THE WATER MANAGEMENT TEAM

With the support of management, employee participation can begin with the formation of a team committed to carrying out the investigation and implementation of the water management plan.

The assignment of responsibilities for plan implementation should include the establishment of a water conservation committee headed by a responsible leader or, in smaller facilities, one employee who should be assigned to develop and implement the plan with full support of management. If you have a larger facility, the first step is to assemble a team of professionals and identify their functions. Your team may consist of a combination of the following:

- Representatives from your facility's management
- The director of the physical plant or the chief operating engineer
- A representative from the maintenance department
- Representatives of departments known to use significant volumes of water
- Design or water management consultants
- Qualified contractors who specialize in plumbing and mechanical, landscape, or other water management fields

If possible, get a representative from your water utility involved in the survey. Generate a written list of team participants, describe their responsibilities, and, if applicable, due dates for performing their assigned tasks.

FACILITY-WIDE PARTICIPATION

The importance of employee awareness and cooperation to the program cannot be overstated. The first three steps of water efficiency planning (Commitment of Management, Understanding Your Water System, and Developing a Conservation Plan) will be unworkable without the willing participation of employees. There are a number of ways in which a company can communicate its water conservation plan, including employee awareness programs such as environmental fairs, suggestion awards, annual resource conservation recognition, distribution of water-saving fixtures for the home, workshops on home landscaping, and sharing cost information on facility utility bills with employees.

PROGRAM KICK-OFFS

- Start the awareness program by sending a letter to all employees from the head of the company (CEO, president, owner, etc.) discussing the policy statement, discussing goals if available at that time, and giving full support to the water conservation plan. A sample letter is provided on the following page.

- Promote a suggestion and incentive system and recognize people who have water saving ideas. A suggestion program that rewards employees with a percentage of the first year's direct savings has proven to be a very successful motivational vehicle.

- Promote slogan and poster contests.

- Once your plan has shown significant water savings, publicize your success. Print an article in your company or community newsletter. Include the results in the corporate annual report. Develop a full-flight public relations program. Interview with local radio or TV stations or newspapers about your water conservation efforts. A sample press release is provided.

SAMPLE LETTER FOR PROGRAM AWARENESS

Dear Employee:

Water resource management is one of the most important issues facing the Valley of the Sun. In our desert environment, it is critical that we balance our water equation carefully to make sure that the water supply will meet our immediate and future demands. Water conservation is an essential component of the water management effort.

Those of us who have lived in the Valley for any length of time know that periods of low precipitation are inevitable. No one can predict when those dry years will occur. Nor can they predict whether a water shortage will result. We can be prepared for times of drought or other types of water shortages by learning not to waste the water we have, thereby minimizing the effects of any future shortage by integrating water conservation into our daily lives.

There are other very good reasons for a business like ours to conserve water: decreases in water consumption, decreases in water and sewer costs, reductions in the energy needed to heat the water, and reductions in water pretreatment costs.

In the Phoenix metropolitan area, 30 percent of the water is used by industrial and commercial customers. This translates into 44.6 trillion gallons of water each year. A 10 percent reduction in annual commercial and industrial water use would provide more than 137,000 families with water for one year.

I am confident that small changes in our business routine will increase the effectiveness of our water management plan without jeopardizing efficiency or productivity. I encourage you to work with your team leader, division head, or shift leader to identify water saving opportunities in your work area.

Over the next several months you will hear many suggestions for saving water at home and at work. Follow those water saving suggestions most appropriate for your area. Since you will probably have some very good ways of your own to save water, feel free to share them with the management.

Working together, we can make every drop count.

SAMPLE PRESS RELEASE

PRESS RELEASE

For Immediate Release

Date: **May 25, 1998**
Contact: **Thomas Smith**
Phone: **(717) 342-3058**
Fax: **(717) 342-2768**

Springfield, MO

Each year, the City of Springfield Utilities recognizes local companies for their significant achievements in water conservation. The 1998 award goes to Cushman Enterprises. Through their dedication to the community and the environment, the management and employees of Cushman Enterprises have reduced their water consumption by 29 percent.

CONTINUING PROGRAM ACTIVITIES

The following are a list of suggestions for maintaining employee awareness of your facilities commitment to water conservation.

- Hold regular staff meetings to communicate the company's water conservation plan and progress in water savings.

- Publicize international, national, and local water and environmental issues that highlight the sensitivity of our precious resources.

- Take advanatage of audio-visual programs and use outside speakers for employee meetings.

- Send members of your water conservation team to community conservation seminars.

- Circulate information about what others in your industry are doing to conserve water.

- State savings in relevant terms such as dollars, earnings per share, or annual consumption per household.

- Establish a system for employees to notify the proper parties about leaks, dripping faucets, broken sprinklers, or other occurances of water waste.

- Dedicate a percentage of your corporate sponsorship budget to water conservation projects such as a public Xeriscape demonstration garden.

- Initiate a suggestions and incentives system in recognition of water saving ideas. Suggestion programs that include rewarding employees who have made significant contributions to the water conservation efforts with a percentage of the first year's direct savings have proven very successful.

- Use bulletins, newsletters, and paycheck stuffers, such as those listed below, to communicate policies, programs, ideas, announcements, progress reports, and special achievements.

  - **FUN FILLER FACTS FOR NEWSLETTERS** - A list of these facts are provided in the following pages.

  - **PAYCHECK STUFFERS** - Two versions of the preprinted paycheck stuffers are supplied at the end of this section: one in black and white and the other in color. A suggested two-year calendar for the distribution of the paycheck stuffers is also included.

  - **PREPRINTED ARTWORK** for paycheck stuffers, newsletters, table tents, and signs for employee areas such as bathrooms may be available from your city's water conservation office.

- Distribute water conservation booklets from your city’s water conservation office.

- Two or three times a year, have a water conservation display set up in the employee cafeteria or lounge highlighting different aspects of water use -- landscaping, low-flow plumbing fixtures, water-use habits, etc.

- Offer home water-saving devices to employees free or at cost. Sponsor demonstrations of these devices by suppliers of this type of hardware.

- Display posters and other material that may be available from your city's water conservation office.

- Post water conservation stickers and signs in bathrooms, kitchens, and cafeterias.

- Place signs on your drought-tolerant landscape identifying the various types of Xeriscape plants.

- Develop displays to place in public reception areas outlining your company's water conservation policy.

- At convenient intervals, prepare a public water conservation display and locate it in a prominent location covering the different aspects of both residential and non-residential water use: landscaping, low-flow plumbing fixtures, water-use habits, etc.

FUN FILLER FACTS FOR NEWSLETTERS

ADJUST SPRINKLERS, SET TIMERS

Adjust your sprinklers to water only landscaped areas, and be sure to repair broken sprinkler heads promptly. Also, use a timer. Timers can help prevent over-watering that often results in street flooding.

PUT YOUR LAWN ON A WATER DIET

Many people over-water their lawns. Put your lawn on a "water diet" and it will be healthier. An established lawn only needs to be watered twice a week in the summer, once a week in the spring and fall, and once a week in the winter if you overseed with winter rye. Your water conservation office can give you a free lawn watering guide.

Don't forget to:

- Water in the early morning (2 to 9 a.m.) or late evening (after 6 p.m.) for less evaporation.
- Water deeply and infrequently to leach salts and encourage healthy root growth.

LOW-FLOW DEVICES: THE INVISIBLE WATER SAVERS

Water is a precious resource in our desert environment. Saving water doesn't mean "doing without," but rather doing the same things more efficiently. Good quality water saving fixtures work just as well as conventional ones while reducing your water usage and your water bill.

SAVE WHEN YOU SHOWER

Most showers use four to seven gallons of water per minute. Low-flow shower heads reduce the flow rate but maintain the velocity and pressure of the spray. You can cut your water usage by about one-fourth and still enjoy a great shower! They are easy to install and available at most hardware stores.

SAVE WHEN YOU FLUSH

Toilets can account for over one-third of the water you use indoors. If your home was built before 1980, five to seven gallons of clean water are lost with every flush. Call your water conservation office for ideas on how to save water.

XERISCAPE: COLORFUL, WATER-EFFICIENT LANDSCAPING

Tired of high water bills and spending your weekends mowing your lawn? Why not try Xeriscape? Xeriscape is water conservation through creative landscaping using low-water-use plants that are drought tolerant and heat resistant. To learn more about this concept, contact your water conservation office.

CONSERVATION HELPS KEEP SUMMER WATER BILLS IN CHECK

In the Valley of the Sun, we use up to twice as much water in the summer as we do during the winter. Most of this is used outside to water grass and other thirsty plants. Our plants need more water during the summer to survive higher temperatures and the blazing sun. But much of the water we use outside during the summer is wasted due to inefficient irrigation practices. By watering efficiently, you can help to conserve our water resources and reduce your summer water bill at the same time.

SAVE WATER WHILE WASHING CARS AND CLEANING DRIVEWAYS
Put a turn-off nozzle on your hose or use a bucket of water to wash your car, rather than allowing water to run continuously. Use a push broom, instead of water, to clean your driveway and sidewalk.

SAVE WATER IN THE KITCHEN
Wait to use your dishwasher until you have a full load. Fill the sink to wash vegetables instead of letting the water run constantly. Also, fill a pitcher with drinking water and store it in the refrigerator. This eliminates the wasteful practice of running the tap while waiting for water to cool.

LEARN MORE ABOUT LOW-WATER-USE PLANTS
Low-water-use plants can serve nearly every landscape function. Some provide shade and screening while others are perfect for borders and accent areas. Many provide seasonal color as well as year-round greenery. Learn more about low-water-use plants. For more information on low-water-use plants, call your water conservation office.

RECYCLE OR REUSE WATER
Use water from cooking or washing to water potted plants. The added nutrients are healthy, and every little bit helps.

INSPECT YOUR IRRIGATION SYSTEM TO ENSURE TOP PERFORMANCE
One key to saving water and money is to periodically check your irrigation system. To make your job easier, follow this checklist. Monitor your system while it is in operation and check off each item when completed.

Checklist

- ✓ Replace missing or broken sprinkler and bubbler heads.
- ✓ Place bubblers close enough to shrubs and plants to water them effectively.
- ✓ Set sprinkler heads at the proper height to prevent them from becoming blocked or submerged by grass and other invasive plants.
- ✓ Be sure your system is watering only the areas intended, with no water running onto walks, into streets, or down the gutter.
- ✓ To prevent over watering or water running into the street, remember the importance of timing. If you have an automatic system, adjust the time clock as the temperature changes to give your plants only the amount of water they need to stay healthy. If you have a manual system, carefully watch a clock or set a kitchen timer.
- ✓ If you have a sloped yard, reduce the volume on sprinkler heads close to the street (or the lowest point). This will help to avoid runoff.

DO YOU HAVE A LEAKY TOILET?
The most common place for leaks is the toilet. Here's how to check for the most simple leaks. Place several drops of food coloring in the toilet tank and wait 15 minutes. If colored water appears in the bowl you probably have a plunger ball or flush valve (flapper) that needs to be replaced.

XERISCAPE: WATER CONSERVATION THROUGH CREATIVE LANDSCAPING
Whether old or new, your landscapes can be more water efficient simply by using the water-wise principles of Xeriscape or low-water-use landscaping. Not only will your yard look great, but Xeriscape improvements can increase the value of your home and decrease your maintenance time.

What Are the Xeriscape Principles?

1. Start with a plan.
2. Limit turf areas.
3. Install an efficient irrigation system.
4. Improve the soil.
5. Cover the soil with mulch or rock.
6. Use low-water-use plants.
7. Remember appropriate maintenance.

THE FALL PLANTING SEASON: A PERFECT TIME TO BE WATER WISE
It is time to consider fall planting and winter gardens. Since approximately one-half of the residential water used in the Valley is applied to landscapes, the plant and gardening decisions you make can help determine how high your water bill is each month.

SHOP CAREFULLY FOR XERISCAPE, OR LOW-WATER-USE PLANTS
For ideas on selecting appropriate low-water-use plants, visit the Desert Botanical Garden, your local nursery, or call your water conservation office for a free brochure.

TURN BACK THE CLOCK ON YOUR WINTER WATERING SCHEDULE
During the winter season, your landscape plants require only about one-third as much water as they do during the summer. This is due to cooler temperatures, shorter days, and increased rainfall. December is a great month to adjust your irrigation schedule in accordance with winter water needs. Not only will this help to reduce unnecessary irrigations, it also can help to reduce your water bills.

HOW TO SAVE WATER AND MONEY BY FINDING AND FIXING LEAKS
It happens all the time. A dripping faucet keeps you awake at night. The toilet runs continuously. Your yard suddenly develops a "soggy" spot. If there's been a sudden increase in your water bill, chances are you have a leak. Leaks waste water and cost a lot of money.

MAKE YOUR COOLER WORK SMARTER, NOT HARDER

Arizonans have relied for decades on evaporative coolers to help survive the hot summer months.

Give Your Cooler a Check-Up

Before using your cooler this season, give it a complete maintenance check. First, the cooler probably will require new pads. Turn on the cooler to find out if the water is evenly distributed at the top of the pad. Clean out the distribution holes. Make sure the pump inlet isn't blocked. Check the float valve to make sure that it isn't stuck open or shut. If you have an older cooler, you may need to re-coat the cooler pan with sealer to keep water from leaking. If you have a plastic cooler, make certain the bottom has not sagged or cracked.

Recycle Your Cooler Water

Evaporative coolers can use large amounts of water. A recirculating water pump can reduce water consumption by twenty gallons or more per hour.

WATER CONSERVATION: THE RIGHT CHOICE

Make the right choice and reduce the amount of water you are giving your lawn. Remember, your lawn does not require as much water in the cooler winter months as it did in the warmer summer months. For further information, please call your water conservation office.

TWO YEAR CALENDAR FOR PAYCHECK STUFFERS

	Year 1	Year 2
JANUARY	Water Supply Facts	Workplace Conservation: Get involved in Your Organization's Water Conservation Program
FEBRUARY	Home Conservation Tips: Low Water Use Devices	Home Conservation Tips: Finding and Fixing Toilet Leaks *(include dye tabs for leak detection)*
MARCH	Workplace Conservation: Make it Your Goal	Workplace Conservation: Corporate Conservation – Concern and Profit
APRIL	Home Conservation Tips: Using Water Outdoors	Home Conservation Tips: Visit the Desert Botanical Garden *(include free or discounted tickets)*
MAY	Home Conservation Tips: Xeriscape Your Yard	Home Conservation Tips: Watering Schedule Guidelines
JUNE	Home Conservation Tips: Greener Lawns with Less Water	Home Conservation Tips: Evaporative Coolers
JULY	Home Conservation Tips: Summertime Water Survival	Home Conservation Tips: Summertime Water Survival
AUGUST	Home Conservation Tips: Change Your Habits, But Not Your Lifestyle	Home Conservation Tips: Using Water Outdoors
SEPTEMBER	Home Conservation Tips: Fall Planting Season	Home Conservation Tips: Working with Your Nursery
OCTOBER	Home Conservation Tips: Xeriscape: Creative and Colorful *(include package of wildflower seeds)*	Home Conservation Tips: Xeriscape: Creative and Colorful *(include package of wildflower seeds)*
NOVEMBER	Home Conservation Tips: Water Conservation – A Family Project	Workplace Conservation: Leak Detection
DECEMBER	Home Conservation Tips: Winter Watering	Home Conservation Tips: Change Your Habits, But Not Your Lifestyle

Xeriscape Your Yard

Xeriscape offers many ways to conserve water in the landscape. Plan your landscape to contain play areas, shaded areas, and areas that attract natural wildlife. You can select from hundreds of low-water-use plants that provide color, texture, form, and interest.

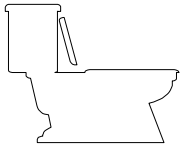
To find out more about Xeriscaping, call your city Water Conservation Office for free colorful brochures, workshops and classes, or visit one of their Demonstration Gardens for ideas. You may also be eligible for a rebate from your city for installing a low water use landscape.

Using Water Outdoors

Water Saving Tips for Outdoors:

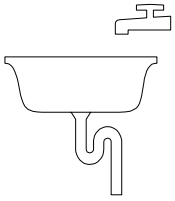
- Adjust sprinkler heads and remember to reset your irrigation controllers with the change of seasons.
- Water your grass in the early morning (2:00 a.m. - 9:00 a.m.) for less evaporation loss.
- Put a shutoff nozzle on your hose or use a bucket of water when washing your car.
- When backwashing pools, try to water adjacent lawn areas. This can also be done with evaporative cooler run-off.

Low Water Use Devices



Water conserving toilets can save up to 4 gallons per flush. You may be eligible for a rebate through your city's Water Conservation Program by replacing existing fixtures. Faucets, showerheads, and toilets can be equipped with retrofit devices that will allow them to conserve water. These items are easy to install and may be distributed by your city's Water Conservation Office.

Water is Arizona's most precious natural resource. Through wise water use, we can protect this vital resource for years to come.



Workplace Conservation: Make it your GOAL

There is a pressing need for improved water efficiency by all water users in order to ensure an adequate supply now and in the future. Reduced water use will also enable you to control your water, sewer, and energy costs. You can help by taking the time to find out where, how much, and how efficiently water is being used at your facility. In the weeks and months ahead, you can use this initial information to measure the success of your conservation efforts.

For more information contact the conservation office in the city in which you work

Water Facts

Only 1% of the water on the earth is usable for fresh drinking water. The average daily requirement for fresh water in the United States is 338 billion gallons per day, with about 300 billion gallons used as untreated water for agriculture.

Leaks add up in a hurry. A faucet or invisible toilet leak that totals only two tablespoons a minute adds up to 15 gallons per day, 105 gallons per week and 5,460 wasted gallons of water per year.

An average swimming pool that is not covered, with average sun and wind exposure will evaporate up to 1000 gallons per month. A pool cover will cut this loss by 90%.

For the price of a single 12 ounce can of soda - about 50 cents - many communities deliver up to 1,000 gallons of fresh, clean drinking water to homes 24 hours per day. If drinking water and soda pop were equally costly, your water bill would skyrocket more than 10,000 %.

Home Conservation - Evaporative Coolers

Evaporative coolers are durable and dependable, as well as an energy-efficient way to cool your home.

The following suggestions will help you have a more water-efficient cooler.

- Give your cooler an annual maintenance check-up. Check the cooler pads for even water distribution. Make sure the pump inlet is not blocked. Check the float valve to make sure it is not stuck open or shut. Check the cooler pan for leaks.
- Consider installing a thermostat which turns the cooler off when your home reaches the set temperature.
- Recycle your water by installing a recirculating water pump.

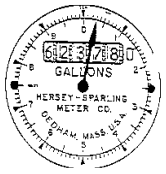
A properly maintained evaporative cooler will help you survive the hot summer months while saving water and money.

Checking for Leaks

Have you read any good meters lately?

If there has been a sudden unexplained increase in your water bill, chances are you have a leak. Leaks waste water and cost a lot of money. Use your water meter to help you check for "silent leaks."

- Locate your water meter.
- Turn off all the water, both inside and outside.
- Read your meter and record the numbers.
- Wait 1 or 2 hours and read the meter again.
- If the dials have changed, you have a leak and need to locate the source. Some meters have a small triangular leak detector that will move if any water is flowing through the meter.



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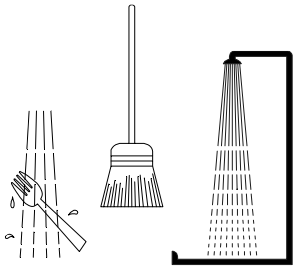

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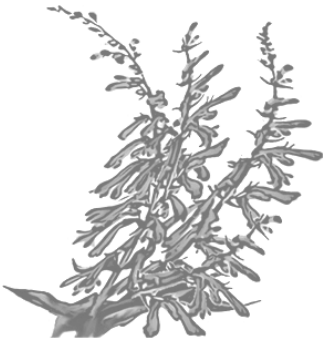

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Cool Season Grass		3-5 days	none	3-5 days	5-10 days	8-10 inches

Guidelines for established plants (2 years for shrubs, 5 years for trees). More water is required for new plantings, sandy soils, and extremely hot, dry weather. Water as deep as the root zone and 1 1/2 times the canopy width.

Xeriscape Your Yard

Xeriscape offers many ways to conserve water in the landscape. Plan your landscape to contain play areas, shaded areas, and areas that attract natural wildlife. You can select from hundreds of low-water-use plants that provide color, texture, form, and interest.

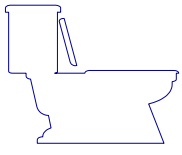
To find out more about Xeriscaping, call your city Water Conservation Office for free colorful brochures, workshops and classes, or visit one of their Demonstration Gardens for ideas. You may also be eligible for a rebate from your city for installing a low water use landscape.

Using Water Outdoors

Water Saving Tips for Outdoors:

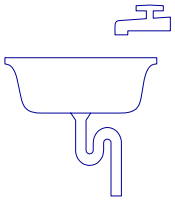
- Adjust sprinkler heads and remember to reset your irrigation controllers with the change of seasons.
- Water your grass in the early morning (2:00 a.m. - 9:00 a.m.) for less evaporation loss.
- Put a shutoff nozzle on your hose or use a bucket of water when washing your car.
- When backwashing pools, try to water adjacent lawn areas. This can also be done with evaporative cooler run-off.

Low Water Use Devices



Water conserving toilets can save up to 4 gallons per flush. You may be eligible for a rebate through your city's Water Conservation Program by replacing existing fixtures. Faucets, showerheads, and toilets can be equipped with retrofit devices that will allow them to conserve water. These items are easy to install and may be distributed by your city's Water Conservation Office.

Water is Arizona's most precious natural resource. Through wise water use, we can protect this vital resource for years to come.



Workplace Conservation: Make it your GOAL

There is a pressing need for improved water efficiency by all water users in order to ensure an adequate supply now and in the future. Reduced water use will also enable you to control your water, sewer, and energy costs. You can help by taking the time to find out where, how much, and how efficiently water is being used at your facility. In the weeks and months ahead, you can use this initial information to measure the success of your conservation efforts.

For more information contact the conservation office in the city in which you work

Water Facts

Only 1% of the water on the earth is usable for fresh drinking water. The average daily requirement for fresh water in the United States is 338 billion gallons per day, with about 300 billion gallons used as untreated water for agriculture.

Leaks add up in a hurry. A faucet or invisible toilet leak that totals only two tablespoons a minute adds up to 15 gallons per day, 105 gallons per week and 5,460 wasted gallons of water per year.

An average swimming pool that is not covered, with average sun and wind exposure will evaporate up to 1000 gallons per month. A pool cover will cut this loss by 90%.

For the price of a single 12 ounce can of soda - about 50 cents - many communities deliver up to 1,000 gallons of fresh, clean drinking water to homes 24 hours per day. If drinking water and soda pop were equally costly, your water bill would skyrocket more than 10,000 %.

Home Conservation - Evaporative Coolers

Evaporative coolers are durable and dependable, as well as an energy-efficient way to cool your home.

The following suggestions will help you have a more water-efficient cooler.

- Give your cooler an annual maintenance check-up. Check the cooler pads for even water distribution. Make sure the pump inlet is not blocked. Check the float valve to make sure it is not stuck open or shut. Check the cooler pan for leaks.
- Consider installing a thermostat which turns the cooler off when your home reaches the set temperature.
- Recycle your water by installing a recirculating water pump.

A properly maintained evaporative cooler will help you survive the hot summer months while saving water and money.

Checking for Leaks

Have you read any good meters lately?

If there has been a sudden unexplained increase in your water bill, chances are you have a leak. Leaks waste water and cost a lot of money. Use your water meter to help you check for "silent leaks."

- Locate your water meter.
- Turn off all the water, both inside and outside.
- Read your meter and record the numbers.
- Wait 1 or 2 hours and read the meter again.
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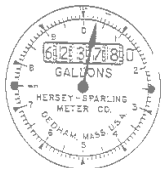

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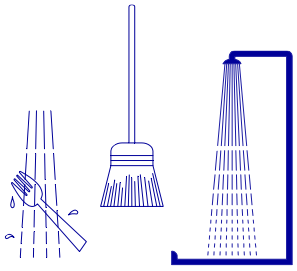

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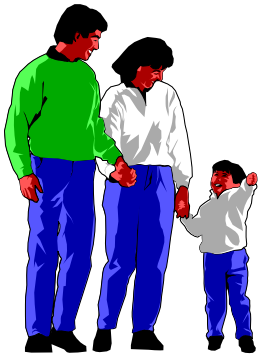

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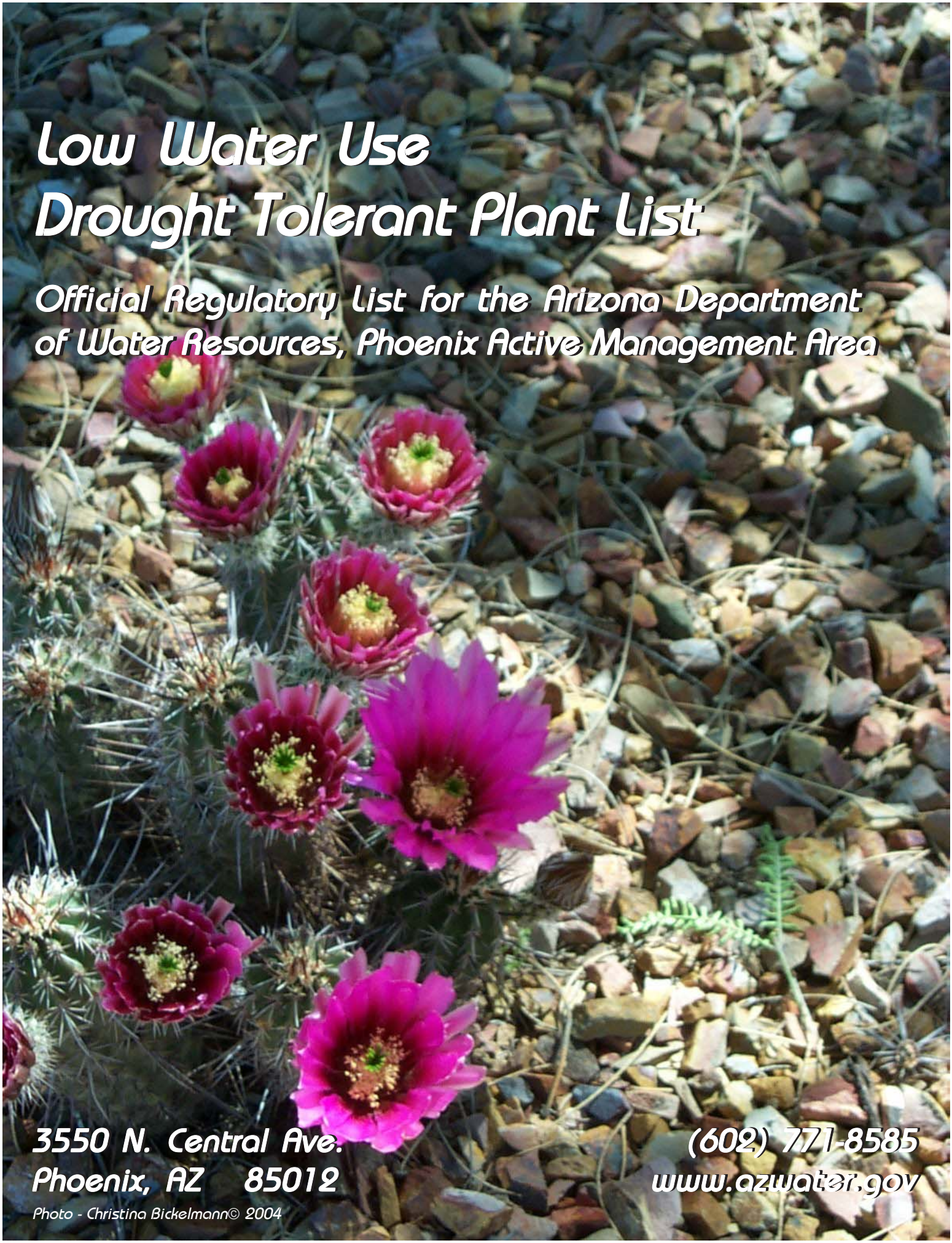

Low Water Use Drought Tolerant Plant List

Official Regulatory List for the Arizona Department of Water Resources, Phoenix Active Management Area

3550 N. Central Ave.
Phoenix, AZ 85012

(602) 771-8585
www.azwater.gov

LOW WATER USE/DROUGHT TOLERANT PLANT LIST

PHOENIX ACTIVE MANAGEMENT AREA

ARIZONA DEPARTMENT OF WATER RESOURCES

The Low Water Use/Drought Tolerant Plant List (List) is used by the Department of Water Resources as a regulatory document in both the Municipal and Industrial Conservation Programs of the Third Management Plan.

The List was compiled by the Department of Water Resources in cooperation with the Landscape Technical committee of the Arizona Municipal Water Users Association, comprised of experts from the Desert Botanical Garden, the Arizona Department of Transportation and various municipal, nursery and landscape specialists in the Phoenix AMA. Individuals wishing to add or delete plants from the list may submit information to the Director of the Arizona Department of Water Resources (Director) for consideration. The Director will amend the list as appropriate.

The List does not imply that every plant listed is suited to every right-of-way or low water use landscape situation. It is the responsibility of the landscape designer, architect or contractor to determine which plants are suitable for a specific location and situation. The bibliography provides substantial educational information to determine specific plant characteristics and needs.

PLANTS ARE PLACED IN THE CATEGORIES WHERE THEY ARE MOST OFTEN USED. THIS DOES NOT PRECLUDE THE USE OF ANY PLANT IN ANOTHER GROWTH FORM.

Phoenix AMA Low Water Use/Drought Tolerant Plants

Arizona Department of Water Resources Phoenix AMA- 3550 N. Central Ave. - Phoenix, AZ 85012 Tel. 602-771-8585

Annual Wildflowers

Botanical Name

Common Name

Abronia villosa
Sand-verbena

Amsinckia intermedia
Fiddleneck

Argemone pleiacantha
Prickly-poppy

Camissonia brevipes
Yellow Cups

Camissonia cardiophylla
Heartleaf Suncup

Catharanthus roseus
Madagascar Periwinkle

Centaurea rothrockii
Basket Flower

Cirsium neomexicanum
Thistle

Clarkia amoena
Farewell-to-Spring

Collinsia heterophylla
Chinese-houses

Coreopsis bigelovii
Desert Coreopsis

Cosmos spp.
Cosmos

Dimorphotheca spp.
African Daisy

Eriastrum diffusum
Prickly Stars

Eriophyllum lanosum
Woolly Daisy

Annual Wildflowers

Botanical Name

Common Name

Eriophyllum wallacei
Woolly Daisy

Eschscholtzia californica
California, Mexican Poppy

Euphorbia heterophylla
Painted Spurge

Gaillardia pulchella
Fire Wheel, Blanket Flower

Geraea canescens
Desert Sunflower

Gilia leptantha
Showy Blue Gilia

Gomphrena globosa
Globe Amaranth

Helianthus annuus
Wild Sunflower

Helichrysum bracteatum
Everlasting Daisy

Helipterum spp.
Helipterum

Ipomoea cristulata
Morning Glory

Ipomoea leptotoma
Morning Glory

Kallstroemia grandiflora
Arizona poppy

Lasthenia chrysostoma (Baeria chrysostoma)
Goldfield

Layia platyglossa
Tidy Tips

Lesquerella gordonii
Yellow Blanket

Linaria spp.
Toadflax

Linum grandiflorum cv. 'Rubrum'
Red Flax

Annual Wildflowers

Botanical Name

Common Name

Lupinus arizonicus
Arizona Lupine

Lupinus densiflorus
Lupine

Lupinus sparsiflorus
Desert Lupine

Lupinus succulentus
Arroyo Lupine

Machaeranthera asteroides (Psilactis leptos)
Purple Aster

Machaeranthera canescens (Aster bigelovii)
Blue Aster

Machaeranthera tanacetifolia (Aster)
Tahoka Daisy

Matricaria grandiflora
Pineapple Weed

Matthiola longipetala cv. 'Bicornis'
Evening Scented Stock

Mentzelia spp.
Blazing Star

Mimulus bigelovii
Bigelow's Monkeyflower

Mohavea confertiflora
Ghost Flower

Monarda austromontana
Bee Balm

Monoptilon bellioides
Belly Flower

Nama demissum
Purple Mat

Nama hispidum
Purple Mat

Nemophila maculata
Five Spot

Nemophila menziesii
Baby Blue Eyes

Annual Wildflowers

Botanical Name

Common Name

Oenothera deltoides
Birdcage Evening Primrose

Oenothera primiveris
Evening Primrose

Orthocarpus purpurascens
Owl's Clover

Papaver rhoeas
Shirley Poppy

Pectis papposa
Chinch Weed

Perityle emoryi
Rock Daisy

Phacelia spp.
Scorpion Weed

Plantago spp.
Indian-wheat

Platystemon californicus
Cream Cups

Proboscidea parviflora
Devil's Claw

Rafinesquia neomexicana
Desert-chicory

Salvia columbariae
Chia

Sisymbrium ambiguum
Purple Rocket

Solanum xanti
Solanum

Tithonia rotundifolia
Mexican Sunflower

Ursinia spp.
Ursinia

Verbesina encelioides
Golden Crown Beard

Viguiera annua
Golden Eye

Annual Wildflowers

Botanical Name

Common Name

Zinnia angustifolia x elegans

Zinnia "Profusion"

Grasses

Botanical Name

Common Name

Aristida purpurea	Erioneuron pulchellum	Muhlenbergia porteri
Purple Three-awn	**Fluffgrass**	**Bush Muhly**
Bothriochloa barbinodis	Hilaria rigida	Muhlenbergia rigens
Cane Bluestem	**Big Galleta**	**Deer Grass**
Bothriochloa gerardii	Muhlenbergia capillaris	Muhlenbergia rigida
Big Bluestem	**Gulf Muhly**	**Purple Muhly**
Bouteloua aristidoides	Muhlenbergia dumosa	Nasella tenuissma (Stipa tenuissima)
Six-weeks Grama	**Giant Muhly**	**Mexican Feather Grass**
Bouteloua curtipendula	Muhlenbergia emersleyi	Pennisetum setaceum cv. 'Cupreum'
Side Oats Grama	**Bull Grass**	**Purple Fountain Grass**
Bouteloua gracilis	Muhlenbergia lindheimeri	Schismus barbatus
Blue Grama	**Lindheimer Muhly**	**Mediterranean Grass**

Grasses

Botanical Name

Common Name

Setaria macrostachya

Plains Bristlegrass

Sporobolus airoides

Alkali Sacaton

Sporobolus cryptandrus

Sand Dropseed

Sporobolus wrightii

Big Sacaton

Trichachne californica

Cotton top

Groundcovers

Botanical Name

Common Name

Acacia spp.
Acacia

Acalypha monostachya
Raspberry Fuzzies

Asparagus densiflorus cv. 'Sprengeri'
Sprenger Asparagus

Atriplex spp.
Saltbush

Baccharis pilularis
Coyote Brush

Calylophus hartwegii v. fendleri
Sundrops

Clianthus formosus
Sturt's Desert Pea

Convolvulus mauritanicus
Ground Morning Glory

Dalea spp.
Indigo Bush

Eschscholzia mexicana
Mexican Gold Poppy

Gazania spp.
Gazania

Glandularia bipinnatifida (Verbena bipinnatifida
Verbena

Glandularia peruviana (Verbena peruviana)
Peruvian Verbena

Glandularia rigida (Verbena rigida)
Sandpaper Verbena

Glandularia tenera (Verbena tenera)
Moss Verbena

Lantana spp.
Trailing Lantana

Myoporum parvifolium
Myoporum

Oenothera berlandieri (O.speciosa)
Mexican Evening Primrose

Groundcovers

Botanical Name

Common Name

Oenothera stubbei

Saltillo Primrose

Pentzia incana

Karoo Bush

Rosmarinus officinalis cv.'Prostratus'

Prostrate Rosemary

Salvia chamaedryoides

Blue Sage

Salvia farinacea

Mealy Cup Sage

Santolina chamaecyparissus

Lavender Cotton

Santolina virens

Green Santolina

Sesuvium verrucosum

Sea Purslane

Teucrium chamaedrys cv. `Prostrata'

Germander

Wedelia trilobata

Yellow Dot

Zauschneria spp.

Hummingbird Flower

Perennial Wildflower

Botanical Name

Common Name

Allionia incarnata
Trailing Windmills

Amsonia palmeri
Amsonia

Anigozanthos spp.
Kangaroo-paw

Anisodontea hypomandrum
African Mallow

Arctotis spp.
African Daisy

Argemone munita
Prickly Poppy

Argemone platyceras
Prickly Poppy

Bahia absinthifolia
Bahia

Baileya multiradiata
Desert Marigold

Berlandiera lyrata
Chocolate Flower

Castilleja chromosa
Indian Paintbrush

Castilleja lanata
Indian Paintbrush

Conoclinium greggii (Eupatorium greggii)
Eupatorium

Datura metaloides (wrightii, inoxia)
Sacred Datura, Jimsonweed

Delphinium amabile
Larkspur

Delphinium scaposum
Barestem Larkspur

Dichelostemma pulchellum
Bluedicks

Erigeron divergens
Spreading Fleabane

Perennial Wildflower

Botanical Name

Common Name

Erigeron karvinskianus	Hibiscus coulteri	Machaeranthera tortifolia
Santa Barbara Daisy	**Desert Rose Mallow**	**Mohave Aster**
Evolvulus arizonicus	Ipomopsis longiflora	Melampodium leucanthum
Arizona Blue Eyes	**Pale Blue Trumpets**	**Blackfoot Daisy**
Gaura lindheimeri	Justicia sonorae	Mirabilis multiflora
Desert Orchid	**Sonoran Justicia**	**Desert Four O'Clock**
Glandularia gooddingii (Verbena gooddingii)	Linum lewisii	Oenothera caespitosa
Goodding Verbena	**Blue Flax**	**Tufted Evening Primrose**
Helianthus maximiliana	Lotus rigidus	Penstemon spp.
Maximilian's Sunflower	**Desert Rock Pea**	**Penstemon**
Hesperocallis undulata	Machaeranthera gracilis	Proboscidea altheaefolia
Ajo Lily	**Yellow Aster**	**Devil's Claw**

Perennial Wildflower

Botanical Name

Common Name

Psilostrophe cooperi
Paperflower

Psilostrophe tagetina
Paperflower

Ratibida columnaris
Mexican Hat, Coneflower

Romneya coulteri
Matilija Poppy

Senna covesii (Cassia covesii)
Desert Senna

Sphaeralcea spp.
Globe-mallow

Stachys coccinea
Red Mint, Betony

Tagetes spp.
Marigold

Tetraneuris acaulis (Hymenoxys acaulis)
Angelita Daisy

Thymophylla acerosa (Dyssodia acerosa)
Dyssodia

Thymophylla pentachaeta (Dyssodia pentachaet
Dyssodia

Zephryanthes spp.
Rain Lily

Zinnia acerosa
Desert Zinnia

Zinnia grandiflora
Rocky Mountain Zinnia

Shrubs

Botanical Name

Common Name

Abutilon palmeri
Superstition Mallow

Acacia spp.
Acacia

Aloysia spp.
Beebrush

Ambrosia ambrosioides
Canyon Ragweed

Ambrosia deltoidea
Triangleleaf Bur-sage

Ambrosia dumosa
White Bur-sage

Anisacanthus spp.
Desert Honeysuckle

Artemisia spp.
Sagebrush

Asclepias linaria
Pine-leaf Milkweed

Asclepias subulata
Desert Milkweed

Atriplex spp.
Saltbush

Baccharis spp.
Desert Broom, Coyote Brush

Bauhinia lunarioides (congesta)
Anacacho

Bauhinia macaranthera
Orchid Tree

Bauhinia ramosissima
Orchid Tree

Bebbia juncea
Sweet Bush

Berberis haematocarpa
Red Barberry

Berberis trifoliolata
Agarita

Shrubs

Botanical Name

Common Name

Buddleia marrubifolia **Woolly Butterfly Bush**	Callistemon phoeniceus **Salt Resistant Bottlebrush**	Cistus spp. **Rockrose**
Caesalpinia spp. **Bird-of-Paradise**	Callistemon viminalis **Bottlebrush**	Condalia globosa **Bitter Condalia**
Calliandra californica **Baja Red Fairy Duster**	Calothamnus spp. **Net Bush**	Convolvulus cneorum **Bush Morning Glory, Silverbush**
Calliandra eriophylla **Pink Fairy Duster**	Celtis pallida **Desert Hackberry**	Cordia boissieri **Anacahuita**
Calliandra peninsularis **Fairy Duster**	Chrysactinia mexicana **Damianita**	Cordia parvifolia **Little Leaf Cordia**
Callistemon citrinus **Lemon Bottlebrush**	Chrysothamnus nauseosus **Rabbit Brush**	Coursetia glandulosa **Baby Bonnets**

Shrubs

Botanical Name

Common Name

Cycas revoluta **Sago Palm**	Eremophila spp. **Emu Bush**	Euphorbia biglandulosa (rigida) **Euphorbia**
Dalea spp. **Smoketree, Indigo Bush**	Ericameria laricifolia **Turpentine Bush**	Feijoa sellowiana **Pineapple Guava**
Dicliptera resupinata **Native Dicliptera**	Ericameria linearifolia **Turpentine Bush**	Forestiera neomexicana **Desert Olive**
Dodonaea viscosa **Hopbush**	Eriogonum spp. **Buckwheat**	Fraxinus greggii **Littleleaf Ash**
Encelia spp. **Brittlebush**	Erythrina flabelliformis **Southwest Coralbean**	Genista hispanica **Spanish Broom**
Ephedra spp. **Mormon-tea**	Euphorbia antisyphilitica **Wax Plant, Candelilla**	Gossypium harknessii **San marcos Hibiscus**

Shrubs

Botanical Name

Common Name

Guiacum coulteri	Jatropha spp.	Leucophyllum spp.
Guayacan	**Limberbush**	**Texas Sage, Texas Ranger**
Gutierrezia sarothrae	Juniperus chinensis varieties	Lippia graveolens (berlandieri)
Snakeweed	**Juniper**	**Mexican Oregano**
Hamelia patens	Justicia spp.	Lycium spp.
Fire Bush	**Mexican Honeysuckle, Chuparosa**	**Wolfberry**
Hymenoclea monogyra	Krameria parvifolia	Maireana sedifolia
Burrobrush	**Ratany**	**Bluebush**
Hyptis emoryi	Lantana spp.	Malpighia emarginata
Desert-lavender	**Lantana**	**Barbados Cherry**
Jasminum mesnyi	Larrea tridentata	Maytenus phyllanthoides
Primrose Jasmine	**Creosote Bush**	**Mangle Dulce**

Shrubs

Botanical Name

Common Name

Melaleuca spp.
Australian Myrtle

Mimosa biuncifera
Wait-a-Minute Bush

Mimosa dysocarpa
Velvet Pod Mimosa

Myrtus communis
Myrtle

Nandina domestica
Heavenly-bamboo

Nerium oleander varieties
Oleander

Perovskia atriplicifolia cv. `Heavenly Blue'
Russian Sage

Phlomis fruticosa
Jerusalem Sage

Plumbago capensis
Cape Plumbago

Plumbago scandens
Plumbago

Poliomintha maderensis
Lavender Spice

Punica granatum varieties
Pomegranate

Pyracantha spp.
Pyracantha, Fire-thorn

Rhus choriophylla
Mearns Sumac

Rhus microphylla
Desert Sumac

Rhus ovata
Sugarbush

Rhus trilobata
Skunkbush

Rhus virens
Evergreen Sumac

Shrubs

Botanical Name

Common Name

Rosmarinus officinalis
Bush Rosemary

Ruellia ssp.
Ruellia

Salvia spp.
Sage

Senna spp. (Cassia spp.)
Cassia

Simmondsia chinensis
Jojoba

Solanum xanti
Solanum

Sophora arizonica
Arizona Sophora

Sophora formosa
Sophora

Tecoma spp.
Tacoma

Tecomaria capensis
Cape Honeysuckle

Teucrium fruticans
Bush Germander

Thamnosma montana
Turpentine Broom

Thevetia peruviana
Yellow Oleander

Trixis californica
Trixis

Vauquelinia spp.
Rosewood

Viguiera parishii (Viguiera deltoidea)
Golden Eye

Viguiera stenoloba
Skeleton-leaf Goldeneye

Viguiera tomentosa
Golden Eye

Shrubs

Botanical Name

Common Name

Wedelia texana (Zexmenia hispida)

Rough Zexmenia

Westringia rosmariniformis

Westringia

Ziziphus obtusifolia

Greythorn

Succulents / Accents

Botanical Name

Common Name

Agave spp.

Century Plant, Agave

Aizoaceae spp.

Ice Plant Family

Aloe spp.

Aloe

Bulbine frutescens

Bulbine

Cactaceae

Cactus Family

Dasylirion spp.

Desert Spoon

Fouquieria spp.

Ocotillo

Hechtia montana

Hechtia

Hesperaloe spp.

Hesperaloe

Manfreda maculosa

Manfreda

Nolina spp.

Bear-grass

Pedilanthus macrocarpus

Lady Slipper

Portulaca grandiflora

Moss Rose

Portulacaria afra

Elephant Food

Yucca spp.

Yucca

Tree

Botanical Name

Common Name

Acacia spp.
Acacia, Wattle

Bauhinia lunariodes (B.congesta)
Anacacho Orchid Tree

Bauhinia mexicana
Orchid Tree

Brachychiton populneus
Bottle Tree

Brahea spp.
Fan Palm

Bursera spp.
Elephant Tree

Butia capitata
Jelly Palm

Caesalpinia spp.
Bird-of-Paradise

Callistemon ssp.
Bottlebrush

Canotia holacantha
Crucifixion Thorn

Casuarina spp.
Beefwood

Celtis reticulata
Western Hackberry

Ceratonia siliqua
St. John's Bread Tree, Carob Tree

Cercis canadensis var. mexicana
Mexican Redbud

Cercis canadensis var. texensis
Texas Redbud

Chamaerops humilis
Mediterranean Fan Palm

Chilopsis linearis
Desert-willow

Chitalpa tashkentensis
Chitalpa

Tree

Botanical Name

Common Name

Chorisia speciosa
Silk Floss Tree

Cupressus arizonica
Arizona Cypress

Cupressus sempervirens
Italian Cypress

Dalbergia sissoo
Sissoo Tree

Ebenopsis spp. (Pithecellobium spp.)
Ebony

Eucalyptus spp.
Eucalyptus

Eysenhardtia orthocarpa
Kidneywood

Geijera parviflora
Australian-willow

Gleditsia triacanthos
Honey Locust

Holacantha emoryi (Castela emoryi)
Crucifixion Thorn

Leucaena retusa
Golden Ball Lead Tree

Lysiloma spp.
Desert-fern

Olea europaea
Olive

Olneya tesota
Ironwood

Parkinsonia aculeata
Mexican Palo Verde, Jerusalem Thorn

Parkinsonia spp. (Cercidium spp.)
Palo Verde

Phoenix canariensis
Canary Island Date Palm

Phoenix dactylifera
Date Palm

Tree

Botanical Name

Common Name

Pinus canariensis
Canary Island Pine

Pinus eldarica
Afghan Pine

Pinus halepensis
Aleppo Pine

Pinus pinea
Italian Stone Pine

Pinus roxburghii
Chir Pine

Pistacia spp.
Pistachio

Pittosporum phillyraeoides
Willow Pittosporum

Prosopis spp.
Mesquite

Quercus spp.
Oak

Rhus lancea
African Sumac

Rhus lanceolata
Prairie Flameleaf Sumac

Schinus molle
California Pepper Tree

Schinus terebinthifolius
Brazilian Pepper Tree

Sophora secundiflora
Texas Mountain Laurel, Mescal Bean

Tamarix aphylla
Athel Tree

Tipuana tipu
Tipu Tree

Ulmus parvifolia cv.'Sempervirens'
Chinese Evergreen Elm

Ungnadia speciosa
Mexican-buckeye

Tree

Botanical Name

Common Name

Vitex agnus-castus

Chaste Tree

Washingtonia spp.

Desert Fan Palm

Xylosma congestum

Xylosma

Ziziphus jujuba

Chinese Jujube

Vines

Botanical Name

Common Name

Antigonon leptopus	Curcurbita digitata	Mascagnia lilacina
Coral Vine, Queen's Wreath	**Coyote Gourd, Finger Leaf Gourd**	**Purple Mascagnia**
Bougainvillea spp.	Hardenbergia comptoniana	Maurandya antirrhiniflora
Bougainvillea	**Lilac Vine**	**Snapdragon Vine**
Callaeum macropterum (Mascagnia macroptera)	Hardenbergia violacea	Maurandya wislizeni
Yellow Orchid Vine	**Purple Coral Pea**	**Snapdragon Vine**
Campsis radicans	Janusia gracilis	Merremia aurea
Common Trumpet Creeper	**Slender Janusia**	**Yellow Morning Glory Vine**
Cissus trifoliata	Kennedia nigricans	Passiflora foetida
Grape Ivy	**Black Yellow Vine**	**Passion Vine**
Clematis drummondii	Macfadyena unguis - cati	Podranea ricasoliana
Virgin's Bower	**Cat's Claw**	**Pink Trumpet Vine**

Vines

Botanical Name

Common Name

Rhynchosia texana

Rosary Bead Vine

Rosa banksiae

Lady Bank's Rose

Solanum jasminoides

Potato Vine

LOW WATER USE/DROUGHT TOLERANT PLANT BIBLIOGRAPHY

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ARIZONA DEPARTMENT OF WATER RESOURCES

JANET NAPOLITANO
Governor

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Director

The Low Water Using Plant Bibliography was created as a reference tool for those interested in additional information about the plants listed in the Department of Water Resource Low Water Using Plant List.

The bibliography was compiled by the Department of Water Resources in cooperation with the Arizona Municipal Water Users Association, Landscape Technical Committee, comprised of experts from the Desert Botanical Garden, the Arizona Department of Transportation and various municipal, nursery and landscape specialists in the Phoenix AMA.

Referenced sources are available at local libraries, bookstores, the Arizona State University Library, the Desert Botanical Garden Library and on library catalogue computer networks.

GENERAL DESERT PLANTS AND XERISCAPE

Aljilvsgi, Geyata. 1991. *Butterfly Gardening for the South*. Taylor Publishing Co., Dallas, Texas. 342 pages.

Arizona Game and Fish Department. *Landscaping for Desert Wildlife.* Arizona Game and Fish Department, Phoenix, Arizona. http://www.azgfd.gov/w_c/landscaping_desert_wildlife.shtml.

Arizona Municipal Water User Association. 1991. *Landscape Plants for the Arizona Desert.* Arizona Municipal Water Users Association, Phoenix, Arizona. 47 pages.

Arizona Municipal Water Users Association. 1991. *Landscape Watering by the Numbers.* Arizona Municipal Water Users Association, Phoenix, Arizona. 30 pages.

Arizona Municipal Water Users Association. 1994. *Xeriscape: Landscaping With Style*. Arizona Municipal Water Users Association, Phoenix, Arizona. 23 pages.

Arizona Native Plant Society Urban Landscape Committee. 1992. *Desert Butterfly Gardening.* Arizona Native Plant Society, Tucson, Arizona. 32 pages.

Arizona Native Plant Society Urban Landscape Committee. 1993. *Desert Grasses.* Arizona Native Plant Society, Tucson, Arizona. 41 pages.

Arizona Native Plant Society Urban Landscape Committee. 1991. *Desert Groundcovers and Vines.* Arizona Native Plant Society, Tucson, Arizona. 26 pages.

Arizona Native Plant Society Urban Landscape Committee. 1991. *Desert Shrubs.* Arizona Native Plant Society, Tucson, Arizona. 34 pages.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

Arizona Native Plant Society Urban Landscape Committee. 1990. *Native Trees.* Arizona Native Plant Society, Tucson, Arizona. 48 pages.

Arizona Native Plant Society Urban Landscape Committee. 1991. *Desert Wildflowers.* Arizona Native Plant Society, Tucson, Arizona. 45 pages.

Art, Henry W. 1990. *The Wildflower Gardener's Guide - California, Desert Southwest, and Northern Mexico Edition.* Storey Communications Inc., Pownal, Vermont. 192 pages.

Boring, J.K., Eric A. Glassner, Glenn Keator, Jim Knopf, Jane Scott, and Sally Wasowski. 1996. *Natural Gardening*. Time-Life Books, Virginia Beach, VA. 288 pages.

Brenzel, Kathleen Norris (editor). 2006. *Sunset Western Landscaping Book*. Sunset Books Inc., Menlo Park, California. 416 pages.

Brenzel, Kathleen Norris (editor). 2007. *Sunset Western Garden Book*. Lane Publishing Co. Menlo Park, California. 768 pages.

Brookbank, George. 1992. *Desert Landscaping: How to Start and Maintain a Healthy Landscape in the Southwest.* University of Arizona Press, Tucson, Arizona. 275 pages.

Coate, Barrie. 1980. *Selected California Native Plants in Color.* Saratoga Horticultural Foundation, Saratoga, California. 120 pages.

Cromell, Cathy (editor). 2001. *Desert Landscaping for Beginners*. Arizona Master Gardener Press, Phoenix, Arizona. 224 pages.

Cromell, Cathy L. 2003. *Earth Friendly Desert Gardening*. Arizona Master Gardener Press, Phoenix, Arizona. 136 pages.

Defreitas, Stan. 1993. *The Water Thrifty Garden.* Taylor Publishing Company, Dallas, Texas. 160 pages.

Denver Water and American Water Works Association. 1999. *Xeriscape Plant Guide: 100 Water-Wise Plants for Gardens and Landscapes*. Fulcrum Publishing, Golden, Colorado. 192 pages.

Dewolf, Gordon P. 1990. *Taylor's Guide to Water-Saving Gardening: A Sourcebook for Gardeners.* Houghton-Mifflin Company, Boston, Massachusetts. 448 pages.

Dinchak, Ronald K. 1981. *An Illustrated Guide to Landscape Shrubs of Southern Arizona.* Three-D Publishers, Mesa, Arizona. 127 pages.

Dinchak, Ronald K. 1981. *An Illustrated Guide to Landscape Trees of Southern Arizona.* Three-D Publishers, Mesa, Arizona. 122 pages.

Druse, Ken. 2004. *The Natural Habitat Garden*. Timber Press, Inc., Portland, Oregon. 264 pages.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

Duffield, Mary Rose and Warren D. Jones. 2001. *Plants for Dry Climates: How to Select, Grow and Enjoy.* Fisher Books, Tucson, Arizona. 176 pages.

Ellefson, Connie L. 1992. *Xeriscape Gardening: Water Conservation for the American Landscape.* MacMillan Publishing, New York, New York. 320 pages.

Frey, Susan Rademacher and Barbara W. Ellis. 1992. *Outdoor Living Spaces: How to Create a Landscape You Can Use and Enjoy.* Rodale Press, Emmaus, Pennsylvania. 342 pages.

Greenlee, John. 1992. *The Encyclopedia of Ornamental Grasses: How to Grown and Use Over 250 Beautiful and Versatile Plants*. Rodale Press, Emmaus, Pennsylvania. 186 pages.

Guy, Linda A., Lucy K. Bradley and Cathy L. Cromell. 1996. *Success With School Gardens: How to Create a Learning Oasis in the Desert*. Arizona Master Gardener Press, Phoenix, Arizona. 144 pages.

Hoboba, Theodore B. 1995. *Growing Desert Plants: From Windowsill to Garden*. Red Crane Books, Santa Fe, New Mexico. 224 pages.

Johnson, Eric A. 1997. *Pruning, Planting and Care: Johnson's Guide to Gardening Plants for the Arid West*. Ironwood Press, Tucson. 160 pages.

Johnson, Eric A. and Scott Millard. 1992. *The Low Water Flower Gardener.* Ironwood Press, Tucson, Arizona. 144 pages.

Jones, Warren D., and Charles Sacamano. 2000. *Landscape Plants for Dry Regions: More Than 600 Species from Around the World*. Fisher Books, Cambridge, Massachusetts. 366 pages.

Kourik, Robert. 1993. *Drip Irrigation for Every Landscape and All Climates: Helping Your Garden Flourish While Conserving Water!* Metamorphic Press, New York, New York. 128 pages.

Labadie, Emile. 1978. *Native Plants for Use in California Landscapes.* Sierra City Press, Sierra City, California. 244 pages.

Lenz, Lee. 1977. *Native Plants for California Gardens.* Day Printing, Pomona, California. 166 pages.

Ludwig, Art. 2006. *The New Create an Oasis With Greywater: Choosing, Building and Using Greywater Systems*. Oasis Design, Santa Barbara, California. 144 pages.

Mathias, Mildred. 1973. *Color for the Landscape - Flowering Plants for Subtropical Climates.* Los Angeles Beautiful Foundation, Los Angeles, California. 205 pages.

McPherson, E. Gregory and Charles Sacamano. 1989. *Southwestern Landscaping That Saves Energy and Water.* Cooperative Extension, College of Agriculture, University of Arizona, Tucson, Arizona. 61 pages.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

Mielke, Judy. 1993. *Native Plants for Southwestern Landscapes.* University of Texas Press, Austin, Texas. 310 pages.

Miller, George O. 1991. *Landscaping with Native Plants of Texas and the Southwest.* Voyageur Press, Stillwater, Minnesota. 128 pages.

National Wildflower Research Center. 1992. *Wildflower Handbook.* Voyageur Press, Stillwater, Minnesota. 304 pages.

Ogden, Scott. 1992. *Gardening Success with Difficult Soils: Limestone, Alkaline Clay, and Caliche Soils.* Taylor Publishing Company, Dallas, Texas. 272 pages.

O'Keefe, John M. 1992. *Water-Conserving Gardens and Landscapes.* Storey Publishing, Pownal, Vermont. 156 pages.

Perry, Bob. 1992. *Landscape Plants for Western Regions: An Illustrated Guide to Plants for Water Conservation.* Land Design Publishing, Claremont, California. 318 pages.

Perry, Bob. 1981. *Trees and Shrubs for Dry California Landscapes.* Land Design Publishing Co., San Dimas, California. 180 pages.

Phillips, Judith. 1996. *Natural by Design - Beauty and Balance in Southwest Gardens*. Museum of New Mexico Press, Santa Fe, New Mexico. 208 pages.

Phillips, Judith. 1995. *Plants for Natural Gardens - Southwestern Native and Adapative Trees, Shrubs, Wildflowers and Grasses*. Museum of New Mexico Press. Santa Fe, New Mexico. 148 pages.

Phillips, Judith. 1987. *Southwestern Landscaping with Native Plants.* Museum of New Mexico Press, Santa Fe, New Mexico. 160 pages.

Rubin, Carole. 2002. *How to Get your Lawn off Grass: A North American Guide to Turning off the Water Tap and Going Native*. Harbour Publishing, Madeira Park, Canada. 208 pages.

Sacamano, Charles M. and Warren D. Jones. 1975. *Native Trees and Shrubs for Landscape Use in the Desert Southwest.* University of Arizona Press, Tucson, Arizona. 40 pages.

Shuler, Carol. 1995. *Low Water Use Plants for California and the Southwest.* Fisher Books, Tucson, Arizona. 138 pages.

Soil Water Conservation Society of America, Arizona Chapter. 1973. *Landscaping with Native Arizona Plants.* University of Arizona Press, Tucson, Arizona. 194 pages.

Stokes, Donald and Lillian. 1993. *The Wildflower Book from the Rockies West.* Little Brown, Boston, Massachusetts. 93 pages.

Sunset Magazine and Books editors. 1989. *Waterwise Gardening.* Lane Publishing Co., Menlo Park, California. 96 pages.

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GENERAL DESERT PLANTS AND XERISCAPE (continued)

Turner, Raymond M., Janice Bowers and Tony L. Burgess. 2005. *Sonoran Desert Plants: An Ecological Atlas.* University of Arizona Press, Tucson, Arizona. 504 pages.

Wasowski, Sally and Andy. 1995. *Native Gardens for Dry Climates*. Clarkson Potter/Publishers. New York, New York. 176 pages.

Wasowski, Sally. 2002. *Native Texas Plants: Landscaping Region by Region.* Gulf Publishing, Houston, Texas. 405 pages.

Wasowski, Sally and Julie E. Ryan. 1985. *Landscaping with Native Texas Plants.* Texas Monthly Press, Austin,Texas. 233 pages.

Walters, James E. and Balbir Backhaus. 1992. *Shade and Color with Water Conserving Plants.* Timber Press, Portland, Oregon. 240 pages.

Weinstein, Gayle. 1999. *Xeriscape Handbook*. Fulcrum Publishing, Golden, Colorado. 142 pages.

Wilson, William H.W. 1984. *Landscaping with Wildflowers and Native Plants.* Ortho Books, San Francisco, California. 93 pages.

IDENTIFICATION GUIDES - SOUTHWEST/ARIZONA/CALIFORNIA

Belzer, Thomas. 1984. *Roadside Plants of Southern California.* Mountain Press Publishing Co., Missoula, Montana. 158 pages.

Benson, Lyman David and Robert A. Darrow. 1981. *Trees and Shrubs of the Southwestern Deserts.* University of Arizona Press, Tucson, Arizona. 416 pages.

Bowers, Janice E. 1989. *100 Desert Wildflowers of the Southwest.* Southwest Parks and Monuments Association, Tucson, Arizona. 64 pages.

Dodge, Natt Noyes. 1989. *100 Roadside Flowers of the Southwest Woodlands.* Western National Parks Association, Tucson, Arizona. 64 pages.

Dodge, Natt Noyes. 1985. *Flowers of the Southwest Deserts.* Southwest Parks and Monuments Association, Tucson, Arizona. 136 pages.

Elmore, Francis H. 1976. *Shrubs and Trees of the Southwest Upland.* Southwest Parks and Monuments Association, Globe, Arizona. 214 pages.

Epple, Anne Orth. 1995. *A Field Guide to the Plants of the Arizona*. LewAnn Publishing Company, Mesa, Arizona. 88 pages.

Gould, Frank W. 1993. *Grasses of the Southwestern United States.* University of Arizona Press, Tucson, Arizona. 344 pages.

Jaeger, Edmund. 1968. *Desert Wildflowers.* Stanford University Press, Stanford, California. 322 pages.

Kearney, Thomas H. and Robert H. Peebles. 1961. *Arizona Flora (second edition).* University of California Press, Berkeley, California. 1085 pages.

Keator, Glenn. 1994. *Complete Garden Guide to the Native Shrubs of California*. Chronicle Books, San Francisco, California. 314 pages.

Lamb, Samuel H. 1975. *Woody Plants of the Southwest: A Field Guide With Descriptive Text, Drawings, Range Maps and Photographs.* Sunstone Press, Santa Fe, New Mexico. 177 pages.

Leake, Dorothy V, Benjamin J. Leake and Marcelotte L. Roeder. 1993. *Desert and Mountain Plants of the Southwest.* University of Oklahoma Press, Norman, Oklahoma. 229 pages.

Lehr, J. Harry. 1978. *A Catalogue of the Flora of Arizona.* Northland Press, Flagstaff, Arizona. 203 pages.

Martin, William C. and Charles R. Hutchins. 1984. *Spring Wildflowers of New Mexico.* University of New Mexico, Albuquerque, New Mexico. 257 pages.

Martin, William C. and Charles R. Hutchins. 1988. *Fall Wildflowers of New Mexico.* University of New Mexico, Albuquerque, New Mexico. 294 pages.

McMinn, Howard E. 1974. *An Illustrated Manual of California Shrubs.* University of California Press, Berkeley, California. 663 pages.

McMinn, Howard E. and Evelyn Maino. 1981. *An Illustrated Manual of Pacific Coast Trees.* University of California Press, Berkeley, California. 432 pages.

Moore, Michael. 1990. *Medicinal Plants of the Desert and Canyon West: A Guide to Identifying, Preparing and Using Traditional Medicinal Plants Found in the Deserts and Canyons.* Museum of New Mexico Press, Santa Fe, New Mexico. 200 pages.

Munz, Phillip A. 1974. *A Flora of Southern California.* University of California Press, Berkeley, California. 1086 pages.

Munz, Phillip A. and David D. Keck. 1959. *A California Flora.* University of California Press, Berkeley, California. 1681 pages.

Munz, Phillip A. 1962. *California Desert Wildflowers.* University of California Press, Berkeley, California. 120 pages.

Nabhan, Gary Paul. 1988. *Arizona Highways Presents Desert Wildflowers.* Arizona Highways, Phoenix, Arizona. 112 pages.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

IDENTIFICATION GUIDES - SOUTHWEST/ARIZONA/CALIFORNIA (continued)

National Audubon Society. 2001. *National Audubon Society Field Guide to North American Wildflowers: Western Region-Revised Edition*. Alfred Knopf, New York, New York. 896 pages.

Niehaus, Theodore. 1998. *A Field Guide to Southwestern and Texas Wildflowers.* Houghton Mifflin Company, Boston, Massachusetts. 400 pages.

Parker, Kittie F. 1972. *An Illustrated Guide to Arizona Weeds.* University of Arizona Press, Tucson, Arizona. 338 pages.

Peterson, Victor P. 1966. *Native Trees of Southern California.* University of California Press, Berkeley, California. 136 pages.

Raven, Peter. 1976. *Native Shrubs of Southern California.* University of California Press, Berkeley, California. 132 pages.

Schmutz, Ervin. 1978. *Classified Bibliography on Native Plants of Arizona.* University of Arizona Press, Tucson, Arizona. 160 pages.

Stewart, Jon Mark. 1993. *Colorado Desert Wildflowers*. Jon Stewart Photography, Palm Desert, California. 120 pages.

Tull, Delena. 1987. *A Practical Guide to Edible and Useful Plants: Including Recipes, Harmful Plants, Natural Dyes and Textile Fibers.* Texas Monthly Press, Austin, Texas. 518 pages.

IDENTIFICATION GUIDES – TEXAS

Ajlvagi, Geyata. 2003. *Wildflowers of Texas.* Shearer Publshing Company, Bryan, Texas. 524 pages.

Cox, Paul W. and Patty Leslie. 1988. *Texas Trees: A Friendly Guide.* Corona Publishing Co., San Antonio, Texas. 374 pages.

Loughmiller, Campbell and Lynn Loughmiller. 2006. *Texas Wildflowers: A Field Guide (Revised Edition).* University of Texas Press, Austin, Texas. 304 pages.

Powell, A. Michael. 1987. *Trees and Shrubs of Trans - Pecos Texas.* Gulf Publishing, Houston, Texas. 536 pages.

Simpson, Benny J. 2002. *A Field Guide to Texas Trees.* Gulf Publishing, Houston, Texas. 488 pages.

Stewart, Donovan and Marshall C.J. Correll. 1979. *Manual of the Vascular Plants of Texas.* Texas Research Foundation, Renner, Texas. 1881 pages.

Tull, Delena. 2003. *Lone Star Field Guilde to Wildflowers, Trees and Shrubs of Texas (Revised Edition).* Lone Star Books, Houston, Texas. 352 pages.

Vines, Robert A. 2004. *Trees, Shrubs and Woody Vines of the Southwest.* The Blackburn Press, Caldwell, New Jersey. 1104 pages.

IDENTIFICATION GUIDES – TEXAS (continued)

Warnock, Barton W. 1970. *Wildflowers of the Big Bend Country, Texas.* Sul Ross State University, Alpine, Texas. 157 pages.

Warnock, Barton W. 1977. *Wildflowers of the Davis Mountains and Marathon Basin, Texas.* Sul Ross State University, Alpine, Texas. 276 pages.

Warnock, Barton W. 1974. *Wildflowers of the Guadalupe Mountains and the Sand Dune Country, Texas.* Sul Ross State University, Alpine, Texas. 176 pages.

IDENTIFICATION GUIDES - MEXICO

Mason, Charles T. and Patricia Mason. 1987. *A Handbook of Mexican Roadside Flora.* University of Arizona Press, Tucson, Arizona. 380 pages.

Matuda, Eizi and Ignacio Pina Lujan. 1980. *Las Plantas Mexicanas del Genero Yucca.* Collecion Misclelelanea. Estado de Mexico, Toluca, Mexico. 145 pages.

Roberts, Norman. 1989. *Baja California Plant Field Guide.* Natural History Publishing Company, La Jolla, California. 309 pages.

Shreve, Forrest and Ira L. Wiggins. 1964. *Vegetation and Flora of the Sonoran Desert.* Stanford University Press, Stanford, California. 1752 pages.

Wiggins, Ira L. 1980. *Flora of Baja California.* Stanford University Press, Stanford, California. 1025 pages.

IDENTIFICATION GUIDES - AFRICA

Eliovson, Sima. 1973. *South African Wildflowers for the Garden.* MacMillan Publishing, Johannesburg, South Africa. 305 pages.

Palgrave, Keith Coates, R.B. Drummond, Eugene J. Moll and Meg C. Palgrave. 2003. *Trees of Southern Africa.* New Holland Publishers, Ltd., London, England. 1000 pages.

Chippendale, G.M. 1973. *Eucalypts of the Western Australian Goldfields.* Australian Government Publishing Service, Canberra, Australia. 218 pages.

Elliot, W. Roger and David L. Jones. 1980. *Encyclopedia of Australian Plants Suitable for Cultivation Volumes 1-5 (A-J).* Lothian Publishing Co. Pty., Ltd., Melbourne, Australia. 2328 pages.

Kelley, Stan. 1984. *Eucalypts Volumes I and II.* Nelson Publishing Company, Melbourne, Australia. 758 pages.

Wrigley, John W. and Murray Fagg. 2004. *Australian Native Plants.* New Holland Publishers Ltd., London, England. 616 pages.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

Backeberg, Curt. 1978. *Cactus Lexicon.* Sterling Pub. Co. Inc., New York, New York. 828 pages.

Benson, Lyman D. 1969. *Cacti of Arizona.* University of Arizona Press, Tucson, Arizona. 218 pages.

Benson, Lyman D. 1988. *The Native Cacti of California.* Stanford University Press, Stanford, California. 256 pages.

Benson, Lyman D. 1983. *Cacti of the United States and Canada.* Stanford University Press, Stanford, California. 1044 pages.

Court, Doreen. 2004. *Succulent Flora of Southern Africa.* Routledge, Oxford, England. 240 pages.

Earle, W. Hubert. 1987. *Cacti of the Southwest.* Golden Books, New York, New York. 210 pages.

Folsom, Debra Brown. 1995. *American Garden Guides: Dry Climate Gardening with Succulents*. Pantheon Books, New York, New York. 224 pages.

Gentry, Howard Scott. 1978. *The Agaves of Baja California.* California Academy of Sciences, San Francisco, California. 119 pages.

Gentry, Howard Scott. 1972. *The Agave Family in Sonora.* USDA, U.S. Government Printing Office, Washington, D.C. 195 pages.

Gentry, Howard Scott. 1982. *The Agave Family of Continental North America.* University of Arizona Press, Tucson, Arizona. 670 pages.

Innes, Clive and Charles Glass. 1991. *Cacti.* Portland House, New York, New York. 320 pages.

Jacobsen, Hermann. 1976. *Lexicon of Succulent Plants.* Blanford Press, London, England. 664 pages.

Jacobsen, Hermann. 1976. *A Handbook of Succulent Plants.* Blanford Press, London, England. 1441 pages.

Jeppe, Barbara. 1974. *South African Aloes.* Purnell Publishing, Cape Town, South Africa. 150 pages.

Reynolds, Gilbert W. 1966. *The Aloes of Tropical Africa and Madagascar.* Trustees Aloe Book Fund, Mbabane, South Africa. 537 pages.

Reynolds, Gilbert W. 1982. *The Aloes of South Africa.* A.A. Balkema, Leiden, Netherlands. 538 pages.

Sunset Magazine and Books editors. 1978. *Cactus and Succulents.* Lane Publishing Co., Menlo Park, California. 80 pages.

Van Wyk, B. 2003. *Guide to the Aloes of South Africa*. Briza Publications, Pretoria, South Africa. 304 pages.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

Weniger, Del. 1984. *Cacti of Texas and Neighboring States.* University of Texas Press, Austin, Texas. 356 pages.

PLANT PROPAGATION

Hartmann, Hudson T. and Dale E. Kester. 2001. *Hartmann and Kester's Plant Propagation: Principles and Practices.* Prentice Hall, Engelwood Cliffs, New Jersey. 880 pages.

Nokes, Jill. 2001. *How to Grow Native Plants of Texas and the Southwest.* University of Texas Press, Austin, Texas. 624 pages.

Schmidt, Marjorie. 1980. *Growing California Native Plants.* University of California Press, Berkeley, California. 400 pages.

OTHER USEFUL REFERENCES

Arizona Municipal Users Association Water Conservation Website. http://www.amwua.org/conservation/landscape.htm.

Elias, Thomas. 2000. *Complete Trees of North America: Field Guide and Natural History.* Chapman and Hall, New York, New York. 948 pages.

Graf, Alfred. 1992. *Hortica: Color Cyclopedia of Garden Flora and Indoor Plants.* Roehrs Company, East Rutherford, New Jersey. 1216 pages.

Griffiths, Mark. 1994. *Index of Garden Plants: The New Royal Horticultural Society Dictionary*. Trans-Atlantic Publications, Philadelphia, Pennsylvania. 1234 pages.

Hitchcock, A.S. 1971. *Manual of the Grasses of the United States: Volumes 1 and 2.* Dovor Publication Inc. New York, New York. 1051 pages.

Liberty Hyde Bailey Hortorium staff editors. 1976. *Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada.* MacMillian Publishing Co. Inc., New York, New York. 1312 pages.

Little, Elbert. 1980. *The Audubon Society Field Guide to North American Trees: Western Region.* Alfred Knopf, New York, New York. 640 pages.

Petrides, George. 1998. *A Field Guide to Western Trees.* Houghton - Mifflin Company, Boston, Massachusetts. 448 pages.

Rickett, Howard W. 1970. *Wild Flowers of the United States, Volume 4: Southwestern States.* McGraw Hill, New York, New York. 280 pages.

Sunset Magazine and Books editors. 1995. *Sunset Western Garden: The Complete Interactive Guide to Your Yard and Garden*. CD-ROM. Sunset Publishing Corporation, Menlo Park, California.

Phoenix AMA• 3550 North Central Avenue, Phoenix, AZ 85012• Tel. 602-771-8585• Fax 602-771-8688

Water Resources Research Center. 2005. *Desert Landscaping Plants for a Water Scarce Environment: Version 2.0*. CD-ROM. University of Arizona, College of Agriculture, Tucson, Arizona.

SUPPLEMENTAL INFORMATION

PHOENIX ACTIVE MANAGEMENT AREA

ARIZONA DEPARTMENT OF WATER RESOURCES

The Department of Water Resources has created this supplemental listing as an informational appendix to the Low Water Use/Drought Tolerant Plant List. The supplement contains a listing of species, which are considered representatives of the genera listed in the Low Water Use/Drought Tolerant Plant List. This list was compiled by the Department of Water Resources in cooperation with the Arizona Municipal Water Users Association, Landscape Technical Committee, comprised of experts from the Desert Botanical Garden, the Arizona Department of Transportation and various municipal, nursery, and landscape specialists in the Phoenix AMA. Individuals wishing to add or delete plants from the list may submit information to the Director for consideration. The Director will amend the list as appropriate.

This supplement is an informational tool only and is not intended to limit the use of any species or cultivars within a genus.

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TREES

Genus	Species	Common Name
Acacia	*abyssinica*	Abyssinian Acacia
	aneura	Mulga
	coriacea	
	erioloba	Camel Thorn
	farnesiana (smallii, minuta)	Sweet Acacia
	greggii	Catclaw Acacia
	salicina	Willow-leaf Acacia
	schaffneri	Twisted Acacia
	stenophylla	Shoestring Acacia
	willardiana	Palo Blanco
Brahea	*armata*	Mexican Blue Palm
	edulis	Guadalupe Palm
Bursera	*hindsiana*	Copal
	microphylla	Elephant Tree
Caesalpinia	*cacalaco*	Cascalote
Casuarina	*cunninghamiana*	River She Oak
	equisetifolia	Horsetail Tree
	stricta	Coast Beefwood
Cercidium	*floridum*	Blue Palo Verde
	microphyllum	Foothill Palo Verde
	praecox	Sonoran Palo Verde, Palo Brea
Eucalyptus	*erythrocorys*	Red Cap Gum
	formanii	Forman's Eucalyptus
	leucoxylon	White Ironbark
	microtheca	Coolibah
	papuana	Ghost Gum
	populnea	Poplar-leaf Eucalyptus
	spathulata	Narrow-leaf Gimlet
	torquata	Coral Gum
Lysiloma	*candida*	Palo Blanco
	microphylla var. *thornberi*	Desert Fern
Pistacia	*atlantica*	Mt. Atlas Pistache
	chinensis	Chinese Pistache
Pithecellobium	*flexicaule*	Texas Ebony
	mexicanum	Palo Chino
	pallens	Apes-earring

TREES (continued)

Genus	Species	Common Name
Prosopis	*alba*	Argentine Mesquite
	chilensis	Chilean Mesquite
	glandulosa var. *torreyana*	Texas Honey Mesquite
	pubescens	Screwbean Mesquite
	velutina (juliflora)	Velvet Mesquite
Quercus	*buckleyi*	Texas Red Oak
	emoryi	Emory Oak
	suber	Cork Oak
	turbinella	Shrub Live Oak
	virginiana	Southern Live Oak
Washingtonia	*filifera*	California Fan Palm
	robusta	Mexican Fan Palm

SHRUBS

Genus	Species	Common Name
Acacia	*angustissima* var. *hirta*	Fern Acacia
	berlandieri	Guajillo
	constricta	White Thorn Acacia
	craspedocarpa	Leather-leaf Acacia
	millefolia	Santa Rita Acacia
	notabilis	
	rigens	Needle Acacia
	rigidula	Blackbrush Acacia
Aloysia	*gratissima*	Bee Brush
	lycioides	Bee Bush
	macrostachya	Sweet-stem
	wrightii	Oreganillo
Anisacanthus	*andersonii*	Anderson's Honeysuckle
	quadrifidus	Flame Honeysuckle
	thurberi	Desert Honeysuckle
Artemesia	*ludoviciana*	White Sage
Atriplex	*canescens*	Fourwing Saltbush
	hymenelytra	Desert Holly
	lentiformis	Quail Bush
	nummularia	Old Man Saltbush
Baccharis	*sarothroides*	Desert Broom
Caesalpinia	*gilliesii*	Desert Bird of Paradise
	mexicana	Mexican Bird of Paradise
	pulcherrima	Red Bird of Paradise
Calothamnus	*quadrifidus*	
	villosus	Woolly Netbush
Cassia (Senna)	*artemisioides*	Feathery Cassia
	biflora	Twin Flower Cassia
	goldmannii	
	nemophila	Desert Cassia
	phyllodinea	Silver-leaf Cassia
	wislizenii	Shrubby Cassia
Cistus	*incanus (villosus)*	Rockrose

SHRUBS (continued)

Genus	Species	Common Name
Dalea	*bicolor* var. *argyraea*	Silver Dalea
	frutescens	Black Dalea
	pulchra	Indigo Bush
	versicolor var. *sessilis*	Wislizenus Dalea
Encelia	*farinosa*	Brittle Bush
Ephedra	*nevadensis* var. *aspera*	Boundary Ephedra
	trifurca	Mormon Tea
Eremophila	*glabra*	Spotted Emu Bush
	maculata	Emu Bush
Eriogonum	*fasciculatum*	California Buckwheat
Jatropha	*cardiophylla*	Limberbush
	cinerea	Lomboy
	dioica	Leatherstem
Justicia	*californica*	Chuparosa
	candicans (ovata)	Red Justicia
	spicigera	Mexican Honeysuckle
	sonorae	Palm Canyon Justicia
Leucophyllum	*candidum*	Silver Sage (cv. 'Silver Cloud', 'Thunder Cloud')
	frutescens	Texas Sage (cv. 'Green Cloud','White Cloud', 'Compacta')
	laevigatum	Chihuahuan Sage
	langmanniae	Sierra Madre Sage
	pruinosum	Fragrant Sage
	zygophyllum	Blue Ranger
Lycium	*andersonii*	Anderson Thornbush
	brevipes	Frutilla
	fremontii	Wolfberry
Pyracantha	*coccinea*	Firethorn
Salvia	*clevelandii*	Chapparal Sage
	greggii	Autumn Sage
	leucantha	Mexican Bush Sage
	leucophylla	Purple Sage
	dorrii	Desert Sage
	chamaedryoides	Blue Sage

SHRUBS (continued)

Genus	Species	Common Name
Senna (Cassia)	*artemisioides*	Feathery Cassia
	biflora	Twin Flower Cassia
	goldmannii	
	nemophila	Desert Cassia
	phyllodinea	Silver-leaf Cassia
	wislizenii	Shrubby Cassia
Vauquelinia	*corymbosa*	Narrow-leaf Rosewood
	californica	Arizona Rosewood

GROUNDCOVERS

Genus	Species	Common Name
Acacia	*redolens*	Trailing Acacia (cv. 'Desert Carpet')
Atriplex	*semibaccata*	Australian Saltbush
Baccharis	cv. *'Centennial'*	Centennial Baccharis
Dalea	*greggii*	Trailing Dalea
Gazania	*rigens*	Trailing Gazania
Zauschneria	*californica*	Hummingbird Flower

SUCCULENTS/ACCENTS

Genus	Species	Common Name
Agave	*americana*	Century Plant
	colorata	Mescal Ceniza
	parryi	Parry's Agave
	victoriae-reginae	Royal Agave
	vilmoriniana	Octopus Agave
	murpheyi	Murphy's Agave

SUCCULENTS/ACCENTS (continued)

Genus	Species	Common Name
Aizoaceae - Ice Plant Family		
Carpobrotus	*chilensis*	Ice Plant
	edulis	Hottentot Fig
Cephalophyllum	cv. *'Red Spike'*	Red Spike Ice Plant
Drosanthemum	*speciosum*	Dewflower
Malephora	*crocea*	Ice Plant
Mesembryanthemum	*crystallinum*	Common Ice Plant
Aloe	*barbadensis (vera)*	Medicinal Aloe
	ferox	Tree Aloe
	saponaria	Tiger Aloe
	marlothii	
	striata	Coral Aloe
Cactaceae - Cactus Family		
	Carnegiea gigantea	Saguaro
	Cereus hildmannianus	Hildmann's Cereus
	Echinocactus grusonii	Golden Barrel
	Echinocereus engelmannii	Engelmann's Hedgehog
	Ferocactus acanthodes	Compass Barrel
	Ferocactus wislizenii	Fishook Barrel
	Lophocereus schottii	Senita
	Opuntia acanthocarpa	Buckhorn Cholla
	Opuntia basilaris	Beavertail Prickly Pear
	Opuntia bigelovii	Teddy Bear Cholla
	Opuntia engelmannii	Desert Prickly Pear
	Opuntia ficus-indica	Indian Fig
	Opuntia violacea	Purple Prickly Pear
	Pachycereus marginatus	Mexican Organ Pipe
	Stenocereus thurberi	Arizona Organ Pipe
	Trichocereus candicans	Argentine Trichocereus
Dasylirion	*acrotriche*	Green Desert Spoon
	wheeleri	Sotol, Desert Spoon
Fouquieria	*macdougallii*	Chunari
	splendens	Ocotillo

SUCCULENTS/ACCENTS (continued)

Genus	Species	Common Name
Hesperaloe	*campanula*	Bell Flower
	funifera	Coahuilan Hesperaloe
	parviflora	Red Hesperaloe
	nocturna	
Nolina	*matapensis*	Tree Bear Grass
	microcarpa	Bear Grass
Yucca	*aloifolia*	Spanish Bayonet
	baccata	Banana Yucca
	brevifolia	Joshua Tree
	elata	Soaptree Yucca
	rigida	Blue Yucca
	rostrata	Beaked Yucca

ANNUAL WILDFLOWERS

Genus	Species	Common Name
Cosmos	*bipinnatus*	
	parviflorus	
	sulphureus	Yellow Cosmos
Dimorphotheca	*sinuata*	African Daisy
Helipterum	*roseum*	Pink Everlasting
Linaria	*texana*	Toadflax
	pinnifolia	Toadflax
	maroccana	Toadflax
Mentzelia	*involucrata*	Morning Stars
	lindleyi	Blazing Stars
Phacelia	*campanularia*	California Bluebell
	tanacetifolia	Scorpion Weed
Plantago	*insularis*	Indian Wheat
Ursinia	*calenduliflora*	
	chrysanthemoides	
	speciosa	

PERENNIAL WILDFLOWERS

Genus	Species	Common Name
Anigozanthos	*flavidus*	Kangaroo Paw
	viridis	Kangaroo Paw
	manglesii	Kangaroo Paw
Arctotis	*acaulis*	African Daisy
Penstemon	*baccharifolius*	Rock Penstemon
	barbatus	Scarlet Penstemon
	eatonii	Firecracker Penstemon
	palmeri	Palmer's Penstemon
	parryi	Parry's Penstemon
	pseudospectabilis	Canyon Penstemon
	spectabilis	Royal Penstemon
	superbus	Superb Penstemon
Sphaeralcea	*ambigua*	Globe Mallow
Tagetes	*palmeri(lemmoni)*	Mt. Lemmon Marigold
	lucida	Mexican Mint Marigold
Zephyranthes	*candida*	Zephyr Flower
	citrina	Fairy Lily
	grandiflora	Rain Lily

VINES

Genus	Species	Common Name
Bougainvillea	*spectabilis (brasiliensis)*	Bougainvillea