MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A
WATER CONSERVATION METHODS FOR U.S. ARMY INSTALLATIONS: VOLUME I, RESIDENTIAL USAGE MANAGEMENT

by
R. J. Scholze
L. J. Benson
M. A. Kamiya
M. J. Staub
J. T. Bandy

DTIC SELECTED
MAY 25 1983

Approved for public release; distribution unlimited.
The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official indorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.
The objectives of this report were: (1) to compile information on methods of conserving water, and (2) to provide guidance that facilities engineers can use to identify practices that conserve water in residences and that are appropriate for the Army. To accomplish these objectives, the U.S. Army Construction Engineering Research Laboratory (CERL) conducted literature searches and manufacturer surveys to determine the availability, compatibility, cost, and performance of household devices that conserve water.
CERL's work indicates that the following guidelines can help conserve water:

1. Water conservation should be considered as part of the installation's energy conservation program.

2. Water conservation techniques, such as installing devices on household fixtures, are an important part of comprehensive water supply planning, and should be considered for retrofitting and for new construction projects.

3. Because many types of conservation devices are available, the facilities engineer can select proven device technology with which there is little risk of failure or public rejection. The transition from conventional fixtures to water conservation devices usually can be made without major behavior changes by residents.

These guidelines are applicable at installations inside and outside the Continental United States under both peacetime and mobilization conditions.

Volume II provides guidance on identifying practices that conserve water in irrigation.
FOREWORD

This study was performed by the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (CERL) for the Assistant Chief of Engineers, under Project 4A762720A896, "Environmental Quality Technology"; Technical Area A, "Installation Environmental Management Strategy"; Work Unit 031, "Water Conservation and Reuse Guidelines." The applicable QCR is 6.27.20A. The OCE Technical Monitor was Walter Medding, DAEN-ECE-D. Dr. R. V. Jain is Chief of EN.

Appreciation is expressed to Sharen Kloster, Robert Fileccia, and Cynthia Watson, all of CERL, for their work supporting this project — and especially to Joseph Matherly (CERL) for anticipating the Army’s need for this type of research.

For their administrative and technical assistance, appreciation is extended to Mr. Craig Withee, formerly Sanitary Engineer, Fort Carson; Mr. David Hanke, Sanitary Engineer, Fort Lewis; Mr. Manny Ortega, formerly Sanitary Engineer, Fort Bliss; and Mr. Louis Castro, present Sanitary Engineer, Fort Bliss.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD FORM 1473</td>
<td>1</td>
</tr>
<tr>
<td>FOREWORD</td>
<td>3</td>
</tr>
<tr>
<td>LIST OF TABLES AND FIGURES</td>
<td>5</td>
</tr>
<tr>
<td><strong>1 INTRODUCTION</strong></td>
<td>7</td>
</tr>
<tr>
<td>Background</td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>Mode of Technology Transfer</td>
<td></td>
</tr>
<tr>
<td><strong>2 WATER CONSERVATION BY THE ARMY</strong></td>
<td>9</td>
</tr>
<tr>
<td>The Importance of Conservation</td>
<td></td>
</tr>
<tr>
<td>The Army’s Use of Water</td>
<td></td>
</tr>
<tr>
<td>Army Guidance</td>
<td></td>
</tr>
<tr>
<td>Command Emphasis</td>
<td></td>
</tr>
<tr>
<td>Residential Water Usage</td>
<td></td>
</tr>
<tr>
<td><strong>3 METHODS FOR CONSERVING WATER IN RESIDENCES</strong></td>
<td>13</td>
</tr>
<tr>
<td>Leak Detection</td>
<td></td>
</tr>
<tr>
<td>Pressure Reduction</td>
<td></td>
</tr>
<tr>
<td>Conservation Devices</td>
<td></td>
</tr>
<tr>
<td>Water Conservation in Public Buildings</td>
<td></td>
</tr>
<tr>
<td>Device Evaluation and Selection</td>
<td></td>
</tr>
<tr>
<td><strong>4 CONCLUSION</strong></td>
<td>29</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>30</td>
</tr>
<tr>
<td>APPENDIX A: Case Histories</td>
<td>32</td>
</tr>
<tr>
<td>APPENDIX B: List of Manufacturers</td>
<td>33</td>
</tr>
<tr>
<td>METRIC CONVERSION CHART</td>
<td>37</td>
</tr>
<tr>
<td>DISTRIBUTION</td>
<td></td>
</tr>
</tbody>
</table>
TABLES

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Typical Activities Related to Water and Wastewater at Army Installations</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Distribution of Residential Water Use</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Analysis of Water Conservation Methods</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Device Installation and Usage</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Conservation Devices</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>Special Systems</td>
<td>18</td>
</tr>
</tbody>
</table>

FIGURES

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standard Toilet</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>Bottles and Bags</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Bracket</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Toilet Dams</td>
<td>22</td>
</tr>
<tr>
<td>5</td>
<td>Two-Cycle Toilet</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>Low-Flow Showerhead</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>Flow Restrictors</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>Flow Regulator</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>Thermostatic Mixing Valve</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>Pressure-Balancing Mixing Valve</td>
<td>26</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

Background

The U.S. Army uses more than 130 billion gallons of water annually and spends more than $130 million for operation and maintenance (O&M) of its water and wastewater utilities. As demands and costs increase, and limits are imposed on spending, water conservation technology becomes important for effective installation management. To provide facilities engineers with information about this technology, the Office of the Chief of Engineers asked the U.S. Army Construction Engineering Research Laboratory (CERL) to examine methods of conserving the water used in residences and for turf maintenance. These uses account for much of the water consumed at an installation; for example, irrigation for lawn and turf maintenance takes as much as half of the water used during warm months. At one installation, winter per capita usage averaged 100 gallons per day (gpd); in summer, the usage increased to nearly 400 gpd. When shortages appear imminent, the water used in residences and for irrigating lawns and turf can be cut significantly by the techniques described in this report. With this guidance and that described in Volume II for turf maintenance, the threat of shortages can be reduced, and it might not be necessary to go to the expense of finding additional water supplies. The water conservation techniques described are applicable at installations inside and outside the continental United States under both peacetime and mobilization conditions.

Objective

The overall objective of this study is to analyze water conservation at fixed Army installations. The objectives of the phase of the study documented in this report were: (1) to collect information on methods of conserving water, and (2) to provide guidance that facilities engineers can use to identify practices that conserve water in residences and that are appropriate for the Army. Volume II provides guidance on identifying practices that conserve water in irrigation. A future report will assess data collected during field surveys of water used in residences at Fort Carson.

Approach

To accomplish the objectives of this phase of the study, CERL conducted literature searches and manufacturer surveys to determine the availability, compatibility, cost, and performance of household devices that conserve water.
Mode of Technology Transfer

Information from this study may impact Technical Manual (TM) 5-660, TM 5-661, TM 5-551, TM 5-630, TM 5-830-1, TM 5-830-2, and TM 5-830-4.

1 Operation of Water Supply and Treatment Facilities at Fixed Army Installations, Technical Manual (TM) 5-660 (Headquarters [HQ], Department of the Army [DA], November 1952); Inspection and Preventive Maintenance Services for Water Supply Systems at Fixed Installations, TM 5-661 (HQDA, September 1945); Plumbing and Pipefitting, TM 5-551 (HQDA, July 1971); Repairs and Utilities -- Ground Maintenance and Land Management, TM 5-630 (HQDA, December 1967); Planting Design, TM 5-830-1 (HQDA, June 1976); Planting -- Planting Turf, TM 5-830-2 (HQDA, October 1961); Planting and Establishment of Trees, Shrubs, Ground Covers and Vines, TM 5-830-4 (HQDA, June 1976).
The Importance of Conservation

The advantages of conservation have become evident as the supplies and the quality of water have declined in many areas. Where groundwater is the major or sole supply of water, it is being withdrawn faster than the recharge rates. With increased pollution of surface water and groundwater, it will become harder to maintain high quality water supplies. For many years it was thought that increasing demands could be met by increasing supplies, but extensive drought across the country has made severe water shortages a national concern. Conservation measures can be used effectively to help ease some of these shortages.

Conservation has traditionally meant saving or storing water, but today the definition has broadened to include the wise use and management of this resource. Conserving water offers many benefits: energy savings from pumping, handling, and processing; reduced loads on sewage and water treatment plants; less demand for new supplies or less time needed to plan for new supplies; adequate supplies during droughts; and economic savings to the consumer. The goal of conservation is to provide the greatest use from existing supplies.

The Army's Use of Water

There are more than 100 fixed Army installations across the United States. Each post is like a small city, with a large residential section and commercial, industrial, and recreational sectors (Table 1). While the basic water uses by military installations and cities are similar, the unusual features of military posts should be recognized:

1. Because of the large number of civilian employees, the population can fluctuate greatly from day to evening.

2. Maneuvers, leave passes, and training exercises may also cause population fluctuations.

3. Army personnel must follow command orders and instructions; therefore, directives ordering water conservation can be enforced quickly.

4. Activities unique to the Army affect water and wastewater plants — e.g., tactical vehicle washing and maintenance, and aircraft maintenance.

5. Army personnel pay a fixed amount for unlimited quantities of water. Thus, rate structures cannot encourage conservation because personnel do not directly pay for the amount of water they use. Other incentives for conservation must be found.
Table 1

Typical Activities Related to Water and Wastewater at Army Installations

<table>
<thead>
<tr>
<th>Administration/Institutional</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unclassified office space</td>
<td>Vehicle wash racks</td>
</tr>
<tr>
<td>Shipping and receiving facilities</td>
<td>Aircraft wash</td>
</tr>
<tr>
<td>Communications facilities</td>
<td>Steam cleaning</td>
</tr>
<tr>
<td>Command-level headquarters</td>
<td>Metal plating and finishing</td>
</tr>
<tr>
<td>Radar installations</td>
<td>Autoclaves</td>
</tr>
<tr>
<td>Military training and instruction facilities</td>
<td>Boilers</td>
</tr>
<tr>
<td></td>
<td>Metal cleaning</td>
</tr>
<tr>
<td></td>
<td>Paint booth water well</td>
</tr>
<tr>
<td></td>
<td>Air pollution wet scrubbers</td>
</tr>
<tr>
<td></td>
<td>Laboratories</td>
</tr>
<tr>
<td></td>
<td>Cooling towers</td>
</tr>
<tr>
<td></td>
<td>Dynamometers</td>
</tr>
<tr>
<td></td>
<td>Engine test cells</td>
</tr>
<tr>
<td></td>
<td>Ash handling systems</td>
</tr>
<tr>
<td></td>
<td>Industrial laundries</td>
</tr>
<tr>
<td></td>
<td>Pesticide management area</td>
</tr>
<tr>
<td></td>
<td>Photographic laboratory</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wastewater Management</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage treatment</td>
<td></td>
</tr>
<tr>
<td>Industrial waste treatment</td>
<td></td>
</tr>
<tr>
<td>Wastewater disposal</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Housing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Family housing</td>
<td></td>
</tr>
<tr>
<td>Barracks</td>
<td></td>
</tr>
<tr>
<td>Bachelor officers quarters</td>
<td></td>
</tr>
<tr>
<td>Visiting officers quarters</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Commercial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissary</td>
<td></td>
</tr>
<tr>
<td>Post exchange</td>
<td></td>
</tr>
<tr>
<td>Gas station</td>
<td></td>
</tr>
<tr>
<td>Laundromats</td>
<td></td>
</tr>
<tr>
<td>Restaurant/cafeterias</td>
<td></td>
</tr>
<tr>
<td>Post office</td>
<td></td>
</tr>
<tr>
<td>Bank</td>
<td></td>
</tr>
</tbody>
</table>
Army Guidance

The Army now has no official regulations on water conservation devices at fixed military installations. However, many Army posts have developed their own water conservation plans for dealing with drought and reducing the water usage of all activities on post. TM 5-660 has a section on water conservation, stressing its importance and mentioning some simple ways to reduce consumption. For Civil Works projects, OCE has developed an implementation plan for water conservation. But at fixed military installations, the responsibility for water conservation lies with the facility engineer and the base commander.

Command Emphasis

The facilities engineer should seek the commander's support for water conservation. The commander's emphasis on conservation will increase the effectiveness of the program by increasing its priority.

Residential Water Usage

Except for vehicle wash and irrigation, family housing is the largest consumer of water on a military installation. (Average residential water usage is shown in Table 2.) Residential water conservation contributes to savings for the entire installation. Though individual savings may seem small, the overall effect can be a significant reduction in water use. For consumer water management programs to be effective, conservation by individuals must be emphasized.

Flushing toilets and watering the lawn take the most water in an average household. Variations in water use have been correlated with many factors, such as standard of living, climate, personal habits, and the number and ages of the people in a family. Army residential uses are similar to those in the public sector, so the Army should realize similar benefits from water conservation programs: reduction of water consumption, savings of money and energy, reduction of loads on water and wastewater treatment plants, and education of the public about the importance of water. Examples of some benefits are in Appendix A.

The use of the conservation methods discussed in Chapter 3 should be just one element in such programs, which may also include metering and rate structure control, reuse, legislation, and behavioral changes.

---

4 Milne, 1976.
Table 2

Distribution of Residential Water Use

<table>
<thead>
<tr>
<th>Indoor Water Consumption</th>
<th>Percent</th>
<th>Typical Usage, gpcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilets</td>
<td>45</td>
<td>32</td>
</tr>
<tr>
<td>Bathing and Personal</td>
<td>30</td>
<td>21</td>
</tr>
<tr>
<td>Laundry and Dishes</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Drinking and Cooking</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outdoor Water Consumption</th>
<th>Percent</th>
<th>Typical Usage, gpcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>Variable</td>
<td>--</td>
</tr>
<tr>
<td>Swimming Pools</td>
<td>Variable</td>
<td>--</td>
</tr>
<tr>
<td>Car Washing</td>
<td>Variable</td>
<td>--</td>
</tr>
</tbody>
</table>

70 gal total assumed for outdoor uses

Note: gpcd = gallons per capita per day.
3 METHODS FOR CONSERVING WATER IN RESIDENCES

Leak Detection

Water conservation for individual residences should first focus on leaks and waste resulting from poor water-use habits: leaving the water running while brushing teeth, shaving, and preparing meals; not using the proper settings on washing machines; placing sprinklers improperly; and not replacing or repairing leaky fixtures. Tips for conserving water are published by many sources: U.S. Government agencies, local and State governments, and water utilities.5

Residential water leaks can account for 5 to 10 percent of the total water consumption.6 Most of these leaks can be fixed with simple maintenance procedures, such as replacement of worn washers (TM 5-551). Even small leaks of 80 drips per minute can waste 2500 gal a year. Leaks can also be a nuisance, causing noises and water marks. Public education and prompt service by the plumbing maintenance shop can encourage personnel to report leaks.

Programs which check distribution lines for leaks in equipment and fixtures should be instituted.7 Meters are useful in detecting major water losses within the household. For example, the meter can be checked before residents go to sleep and again in the morning. Differences in the meter readings indicate water loss in the system. The high initial cost of installation is the main problem with meters. In the long run, however, the meter can provide information valuable enough to offset this short-term disadvantage. Leaks in mains can be detected by three methods: ultrasound, pressure differential, and meter reading.

Pressure Reduction

The pressure of the mains and laterals of the water distribution system may vary throughout the post. The pressure may be especially high (>80 psi) in certain areas for many reasons, such as a steep gradient. Proper placement of pressure reduction valves can conserve water in two ways. First, less pressure insures that less water is delivered to the consumer; therefore, less water is wasted. Second, because all water mains leak, reduced pressure

6 Milne, 1976.
insures that less water is lost through leaks. The valves are inexpensive, compared with potential savings, and do not require frequent maintenance. Note that when pressure reduction is considered, minimum pressure standards must be complied with.

**Conservation Devices**

The devices most commonly used to conserve water are shallow trap toilets, dual flush toilets, toilet inserts, flow restrictors, aerators, low-flow shower heads, hose attachments, and pressure-reducing valves. Most of these are designed to operate like conventional equipment, thus requiring few changes in residents' habits. Many of the devices may even be more convenient than the originals.

Table 3 analyzes water conservation methods. Appendix B is a list of some of the companies producing conservation devices. Table 4 compares the installation and use of four specific devices. Table 5 lists common conservation equipment, gives its cost, and describes consumers' attitudes toward it. Table 6 lists devices for special situations.

**Toilets**

There are four types of toilets: two-piece with tank detached, two-piece with tank (close coupled), one-piece with tank, and one-piece tankless. The two-piece is an older design. The tank is raised high above the bowl, which gives high water velocity and requires less water per flush. The most common toilet is the two-piece close coupled. Its tank is connected directly to the bowl and generally requires 5 to 8 gal per flush. The one-piece has no tank but is connected directly to the water line. This system generally is not used in individual residences because it requires high water flow rates, which usually cannot be met by standard residential water lines.

**Stopping Leaks.** If the toilet is noisy or runs on after it is flushed, water is probably leaking. Some parts of the toilet mechanism may simply need to be adjusted (Figure 1). Leaks usually can be found if the float and the seat of the valve are checked. Take off the float and shake it; if water can be heard, replace the float. Special floats are now made which rise more efficiently and do not become waterlogged. The signal float is efficient and makes a gurgling noise if there is a leak.

If the toilet still makes noise after these steps have been taken, the flush ball probably needs to be adjusted so it will seat properly. If a new flush ball is needed, it can be replaced with a "flapper assembly." This does not have a guide arm and guide wire, and therefore does not have to be adjusted as a flush ball does.

Silent leaks, which overflow into the bowl, can waste hundreds of gallons of water a day -- a major loss. When checking for these leaks, first make sure that the float is adjusted so that the water does not run into the overflow tube. Also see whether the ballcock is leaking directly into the overflow tube. (Some new types of ballcocks can be adjusted to lower water levels in the tank.) To detect a silent leak, remove the tank cover and add some food coloring to the water. (Commercial dye capsules are also available.)
### Table 3

**Analysis of Water Conservation Methods**

<table>
<thead>
<tr>
<th>Conservation Method</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak detection and repair</td>
<td>Cannot rely on many users to do leak detection in homes or businesses.</td>
</tr>
<tr>
<td>Water-saving fixtures</td>
<td>Simple fixtures that require little change in user habits and are convenient to install would be appropriate; otherwise may be unacceptable.</td>
</tr>
<tr>
<td>Reuse-recycle</td>
<td>Generally too expensive, difficult to operate, socially/aesthetically difficult to accept for full implementation.</td>
</tr>
<tr>
<td>User habit changes</td>
<td>May work temporarily; cannot be relied on for long-term.</td>
</tr>
</tbody>
</table>


### Table 4

**Device Installation and Usage**

<table>
<thead>
<tr>
<th>Device</th>
<th>Cost</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faucet aerator</td>
<td>$2.00</td>
<td>Easy to install, but installation's Water Department should do some to insure full installation. Well accepted — no maintenance problems.</td>
</tr>
<tr>
<td>Plastic bottles for toilet</td>
<td>$1.50</td>
<td>To insure full installation, Water Department should assume some installation duties. Also, bottles very reusable and can fit in most models.</td>
</tr>
<tr>
<td>tank displacement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dams for toilet tank displacement</td>
<td>$2.50 per dam</td>
<td>To insure proper installation, Water Department should install. Dams may not fit all toilet models. Dams must be periodically adjusted.</td>
</tr>
<tr>
<td>Shower flow restrictors</td>
<td>$0.25 per restrictor</td>
<td>To insure proper installation, Water Department should install some. May have problems with customer acceptance.</td>
</tr>
</tbody>
</table>
### Table 5
Conservation Devices*

<table>
<thead>
<tr>
<th>Fixtures</th>
<th>Short-(S) or Long-Term(L)</th>
<th>Capital</th>
<th>Compared to Conventional Fixtures**</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor, For Average Demand Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shallow trap toilet</td>
<td>L</td>
<td>$75</td>
<td>=</td>
<td>Very well accepted by users.</td>
</tr>
<tr>
<td>Dual flush toilet</td>
<td>L</td>
<td>$85</td>
<td>=</td>
<td>Minor change in use pattern required.</td>
</tr>
<tr>
<td>Toilet tank inserts</td>
<td>S,L</td>
<td>$0.90-4.00</td>
<td>N/A</td>
<td>Retrofit to conventional fixtures.</td>
</tr>
<tr>
<td>Shower flow restrictors</td>
<td>S,L</td>
<td>$0.75-25.00</td>
<td>=</td>
<td>Some retrofit to conventional fixtures.</td>
</tr>
<tr>
<td>Faucet aerators</td>
<td>L</td>
<td>$1-5</td>
<td>=</td>
<td>Well-accepted by consumers.</td>
</tr>
<tr>
<td>Hot water pipe insulation</td>
<td>L</td>
<td>$0.50/ft.</td>
<td>N/A</td>
<td>Saves up to 8 gal per capita per day.</td>
</tr>
<tr>
<td>Vacuum flush toilet</td>
<td>L</td>
<td>Expensive</td>
<td>Higher</td>
<td>Mixed acceptance by consumers.</td>
</tr>
<tr>
<td>Pressurized flush toilet</td>
<td>L</td>
<td>$360</td>
<td>Higher</td>
<td>Requires electricity.</td>
</tr>
<tr>
<td>Electrically controlled plumbing</td>
<td>L</td>
<td>New installation not much more than conventional plumbing</td>
<td>75%</td>
<td>Reductions not documented. Probably cost-effective for new developments only.</td>
</tr>
<tr>
<td>Hot water recirculation</td>
<td>L</td>
<td>Hundreds of dollars</td>
<td>Eliminates waste while waiting for hot water</td>
<td>Cost-effective for new developments only.</td>
</tr>
<tr>
<td>Automatic dishwasher</td>
<td>L</td>
<td>$175-350</td>
<td>Could save, if properly used</td>
<td>Widely used.</td>
</tr>
<tr>
<td>Automatic clothes washers–suds saver</td>
<td>L</td>
<td>N/A</td>
<td>$15-20 more than conventional</td>
<td>Not now generally used.</td>
</tr>
<tr>
<td>Functionally designed sinks/tubs</td>
<td>L</td>
<td>Not significantly more than conventional</td>
<td>Potential savings</td>
<td>Reduces volume in tub/sink to minimum necessary. Limits aesthetics of fixtures.</td>
</tr>
</tbody>
</table>

** Not applicable (N/A); equivalent (=).
Table 5 (Cont'd)

<table>
<thead>
<tr>
<th>Fixtures</th>
<th>Short(-S) or Long(-L) Need</th>
<th>Capital Cost</th>
<th>Compared to Conventional Fixtures**</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bidets</td>
<td>L</td>
<td>$70</td>
<td>Potential savings</td>
<td>Not culturally acceptable in America.</td>
</tr>
<tr>
<td>Bottled water</td>
<td>S</td>
<td>$.50/gal</td>
<td>Users generally do not waste</td>
<td>Usually cooking and drinking only.</td>
</tr>
<tr>
<td>Solar stills</td>
<td>L</td>
<td>$500</td>
<td>N/A</td>
<td>Mostly for use where water is brackish.</td>
</tr>
<tr>
<td>Chilled water dispenser</td>
<td>N/A</td>
<td>$200 more than conventional luxury model refrigerator</td>
<td>Saves by eliminating running water</td>
<td>&quot;Luxury&quot; item.</td>
</tr>
<tr>
<td>Thermostatically controlled mixing valve</td>
<td>S,L</td>
<td>$60</td>
<td>Reduces water waste while waiting for correct temperature</td>
<td>&quot;Luxury&quot; item.</td>
</tr>
<tr>
<td>Pressure balancing mixing valve</td>
<td>N/A</td>
<td>$45</td>
<td>Potential savings</td>
<td>Mostly for showers (avoid thermal shock). &quot;Luxury&quot; item.</td>
</tr>
<tr>
<td>Leak signaling ballcock for toilet</td>
<td>L</td>
<td>$6-10</td>
<td>Potential savings is high</td>
<td>Loud noise when there is a leak.</td>
</tr>
</tbody>
</table>

Outdoor, For Peak Demand Problems

| Drip irrigation systems          | L                           | $7-30        | —                                   | For gardens, trees, shrubs only.                                        |
| Time-controlled sprinkler         | L                           | $70 and up   | Higher                              | Needs electricity.                                                      |
| Moisture indicators              | S                           | $0.05-25.00  | —                                   | Mixed acceptance by consumers.                                         |
| Hose attachments                 | L                           | $1-40        | —                                   | Well accepted by consumers.                                             |
| Swimming pool covers             | L                           | $270-4800    | N/A                                 | Mixed acceptance by consumers.                                         |
| Tensiometers                      | L                           | $15-30       | N/A                                 | Mixed acceptance by consumers.                                         |
| Tank flushing valve for toilet   | L                           | Insignificant | —                                   | More efficient flapper type.                                            |
| Variable flush                   | S,L                         | $5 (Retrofit) | Potential savings*                  | User depresses valve for as long as necessary. Not as acceptable as dual flush. |
Table 6
Special Systems*

<table>
<thead>
<tr>
<th>Domestic Indoor Fixtures</th>
<th>Cost</th>
<th>Water Reduction, Compared to Conventional Use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical toilets:</td>
<td>$100</td>
<td>100%</td>
<td>Mostly for recreation areas/vehicles.</td>
</tr>
<tr>
<td>self-contained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh water flushing:</td>
<td>$60</td>
<td>99%</td>
<td>Mostly for recreation areas/vehicles.</td>
</tr>
<tr>
<td>self-contained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh water recirculating:</td>
<td>$250</td>
<td>98%</td>
<td>Mostly for recreation areas/vehicles.</td>
</tr>
<tr>
<td>self-contained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste water recycling toilet</td>
<td>$1400-1650 (capital)</td>
<td>45%</td>
<td>Mostly for remote areas.</td>
</tr>
<tr>
<td></td>
<td>$100-300 (installation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressurized tank toilet</td>
<td>$40 (retrofit costs to</td>
<td>50-60%</td>
<td>35-120 psi needed in supply line. Possible</td>
</tr>
<tr>
<td></td>
<td>conventional unit)</td>
<td></td>
<td>for small development.</td>
</tr>
<tr>
<td>Controlled volume flush toilet</td>
<td>--</td>
<td>--</td>
<td>Mostly for marine use; not adaptable to home.</td>
</tr>
<tr>
<td>Oil flush toilet</td>
<td>$2500 (not installed)</td>
<td>99%</td>
<td>Suitable for areas with waste water disposal problems.</td>
</tr>
<tr>
<td>Composter toilet</td>
<td>$950 (not installed or</td>
<td>100%</td>
<td>Suitable for areas with waste water disposal problems.</td>
</tr>
<tr>
<td></td>
<td>delivered)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging toilet</td>
<td>--</td>
<td>100%</td>
<td>Needs electricity. Difficult to dispose of waste. Use in remote areas.</td>
</tr>
<tr>
<td>Incinerator toilet</td>
<td>$395 (capital)</td>
<td>100%</td>
<td>Needs power, regular maintenance for incinerator. Use in remote areas.</td>
</tr>
<tr>
<td></td>
<td>$75 (installation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freese toilet</td>
<td>$320 (not installed)</td>
<td>100%</td>
<td>Difficult to dispose of wastes; needs power. Use in remote areas.</td>
</tr>
<tr>
<td>Air-assisted shower head</td>
<td>$275</td>
<td>83-95%</td>
<td>Needs power. Too expensive for wide-scale use.</td>
</tr>
<tr>
<td>Self-closing mixing valves</td>
<td>Same as conventional (knee-</td>
<td>Potential savings more in public lavatories.</td>
<td>Most suitable for use in public lavatories.</td>
</tr>
<tr>
<td></td>
<td>or foot-operated are $75-120 or more)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instant hot water</td>
<td>$100 (not installed)</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Then see if the dye leaks into the bowl. To check for slow leaks, let the toilet stand for several hours. If the dye goes into the bowl, the flush ball should be replaced. When this is done, also repair or replace the valve seat if it is scarred or cut.

**Toilet Inserts.** One of the simplest ways to reduce water use is to put weighted plastic bottles in the tank (Figure 2). The cubic area of the object displaces that amount of water; thus, less water is used. Plastic bags which hang in the tank work the same way as the plastic bottles (Figure 2). The problem with bottles and bags is that they may decrease flushing efficiency. Do not use bricks, which can fall and crack the tank; in addition, they eventually crumble and can clog the openings in the bowl. Both bottles and bags must be kept clear of the toilet mechanism to allow proper operation. In some cases, the bottles must be laid lengthwise, depending on how the tank empties. Then they are not effective — especially if the tank has a raised valve and does not empty completely. Bottles and bags are most useful with larger toilet tanks, where there is room for them and the loss of head does not severely affect flushing efficiency.

A bracket which lowers the float can be useful for smaller toilet tanks (Figure 3). It is semi-adjustable and easy to install. This device also lowers the head into the toilet tank, so flushing may be less efficient.

Many companies make toilet dams, which conserve water by damming the bottom portion of the tank, making the effective tank capacity smaller (Figure 4). This system is better than the bottles because it retains the same head

![Figure 1. Standard toilet.](image-url)
Figure 2. Bottles and bags.

Figure 3. Bracket.
velocity. The dams are also very easy to install and relatively cheap. Manufacturers claim that the devices reduce water use 20 to 40 percent and pay for themselves in a few months. Possible problems are poor compatibility with the tank and loss of elasticity, which causes leaks and makes replacement necessary. Plastic dams tend to lose their elasticity more quickly than rubber ones.

The toilet enclosure is a more sophisticated version of the toilet dam. It encircles the valve and conserves water the same way the dam does. The enclosure surrounds the valve on three sides and then is secured with rods against the tank. This system is advantageous because it offers a better, longer-lasting seal.

Weights and Valve Raisers. Weights which attach to the flush valve allow the user to control the amount of water entering the bowl. This variable cycle is controlled by the length of time the trip handle is held down. This system can save water but may be inconvenient because the cycle is not automatic.

A valve raiser can help reduce water usage by not allowing part of the tank water to drain. This system maintains most of the effective head. To save water, the valve raiser must be adjusted to completely flush with each use.

Shallow Trap Toilets. If a new toilet is needed, many companies offer a low-flush model. It has a smaller tank than a conventional toilet, and the trapway is designed to start the siphon jet action earlier. Shallow trap toilets use 3 to 3-1/2 gal of water per flush instead of the standard toilet's 5 to 8 gal.

Two-Cycle Toilets. Less conventional toilets are also available. The two-cycle toilet has separate cycles for liquid and solid wastes (Figure 5). This system attempts to provide an efficient flush using as little water as possible. The solid waste cycle uses 2.5 gal and the liquid waste flush uses even less. The two-cycle mechanism replaces the old parts of the toilet. Though the idea is straightforward, the mechanism is difficult to install and is not adjustable. The initial investment is higher, but two-cycle toilets potentially can save more water than toilet dams.

Special Systems. Some designs do not have water as the transport medium. The oil-vacuum system uses oil; the waste is separated, and the oil is filtered and recycled. The waste is then collected, stored, and periodically dumped at a permanent site. Other innovative technology includes vacuum, incinerator, composting, and freeze toilets (Table 6). These methods are not used often because only special applications make them advantageous, and the initial investment is high.

---

DUAL FLUSH MECHANISMS

Figure 4. Toilet dams.

Figure 5. Two-cycle toilet.
Taking showers instead of baths can be an effective way to save water. Filling a bathtub can use more than 50 gal of water, but a 5-minute shower, with a low-flow showerhead, can take as little as 12.5 gal.

**Low-Flow Showerheads.** Low-flow showerheads can help cut water use without radical changes in washing habits. There are many types to choose from, so the facilities engineer can select models compatible with specific building types. Most of the devices look like conventional showerheads and usually have an adjustable flow (Figure 6). The aerating type -- which mixes air and water -- usually has a smaller spray pattern and is not adjustable. Some of the models have a shut-off valve which one can close while lathering up. This feature can provide a significant savings of water and energy. The costs of the showerheads vary widely, depending on the features and the types of materials used. To avoid weak spray patterns, the showerheads should be chosen carefully to insure that they are compatible with the plumbing.

**Flow Restrictors.** The cheapest way to decrease the flow is to use a flow restrictor. There are two models and two types of restrictors. The internal model is usually a plastic or metal disk which fits between the supply pipe and the showerhead (Figure 7). The external model is a threaded device which screws between the supply pipe and the showerhead (Figure 7). The two types are flow restrictors and flow regulators. The flow restrictor has a fixed opening and allows a specific flow at a specific pressure. The flow regulator compensates for different pressures and closes under increased pressure (Figure 8). This system can save more water than the flow restrictor because it is more flexible under varying conditions.

The major problem with both types of restrictors is that the spray pattern may be weak because of the reduced pressure. The systems are advantageous because of their low cost. Some companies make combination restrictors and shut-off valves which can increase water and energy savings.

**Aerators**

Aerators add air to water; they are installed on faucets to decrease water usage and splashing. Aerators can save 50 percent of the water run at a faucet. The laminar flow unit is useful for objects that are to be rinsed. It produces a stream of water that clings to the objects and allows more efficient rinsing, thus saving water.

**Mixing Valves**

The thermostatic mixing valve is a device which self-adjusts to maintain the proper temperature after the water temperature is set. The mechanism corrects for changes in temperature in the hot and cold water lines within a range of pressure changes. As the line temperature varies, this valve maintains the proper temperature with a bi-metal spring which moves to adjust the hot and cold water lines (Figure 9).

The pressure-balancing mixing valve can be useful for showers. It maintains constant water pressure by compensating for changes in line pressure (Figure 10). The valve is a mechanical device which slides back and forth as
Figure 6. Low-flow showerhead.

Figure 7. Flow restrictors.
PRESSURE COMPENSATOR

Figure 8. Flow regulator.

Figure 9. Thermostatic mixing valve.
the pressure changes. But unlike the thermostatic mixing valve, it does not compensate for fluctuation in the water line temperature.

**Appliances**

Water can be saved if residents use the special features now available on some household appliances. For example, a clothes washer might have variable water levels and a suds-saving cycle which reuses washwater, thus saving hot water and detergent. The average water use of a typical machine is 20 gal for the wash, 4 gal for a spray rinse, and 20 gal for a deep rinse. The suds-saver can cut water use by 20 percent. The savings from use of the adjustable level controls vary but can be significant.  

---

**Figure 10. Pressure-balancing mixing valve.**

---

The dishwasher uses about 13 to 16 gal of water for a 60-minute cycle. Additional water is required for rinsing dishes before automatic washing and for pots if they are hand-washed. Newer models allow residents to vary the amount of water used, depending on the size of the load.

**Hot Water Usage**

Activities and appliances which use hot water can conserve not only the water, but also the energy used to heat it. (In a laundry, 67 percent of the primary energy is for hot water.) These savings are very important because energy costs much more than water. Information on energy conservation which helps conserve water should be included in an installation's water conservation program.

**Water Conservation in Public Buildings**

Many techniques can save water not only in family housing, but also in public buildings such as gyms, offices, and banks. Automatic shutoff valves can be used on urinals and drinking fountains. Some unconventional equipment is being used — e.g., special-media (biological) toilets, air-assisted showers, and chemical toilets like those on campers and boats. Recycle-reuse schemes also are unconventional systems which can save large amounts of water. Although public opinion is against direct reuse for consumption, this water can be useful in other areas. For example, CERL's field investigations have revealed that some Army posts use recycled water for irrigation, the industrial laundry, the car and tactical vehicle wash, recreational lakes, and the industrialized photographic lab.

**Device Evaluation and Selection**

Each post must develop its own criteria for choosing device technology. Equipment, amount of water used, and attitudes toward conservation vary from installation to installation. Therefore, only general principles for selecting and evaluating conservation devices are discussed here.

Because many devices for saving water are available, obtaining the most effective equipment can be difficult. The facilities engineer should consider cost, budget, type of device, type of existing system, conservation goals, and residents' preferences. (The references in this report cite literature which may be helpful in making decisions.) The major concern is choosing components that are compatible with residential systems.

Information about the devices should be available from local dealers, manufacturers (Appendix B), or the General Services Administration.

addition, installations can perform tests to find devices compatible with plumbing and to assess users' reactions to the fixtures.

The relative cost of various devices should be calculated before equipment is chosen. The rate of return on the initial investment may be figured in many ways. The payback period is the easiest to use; this is the number of years required to return the original investment. The method's weakness is that it ignores both returns beyond the payback period and the effects of time on the value of money. The net present value (NPV) method takes the present value of future cash flows, discounted at the appropriate cost of capital, minus the cost of the investment. The project should be accepted if the NPV is positive, and rejected if the NPV is negative. If two projects are mutually exclusive, the one with the greater NPV should be chosen. The internal rate of return method uses the discount rate to equate the present value of future cash flows to the initial cost of the project.

The facilities engineer must also consider whether residents will accept various devices. An education program could explain the purpose and importance of conservation technology. To help keep residents informed, the facilities engineer could use water bill inserts, pamphlets, handbooks and brochures, media advertisements, posters and displays, buttons and bumper stickers, fliers in the mail, information centers, telephone hot lines, school programs, speakers bureaus, film and slide shows, contests, billboards, newsletters, direct customer service, magazine articles, fairs, press releases, and test programs for water saving fixtures.


CERL's investigation of residential usage patterns at Army installations revealed many opportunities for installations to save water with efficient technologies and operating procedures. Most of the water conservation techniques identified would be equally applicable at installations inside and outside the continental United States under peacetime and mobilization conditions. CERL's work indicates that the following guidelines can help save water:

1. Water conservation should be considered as part of the installation's energy conservation program.

2. Water conservation techniques, such as installing devices on household fixtures, are an important part of comprehensive water supply planning.

3. Because many types of conservation devices are available, the facilities engineer can select proven device technology with which there is little risk of failure or public rejection. The transition from conventional fixtures in residence quarters to water conservation devices usually can be made without major behavior changes by occupants.
CITED REFERENCES


"44 Ways To Be Water Wise" (Denver Water Department, n.d.).


Operation of Water Supply and Treatment Facilities at Fixed Army Installations, TM 5-660 (HQDA, November 1952).


Plumbing and Pipefittings, TM 5-551 (HQDA, July 1971).


UNCITED REFERENCES

Ashton, William, Sandra Howard-Ferreira, and Larry Bond, An Incomplete Guide to Water Conservation: Volume 1: Executive Report (Department of Man-Environmental Studies, Faculty of Environmental Studies, University of Waterloo).

Ashton, William, Sandra Howard-Ferreira, and Larry Bond, An Incomplete Guide to Water Conservation: Volume 2: Residential Water Conservation (Department of Man-Environment Studies, Faculty of Environmental Studies, University of Waterloo).


APPENDIX A:

CASE HISTORIES

The following examples from CERL's field surveys indicate the benefits of water conservation programs in civilian communities:

1. California Department of Water Resources.
   a. San Diego
      Water conserved: $9.7 \times 10^8$ gal/year
      Cost of water: $300,000/year
      Energy savings: $860,000/year.
   b. Santa Cruz
      Water conserved: $3.13 \times 10^6$ gal/year
      Cost of water: $96,000/year
      Energy savings: $240,000/year.
   c. El Segundo
      Water conserved: $4.07 \times 10^6$ gal/year
      Cost of Water: $1250/year
      Energy saving: $2600/year.

   Water conserved: 5.4 mgd. Five percent reduction in total household usage.

3. Madison, WI, saved $750,000 by not having to drill new wells.

4. Elmhurst, IL, saved $400,000 by not drilling new wells.

5. Boston Water and Sewer Commission has reduced average usage from 150 to 134 mgd.
APPENDIX B:

LIST OF MANUFACTURERS

Aerators

Conservation Associates, Inc.
P.O. Box 4717
Newark, DE 19711

Crest/Good Manufacturing Company, Inc.
325 Underhill Boulevard
Syosset, L.I., NY 11791

Ecology Products Plus, Inc.
P.O. Box 1517
North Wales, PA 19454

G&E Products, Inc.
2082 South Grand Avenue
Santa Ana, CA 92705

Key Marketing Corp.
21241 Ventura Blvd, Suite 266
Woodland Hills, CA 91364

Lynnwood Distributing Co., Inc.
140 Greenwood Ave, P.O. Drawer T
Midland Park, New Jersey 07432

Melard Mfg. Corp.
153 Linden St.
Passaic, NJ 07055

Metropolitan Watersaving Co., Inc.
5130 MacArthur Blvd. N.W./Suite 106
Washington, DC 20016

Ny-Del Corporation
740 E. Alosta Ave., P.O. Box 155
Glendora, CA 91740

Omni Products, Inc.
55666-B Yucca Trail
Yucca Valley, CA 92284

Sawway Co., Inc.
930 Clarkson Ave.
Brooklyn, NY 11203

Speakman Company
P.O. Box 191
Wilmington, DE 19899

Walker, Crosweller & Co. Ltd.
140 Greenwood Ave.
Midland Park, NJ 07432

Water Saver, Inc.
P.O. Box 401
Frankfort, KY 40602

Wrightway Mfg. Co.
1050 Central Avenue
Park Forest South, IL 60466

Flow Restrictors

American Standard Aquamizer
American Standard Inc.
P.O. Box 2063
New Brunswick, NJ 08903

Business Marketing System
5936-B Don Way
Carmichael, CA 95608
(916) 485-7213

Crest/Good Manufacturing Company, Inc.
325 Underhill Boulevard
Syosset L.I., NY 11791

Eaton Corporation
Controls Division
Plumbing & Heating Products
191 E. North Avenue
Carol Stream, IL 60187

Ecology Products Plus Inc.
P.O. Box 1517
North Wales, PA 19454

G&E Products, Inc.
2082 South Grand Ave.
Santa Ana, CA 92705
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kohler Company</td>
<td>Kohler, WI 53044</td>
</tr>
<tr>
<td></td>
<td>(414) 457-4441</td>
</tr>
<tr>
<td>Melard Mfg. Corp.</td>
<td>153 Linden Street Passaic, NJ 07055</td>
</tr>
<tr>
<td>Mini-Dam Watersaver Corp.</td>
<td>640 S. Pickett Street Alexandria, VA 22304</td>
</tr>
<tr>
<td>Moody Consumer Products</td>
<td>P.O. Box 15486/2201 S. Standard Santa Ana, CA 92705</td>
</tr>
<tr>
<td>Noland Co.</td>
<td>2770 Warwick Blvd Newport News, VA 23607</td>
</tr>
<tr>
<td>Ny-Del Corp.</td>
<td>740 E. Alosta Ave. Glendora, CA 91740</td>
</tr>
<tr>
<td>Omni Products, Inc.</td>
<td>55666-B Yucca Trail Yucca Valley, CA 92284</td>
</tr>
<tr>
<td>Savway Co., Inc.</td>
<td>930 Clarkson Ave. Brooklyn, NY 11203</td>
</tr>
<tr>
<td>Speakman Company</td>
<td>P.O. Box 191 Wilmington, DE 19899</td>
</tr>
<tr>
<td>Water Control Equipment, Inc.</td>
<td>Box 18203-MC Houston, TX 77023 (713) 371-9282</td>
</tr>
<tr>
<td>Water Guard Division</td>
<td>Enden Enterprises P.O. Box 370 Arroyo Grande, CA 93420</td>
</tr>
<tr>
<td>Water Saver, Inc.</td>
<td>P.O. Box 401 Frankfort, KY 40602</td>
</tr>
<tr>
<td>Western Water Conservation, Inc.</td>
<td>10880 Wilshire Blvd., Suite 1600 Los Angeles CA 90024</td>
</tr>
<tr>
<td></td>
<td>(213) 879-5252</td>
</tr>
<tr>
<td>Woodward-Wagner Co.</td>
<td>4041 Ridge Ave. Philadelphia, PA 19129</td>
</tr>
<tr>
<td>Wrightway Mfg. Co.</td>
<td>1050 Central Avenue Park Forest South, IL 60466</td>
</tr>
<tr>
<td>Low-Flow Showerheads</td>
<td></td>
</tr>
<tr>
<td>American Standard</td>
<td>P.O. Box 2003 New Brunswick, NJ 08903</td>
</tr>
<tr>
<td>Aqua-Miser</td>
<td>420 Washington Street Braintree, MA 02184</td>
</tr>
<tr>
<td>Chatham Brass Co., Inc.</td>
<td>5 Olsen Avenue Edison, NJ 08817</td>
</tr>
<tr>
<td>Conservation Associates, Inc.</td>
<td>P.O. Box 4717 Newark, DE 19711</td>
</tr>
<tr>
<td>Eaton Corporation</td>
<td>Control Products 191 E. North Avenue Carol Stream, IL 60187</td>
</tr>
<tr>
<td>Ecology Products Plus, Inc.</td>
<td>P.O. Box 1517 North Wales, PA 19454</td>
</tr>
<tr>
<td>G&amp;E Products, Inc.</td>
<td>2082 South Grand Avenue Santa Ana, CA 92705</td>
</tr>
<tr>
<td>Key Marketing Corp &quot;Nova Lowflow&quot;</td>
<td>21241 Ventura Blvd. Woodland Hills, CA 91364</td>
</tr>
<tr>
<td>Lynnwood Distributing Co., Inc.</td>
<td>P.O. Box Drawer T, 140 Greenwood Avenue Midland Park, NJ 07432</td>
</tr>
</tbody>
</table>
Meland Mfg. Corp.  
153 Linden Street  
Passaic, NJ 07055

Metropolitan Watersaving Co., Inc.  
5130 MacArthur Blvd. N.W. Suite 106  
Washington, D.C. 20016

Omni Products, Inc.  
55606-B Yucca Trail  
Yucca Valley, CA 92284

Sawway Co., Inc.  
930 Clarkson Ave.  
Brooklyn, NY 11203

Southwest Supply, Inc.  
6360 Carpenter Road  
Lucy, WA 98503

Speakman Company  
P.O. Box 191  
Wilmington, DE 19899

Water Saver, Inc.  
P.O. Box 401 West Main St.  
Frankfort, KY 40602

Wrightway Mfg. Co.  
1050 Central Avenue  
Park Forest South, IL 60466

Mixing Valves

Lynwood Distribution Co., Inc.  
P.O. Drawer T, Greenwood Avenue,  
Midland Park, NJ 07432  
(201) 447-1200

Shut-Off Values

Chicago Specialty Manufacturing Company  
7500 Linder Avenue, Box 1022  
Skokie, IL 60077

Sawway Co., Inc.  
930 Clarkson Ave.  
Brooklyn, NY 11203

Speakman Company  
P.O. Box 191  
Wilmington, DE 19899

Toilet Inserts

Baron Manufacturing Co.  
"Water Saver 105"  
14439 N. 73rd St.  
Scottsdale, AZ 85260

Business Marketing Systems  
"Water Saver WS100"  
5936-B Don Way  
Carmichael, CA 95608

Chicago Specialty Manufacturing Company  
7500 Linder Avenue Box 1022  
Skokie, IL 60077

Crest Manufacturing Company  
"Water Skimp -R"  
325 Underhill Blvd.  
Syosset, L.I., NY 11791

Ecology Products Plus, Inc.  
"Moby Dike"  
P.O. Box 1517  
North Wales, PA 19454

G&E Products, Inc.  
2082 South Grand Avenue  
Santa Ana, CA 92705

Key Marketing Corp.  
"Mini-flusher MF544"  
21241 Ventura Blvd.  
Woodland Hills, CA 91364

Metropolitan Watersaving Co., Inc.  
"Little John"  
5130 MacArthur Blvd. N.W./Suite 106  
Washington, D.C. 20016

Ny-Del Corp. "Saveit Watersaver SA 720"  
P.O. Box 155  
Glendora, CA 91740
Savway Co. Inc. "Little John"
930 Clarkson Ave.
Brooklyn, NY 11203

Walker, Crosweller & Co. Ltd.
140 Greenwood Avenue
Midland Park, NJ 07432

Water-Saving and Two-Stage Toilets

American Standard "Cadet" 2.5
gallon flush
P.O. Box 2003
New Brunswick, NJ 08903

Borg-Warner "Artesian Water-Saver"
Siphon-Jet Toilet"
Plumbing Products Division
Mansfield, OH 44901

Briggs "Water-Saving Conserver" 3.5
Gallon Flush, many sytles
Georgia -- 1534 Dunwoody Village
Parkway, Suite 106,
Atlanta, GA 30338
(404) 394-6311

Illinois -- 339 West River Road,
Elgin, IL 60129
(312) 695-8941

Ohio -- 8040 Hosbrook Road, Suite
110 Cincinnati, OH 45236
(312) 695-8941

Texas -- 1010 West Mockingbird Lane,
Suite 177, Dallas TX 75247,
(214) 630-2690

Chicago Specialty Manufacturing Company
"Two-Stage Flush Valve"
7500 Linder Avenue Box 1022
Skokie, IL 60077

Crane "Radcliffe 3143"
17900 Skypark Circle
Irvine, CA 92664

Elgin "Emblem" 3.5 Gallon Flush
Three Gateway Center
Pittsburgh, PA 15222
(412) 471-2402

The Ford Corp. "Superinse"
1.0 Gallon Flush
P.O. Box 1285
Ann Arbor, MI 48106

Gebert Manufacturing, Inc.
1100 Boone Dr.
Michigan City, IN 46360

Idea "IFO Cascade Water Closet"
0.8 Gallon flush
495 Main Street, P.O. Box 1020
Murphys, CA 95247

International Water Saver Toilets Inc.
1.0 Gallon Flush
Box 416
Valley City, OH 44280

Kohler "Wellworth Water-Guard"
3.5 Gallon Flush
Kohler Company
Kohler, WI 53044

Microfer Air Assisted
Two Quart Flush Model LF-210-TE
P.O. Box 40
Willis, CA 94540
(707) 459-5563

Savway Co., Inc. 2 Stage Flush
930 Clarkson Ave.
Brooklyn, NY 11203

Universal-Rundle "Thermo-Tank"
3.5 Gallon Flush
217 North Mill Street
New Castle, PA 16103

Water Savers, Inc. "Two Stage Flush"
P.O. Box 552 401 West Main Street
Frankfort, KY 40602

36
METRIC CONVERSION CHART

1 gal = 3.785 L

1 mgd = 3785.0 kL/day

1 psi = 6.895 x 10³ Pa
US Army Engineer District
New York 10007
ATTN: Chief, MANEN-F
ATTN: Chief, Design Br.
Pittsburgh 15222
ATTN: Chief, Eng Div
Philadelphia 19106
ATTN: Chief, KAPEN-E
Norfolk 23510
ATTN: Chief, NAOEN-D
huntington 29721
ATTN: Chief, GRHEO-H
Wilmingtton 29402
ATTN: Chief, SAWEN-PM
ATTN: Chief, SAWEN-L
Chicago 60604
ATTN: Chief, MCCED-R
ATTN: Chief, MCCED-H
ATTN: Chief, MCCID-ER
St. Louis 63101
ATTN: Chief, ED-B
ATTN: Chief, ED-D
Kansas City 64106
ATTN: Chief, Eng Div
Omaha 68102
ATTN: Chief, Eng Div
Little Rock 72203
ATTN: Chief, Eng Div
Tulsa 74102
ATTN: Chief, Eng Div
Fort Worth 76102
ATTN: Chief, SWED-D
ATTN: Chief, SWED-M/MA
Valleystown 77550
ATTN: Chief, SWGAS-L
ATTN: Chief, SWGDO-M
Los Angeles 90053
ATTN: Chief, SPLED-E
San Francisco 94105
ATTN: Chief, Eng Div
Sacramento 95814
ATTN: Chief, SPLED-D
Seattle 98124
ATTN: Chief, NPSEN-FM
ATTN: Chief, CN-DB-SE
ATTN: Chief, NPSEN-PL-WC
ATTN: Chief, NPSEN-PL-ER
Wallawa 99362
ATTN: Chief, Eng Div
Alaska 99501
ATTN: Chief, NAPSA-R

US Army Engineer Division
Huntsville 35807
ATTN: Chief, HDQEO-C
ATTN: Chief, HDQEO-ME
ATTN: Chief, HDQEO-SR
Lower Mississippi valley 39180
ATTN: Chief, PG-R
Ohio River 45201
ATTN: Chief, Eng Div
North Central 50605
ATTN: Chief, Eng Planning Br
Missouri River 68101
ATTN: Chief, HDQEO-T
Southwestern 75242
ATTN: Chief, SWED-D
North Pacific 97208
ATTN: Chief, Eng Div.
South Pacific 94111
ATTN: Chief, SPLED-D
Pacific Ocean 96858
ATTN: Chief, Eng Div
ATTN: Chief, PODDO-MP
ATTN: Chief, PODDO-P

5th US Army 78234
ATTN: AFKLE-LG-E

6th US Army 94129
ATTN: AFKCE-EN

7th US Army 09407
ATTN: ATETM-HRD-END

10th Medical Laboratory
US Army Foreign Science & Tech Center
ATTN: Far East Office 96328

USA ARRAUCOM
ATTN: ONRMON-LCA-DK
West Point, NY 10996
ATTN: Dept of Mechanics
ATTN: E Library

Fort Belvoir, VA 22060
ATTN: Learning Resources Center
ATTN: ATSE-TD-TL (2)

Ft. Clayton Canal Zone 34004
ATTN: DFAE

Ft. A. P. Hill 24502
ATTN: FE

Ft. Leavenworth, KS 66027
ATTN: ATZLCA-SA

Ft. Lee, VA 23801
ATTN: DRXMC-D (2)

Ft. McPherson, GA 30330
ATTN: AFEN-CD

Ft. Monroe, VA 23651
ATTN: ATEN-AD (3)
ATTN: ATEN-EE-E
ATTN: ATEN-EE-U

Aberdeen Proving Ground, MD 21005
ATTN: ARMSHE
ATTN: HSE-EM
ATTN: OAC-ARI-E

US Army Engineer Design Center 22332
ATTN: Code 04

US Army Oceanographic Office 39527
ATTN: Library

Naval Training Equipment Center 32513
ATTN: Technical Library

Port Hueneme, CA 93043
ATTN: Morell Library

Bolling AFB, DC 20330
AF/LEEEU

WASH DC 20330
AF/MDX

Little Rock AFB
ATTN: 314/DEEE

Patrick AFB, FL 32925
ATTN: XQ

Titan AFB, OK 73145
2854 ABG/DEEE

Tyndall AFB, FL 32401
AFESC/PRT

Bldg Research Advisory Board 20418
Dept of Transportation
Tallahassee, FL 32304

Dept of Transportation Library 20590

Transportation Research Board 20448

Airports and Construction Services Dir
Ottawa, Ontario, Canada KIA ONB

Division of Building Research
Ottawa, Ontario, Canada KIA ORB

National Defense Headquarters
Ottawa, Ontario, Canada KIA OK2
Water conservation methods for U.S. Army installations / by R. J. Schulze... (et al.) - Champaign, Ill. : Construction Engineering Research Laboratory ; available from NTIS, 1981.
Zv. (Technical report / Construction Engineering Research Laboratory ; N-146)

Contents. - v. 1. Residential usage management. - v. 2. Irrigation management.
