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U.S. DEPARTMENT OF COMMERCE/National Bureau of Standards

# Proceedings of the National Water Conservation Conference on Publicly Supplied Potable Water

water conservation '81

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# Proceedings of the National Water Conservation Conference on Publicly Supplied Potable Water



April 14-15, 1981
Denver, CO



Edited by:

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Publicly Supplied Potable water conservation '81 A NATIONAL CONFERENCE

# Abstract


This "Proceedings" is a complete compilation of the papers presented April 14 and 15, 1981, at the National Water Conservation Conference - Publicly Supplied Potable Water in Denver, CO. The Conference was primarily directed toward elected and administrative officials of local governments, the individuals who are responsible in some part for the quantity and quality of water available to their communities.

Techniques for, and analysis of, potable water conservation and wastewater flow reduction were presented. The topics addressed included:

- Water-Saving Technology
  - Plumbing fixtures
  - Testing and performance of low-flow devices
  - Leak detection and repair
  - Potential problems in wastewater flow reduction
  - Landscaping with native vegetation
- Public Education and Motivation
- Economics
  - Water pricing systems
  - Analysis of cost/benefits
  - Development and management of data
- Planning
  - State and local urban planning efforts for conservation
  - Federal programs and incentives
- Case Studies
  - From California, Washington, Utah, Arizona, North Carolina, Maryland, New Jersey, and Massachusetts.



Key words: municipal water systems; potable water reduction; water conservation.

Publicly Supplied Potable

water conservation

'81 A NATIONAL CONFERENCE

# Preface

During a recent Midwest Governors' Conference, the population shift from snowbelt to sunbelt was acknowledged. The speaker continued to forecast that although people are moving to the sunbelt now, snow and ice will melt into water, and the 1990's may witness a new population shift from the sandbelt to the waterbelt!

Residents of the Midwest are not alone in speculating about water. There is today a growing voice of concern for water supply, and for improved water quality, throughout all of the United States.

Over 450 people, from snowbelt, sunbelt, East and West, attended the 1981 National Water Conservation Conference - Publicly Supplied Potable Water. They came to Denver, CO, representing towns and cities; public and private interests; and local, State, and Federal offices. They learned of the latest professional experiences with potable water conservation and wastewater flow reduction from speakers with equally diverse backgrounds.

This "Proceedings" records the speakers' comments and becomes yet another educational tool in the national effort to eliminate the wasteful use of clean water--a luxury we can no longer afford.

I want to thank each speaker, panelist, and moderator who made the Conference possible. The time and effort required in the presentation of their papers are greatly appreciated.

Special thanks is also due to the Federal agencies and individuals who sponsored, planned, and conducted the April Conference:

- <u>U.S. Environmental Protection Agency</u>

The Office of Water Program Operations, in response to section 214 of the Clean Water Act, contributed the major share of funding. Throughout the Conference planning and management, I had the full support and encouragement of:

James N. Smith, Acting Assistant Administrator for Water and Waste Management,

Henry L. Longest, II, Director, Water Program Operations,

William Whittington, Director, Facility Requirements Division, and

Myron F. Tiemens, present Acting Director, Facility Requirements Division.

Without their concern for public education in wastewater flow reduction, this Conference would have remained just another good idea.

- <u>National Bureau of Standards</u>

In February 1980, Dr. Lawrence Galowin, Building Equipment Division, conceived the idea of this gathering in order to appraise the progress in water conservation efforts since EPA's 1978 Chicago Conference. His knowledge, enthusiasm, ideas, and energy sustained the planning group throughout the year of detailed activities. This "Proceedings" is printed by the National Bureau of Standards, thanks to his office. Jacqueline Elder, Research Psychologist, also with the Building Equipment Division, contributed many creative ideas during the conference planning and, in particular, designed and coordinated the workshops on Manuals and Handbooks.

- <u>U.S. Army Corps of Engineers</u>

Following the invitation of Kyle Schilling, Chief, Policy Studies Division, Institute for Water Resources, many of the Nation's leading exponents of water conservation agreed to speak to the April gathering. Steve Light provided a comprehensive analysis of the Conference evaluation, and the Institute for Water Resources provided substantial financial support.

- <u>Office of Water Research and Technology, U.S. Department of the Interior</u>

John Cunningham, John Campbell, and Ken Suter, of OWRT, provided financial support and valuable program suggestions.

I am saddened to learn that their office sustained major cuts in the current effort to curtail Federal spending. OWRT's research efforts in the field of water resources management represented a major national inquiry. OWRT programs enabled the Nation to understand the economics and environmental benefits of water conservation, an understanding that is sure to become increasingly valuable during the next decade.

- <u>U.S. Department of Housing and Urban Development</u>

  Jerome H. Rothenberg, Director of Energy, Building Technology and Standards, assisted throughout the Conference planning and arranged for the HUD printing of the Conference announcements.

- <u>U.S. Water Resources Council</u>

  Denzil Fisher, Acting Director of State Programs Division, contributed knowledge of the Nation's water resource problems and ideas about how and who should address them.

Special mention is due to the Conference host, EPA Region VIII, Denver, CO. David Standley, Water Division Director, provided valuable advice on the selection of speakers, advice that resulted in a well-balanced program. Without his assistance and that of Dean Chaussee and many others in the Water Division Office, the myriad of details that need attention before and during any successful conference would not have been managed.

The administration of the Conference was successfully coordinated by Denis Lussier, EPA Center for Environmental Research Information, Cincinnati, OH, and Dynamac Corporation, Rockville, MD. Tor Rothman, Gail Cioban, and especially Sheri Marshall were extremely efficient and equally gracious in the management of Conference logistics and editorial refinement.

It was a privilege for me to direct the Conference. My task was rewarded with the acquaintance of leaders in conservation who attended and who spoke at the Denver meeting. Their dedication and perseverance continue to be an inspiration to me.

Thank you all.

Barbara Yeaman

Barbara Yeaman
Conference Director

Publicly Supplied Potable water conservation '81 A NATIONAL CONFERENCE

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# Disclaimer

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# Agenda

MONDAY - APRIL 13, 1981

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| 7:30-9:30 p.m. | REGISTRATION |

TUESDAY - April 14, 1981

| | |
|---|---|
| 8:00-9:00 a.m. | REGISTRATION |
| 9:00 a.m. | OPENING REMARKS AND WELCOME<br><br>Roger L. Williams, Regional Administrator<br>Region VIII<br>U.S. Environmental Protection Agency<br>Denver, CO |
| 9:30 a.m. | MORNING PLENARY SESSION<br><br>Panel Discussion: Practical Applications/ Local Experiences<br><br>Moderator: Francis T. Mayo, Director<br>Municipal Environmental Research Laboratory<br>U.S. Environmental Protection Agency<br>Cincinnati, OH<br><br><u>Water Law: Impact on Water Conservation</u><br><br>William R. Walker, Director<br>Virginia Water Resources Research Center<br>Blacksburg, VA |

Motivating the Public to Save Water in the Absence of a Crisis

John O. Nelson, General Manager
North Marin County Water District
Novato, CA

Providing Section Services in Technical Information and Training

David B. Preston, Executive Director
American Water Works Association
Denver, CO

10:20 a.m. BREAK

10:40 a.m. PLENARY SESSION

Panel Discussion: Practical Applications/ Local Experiences (continued)

Moderator: David Farrell
Illinois Department of Commerce and Community Affairs
Springfield, IL

Water-Saving Plumbing: A Flow Control & Maintenance Program to Reduce and Control Water Use in Multi-Housing Properties

David P. Wilborn, Vice President
Metropolitan Watersaving, Inc.
Washington, DC

Landscaping Alternatives and Irrigation Conservation

Nicholas M. Schmidt, Vice President of Marketing
Sanford Homes, Inc.
Englewood, CO

Water Conservation: The Leaks in Implementation

James S. Lyon, Research Associate
Environmental Policy Institute
Washington, DC

12:00 Noon LUNCHEON

1:30-2:30 p.m.

CONCURRENT WORKSHOPS: TECHNICAL ADVANCEMENTS AND REQUIREMENTS

WORKSHOP A - RESOURCES: MANUALS AND HANDBOOKS

Developing and Testing a Water Conservation Handbook

Moderator: Barbara Yeaman, Public Education Consultant
U.S. Environmental Protection Agency
Washington, DC

Flow Reduction: Methods, Analysis Procedures, Examples

Sandra L. Postel, Resource Economist/Analyst
INTASA, Inc.
Menlo Park, CA

State Water Conservation Planning Guide

Denzel L. Fisher, Acting Director
State Programs Division
U.S. Water Resources Council
Washington, DC

The Role of Land Use Planning in Water Conservation

Welford Sanders
American Planning Association
Chicago, IL

Aurora, Colorado: Rational Landscape Alternatives

Joanne D. Rondon, Water Conservation Technician
Aurora Water Conservation
City of Aurora
Aurora, CO

WORKSHOP B - IMPACT OF LOW FLOWS ON WASTE-WATER COLLECTION SYSTEMS AND TREATMENT FACILITIES

Moderator: Myron F. Tiemens, Acting Director
Facility Requirements Division
U.S. Environmental Protection Agency
Washington, DC

Water Conservation and Wastewater Flow Reduction -- Is It Worth It?

Jimmy S. Koyasako, Senior Engineer
California Department of Water Resources
Sacramento, CA

Effects of Water Conservation on Municipal Wastewater Treatment Facilities

John A. Davis, Vice President
Jefferson Associates, Inc.
San Francisco, CA

Larry K. Baker, Vice President*
Weatherby Associates, Inc.
Jackson, CA

WORKSHOP C - PLANNING FOR THE FUTURE

Moderator: Monte Pascoe
Colorado Department of Natural Resources
Denver, CO

Planning for the Future

Polly C. Knox, Program Coordinator
Water Conservation Office
Seattle Water Department
Seattle, WA

Water Conservation in Arizona: Past, Present, and Future

Delores M. Gillum, Municipal Program Specialist
Arizona Department of Health Services
Phoenix, AZ

Water Conservation as a Long-Range Supply Option for Massachusetts: Dispelling the Myths and Facing Reality

Helen S. Linsky, Senior Planner
Wallace, Floyd, Ellenzweig, Moore, Inc.
Cambridge, MA

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*Paper not included.

WORKSHOP D - EDUCATION/INFORMATION: PAST EXPERIENCES AND CURRENT PLANS

Moderator: Jacqueline Elder, Research Psychologist
Center for Building Technology
National Bureau of Standards
Washington, DC

David Farrell*
Illinois Department of Commerce and Community Affairs
Springfield, IL

Water Conservation in Rental Apartment Complexes by Means of Controlled Installation of Watersaving Devices

Albert Frank, Planner
Howard County Department of Public Works
Ellicott City, MD

Enhanced Water Education Versus Status Quo, Et Al.

Jack A. Barnett, Secretary-Treasurer for Board of Trustees
Water and Man, Inc.
Salt Lake City, UT

Information and Consumer Adoption of Water Conservation Measures

Duane D. Baumann
Department of Geography
Southern Illinois University
Carbondale, IL

2:30 p.m. BREAK

3:00-4:00 p.m. CONCURRENT WORKSHOPS: TECHNICAL ADVANCEMENTS AND REQUIREMENTS

WORKSHOP A - RESOURCES: MANUALS AND HANDBOOKS

Moderator: Elroy Spitzer, Deputy Director
American Water Works Association Research Foundation
Denver, CO

*Paper not included.

Residential Water Conservation Handbook

Barry Schechter
Pabon, Sims, Smith, and Associates, Inc.
Washington, DC

A Procedures Manual for Evaluating Water Conservation Planning

James E. Crews, Civil Engineer
Institute for Water Resources
U.S. Army Corps of Engineers
Ft. Belvoir, VA

AWWA Water Conservation Handbook

George L. Craft, Resources Engineer
American Water Works Association
Denver, CO

Before the Well Runs Dry: A Handbook for Designing a Local Water Conservation Plan

F. Michael DiGiano, Program Manager
Water Supply/Conservation Program
New England River Basins Commission
Boston, MA

WORKSHOP B - BENEFITS AND IMPACTS/ECONOMICS

Moderator: David Standley, Director
Water Division
Region VIII
U.S. Environmental Protection Agency
Denver, CO

Cost-Effective Residential Water Conservation Decisions

Stephen F. Weber, Economist
Center for Building Technology
National Bureau of Standards
Washington, DC

A Water Supply Simulation Model: Analyzing for the Implications of Conservation

Richard M. Males, Vice President
W.E. Gates and Associates
Batavia, OH

Cost-Effectiveness of Potable Water Conservation - Multifaceted Approach

William P. Darby, Associate Professor
Department of Technology & Human Affairs
Washington University
St. Louis, MO

Municipal Water Conservation - A Water Project That Pays for Itself

Will B. Betchart, Senior Environmental Engineer
INTASA, Inc.
Menlo Park, CA

WORKSHOP C - DEVICES AND TECHNOLOGY

Devices and Technologies for Water Conservation - State of the Art: Standards for Industry

Moderator: Jim Burgess, President
Canadian Standards Association
Ontario, Canada

Performance Requirements and Test Procedures for Water Closets

Thomas P. Konen, Chief
Building Technology Research Division
Davidson Laboratory
Stevens Institute of Technology
Hoboken, NJ

Experiences and Benefits of the Application of Minimum Flow Water Conservation Hardware

Larry K. Baker, Vice President
Weatherby Associates, Inc.
Jackson, CA

Technical Requirements for Low-Flow Devices

Frank R. Holycross, Manager
Manufacturing Engineering
Delta Faucet Company
Greensburg, IN

A Model for the Transport Mechanisms of Solids in Building Pipe Drains

Lawrence S. Galowin, Senior Engineer
Building Equipment Division
National Bureau of Standards
Washington, DC

WORKSHOP D - DEMONSTRATION PROJECTS/DATA COLLECTION

Developing Data for Residential Water Savings

William O. Maddaus, Supervising Engineer
Brown & Caldwell
Walnut Creek, CA

How to Implement a Water Conservation Program - The Denver Experience

John J. Wilder, Conservation Officer
Denver Water Department
Denver, CO

Management Information Systems for Water Resources

Frank J. Smith, Associate Professor
North Carolina State University
Raleigh, NC

4:00-6:00 p.m. RECEPTION/CASH BAR

4:15-5:15 p.m. FURTHER PERSPECTIVES ON WATER AND ITS CONSERVATION*

The Water Conservation Program for the Regional Municipality of Waterloo: A Review of Research and Experience

Moderator: James E. Robinson, Assistant Professor
Department of Man-Environment Studies
University of Waterloo
Ontario, Canada

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*Papers presented on this panel are not included.

A Residential Retrofit Program: Research and Evaluation

Roger Needham, Research Coordinator
Water Conservation Program
Regional Municipality of Waterloo
University of Waterloo
Ontario, Canada

Interactions of Water Closet Performance with a Sanitary Drainage System

Thomas P. Konen, Chief
Building Technology Research Division
Davidson Laboratory
Stevens Institute of Technology
Hoboken, NJ

Research Activities in Plumbing at the National Bureau of Standards

Lawrence S. Galowin, Senior Engineer
Building Equipment Division
National Bureau of Standards
Washington, DC

WEDNESDAY - April 15, 1981

8:00 a.m. MORNING PLENARY SESSION

Dean R. Chaussee*
Region VIII
U.S. Environmental Protection Agency
Denver, CO

8:45 a.m. KEYNOTE ADDRESS

Major General E.R. Heiberg, III
Director of Civil Works
Department of the Army
Office of the Chief of Engineers
Washington, DC

9:05 a.m. FEDERAL PERSPECTIVES - PROGRAMS/INCENTIVES

Moderator: Kyle E. Schilling, Chief
Policy Studies Division
Institute for Water Resources
U.S. Army Corps of Engineers
Ft. Belvoir, VA

*Paper not included.

Comparison Between Water Conservation Practices in the United Kingdom and the United States

Derek G. Jamieson
Thames Water Authority
Reading, England

Federal Water Resource Agency Planning Requirements and Implications for Water Conservation

Gerald D. Seinwill, Acting Director
U.S. Water Resources Council
Washington, DC

Plumbing Codes - Essential in Water Conservation Programs

Lawrence S. Galowin, Senior Engineer
Building Equipment Division
National Bureau of Standards
Washington, DC

| | |
|---|---|
| 10:20 a.m. | BREAK |
| 10:45 a.m. | LOCAL PERSPECTIVE - PROGRAMS/INITIATIVES |

Moderator: Evan Vlachos
Governor's Front Range Committee
Denver, CO

Water Conservation in California

Ronald B. Robie, Director
California Department of Water Resources
Sacramento, CA

The Need for a New Federal Water Policy

Francis X. McArdle, Commissioner
NYC Department of Environmental Protection
New York, NY

Local Response for Officials and Consumers

William H. Miller, Manager
Denver Water Department
Denver, CO

12:00 Noon LUNCHEON

1:00 p.m. CASE HISTORIES - EXPERIENCES WITH SOLUTIONS

Moderator: John Campbell
Office of Water Resources & Technology
U.S. Department of the Interior
Washington, DC

A Future Look - What Are the Unknowns?

Jerome B. Gilbert, President
American Water Works Association
General Manager, East Bay Municipal Utility District
Oakland, CA

Appraisal of 1978 Conference Case History: Do the Benefits Endure?

John M. Brusnighan, Assistant General Manager
Washington Suburban Sanitary Commission
Hyattsville, MD

Conservation in a Noncrisis Environment - Township of East Brunswick, New Jersey

Michael J. Opaleski, Water Superintendent
L. Mason Neely, Finance Director
Township of East Brunswick
East Brunswick, NJ

Theodore B. Shelton, Associate Specialist
Water Resources Management
Cook College - Rutgers University
New Brunswick, NJ

Case Study - In-School Water Conservation Education Program

Case Study - Distribution of Residential Water Saving Devices

Suzanne Butterfield, Chief
Office of Water Resources
California Department of Water Resources
Sacramento, CA

2:30 p.m. BREAK

2:50 p.m. CASE HISTORIES - EXPERIENCES WITH SOLUTIONS (continued)

Moderator: Robert J. Foxen, Chief
Engineering & Economic Policy Section
U.S. Environmental Protection Agency
Washington, DC

<u>Results of a Peak Management Plan for Tucson, Arizona</u>

Gene E. Cronk, Director
Tucson Water, City of Tucson
Tucson, AZ

<u>Water Conservation Efforts in Rural Areas</u>

A.R. Rubin, Professor
Biological & Agricultural Engineering Department
North Carolina State University
Raleigh, NC

<u>Water Conservation/Flow Reduction in Facilities Planning for Salt Lake County</u>

Gerald H. Kinghorn, Partner
Kapaloski, Kinghorn & Alder
Salt Lake City, UT

4:20 p.m. ADJOURNMENT

OPENING REMARKS AND WELCOME

Roger L. Williams
Regional Administrator
Region VIII
U.S. Environmental Protection Agency
Denver, Colorado

Good morning and welcome to Denver. We are very pleased to host this conference because of the importance of water conservation -- particularly in the West. Due to a dry winter, cities all over the country will be facing water shortages this year. We are certainly feeling the pinch in this area. For example, in Denver, outside water restrictions will have to begin a month earlier this year. Another city has recently doubled the water rates for use above 20,000 gal/month and quadrupled the rates for use above 30,000 gal/month in an effort to cut demand.

However, it is a serious mistake to consider conservation measures only during dry spells or emergencies. The problem does not disappear with the first rainfall. Effective management of our water resources is becoming increasingly important because of steadily increasing and competing demands for water. This in concert with the difficulty, expense, and long lead time of developing new sources underlines the importance of sound conservation measures.

This conference will be particularly useful in discussing how successful some of these measures have been in reducing water use. However, I feel the major challenge in potable water conservation is not technology but public education. In this sense, the drought is helpful because it certainly brings home the importance of water conservation to each consumer. Conservation measures will not be completely effective unless the public understands and supports them. Since conservation may require modifications to lifestyles, public support is definitely not automatic.

Water use restrictions and rate increases can also result in public opposition as many city managers and mayors can attest. This is largely due to the public being accustomed to having their water demands met regardless of weather or community growth. In turn, the water utilities have felt it was their primary responsibility to meet these demands to protect public health and foster a more pleasant environment, at the lowest cost possible. In fact, water rate structures have traditionally encouraged use rather than conservation. This management approach has resulted in many cases where demands have outstripped supply or treatment capacity.

We can no longer afford management policies that encourage continued increases in per capita use. Communities must take a critical look at their future water needs to determine the most effective means to meet those needs. A sound conservation program should be a part of the overall plan.

A variety of conservation alternatives are available, many of which will be discussed at this conference. The key point is that each community must decide on the measures that will be the most effective for their situation.

For example, Denver feels that potable reuse in addition to other measures may be necessary to meet future needs. As a result, Denver, with financial assistance from EPA, has launched a progressive effort to determine the feasibility and health implications of potable reuse. Construction on a 1-million-gallon-per-day demonstration plant has begun. The plant will begin operation in the spring of 1983 and will be the major part of a $31-million program including several years of water quality and health effects testing. Denver is certainly a national leader in potable reuse, and I commend them for their foresight and commitment.

In summary, I feel we all share the responsibility of educating the public on the importance of water conservation and involving them in developing effective water conservation plans. I think all of us have underestimated the public's interest in, and willingness to try, water conservation measures. To encourage this interest and willingness, we must do a better job of stressing the positive aspects of conservation by:

- improving the efficiency of a water system, thereby reducing costs
- easing short-term water shortages
- deferring the need for additional sources or treatment capacity (water and wastewater), in some cases
- conserving energy
- maintaining water quality and aquatic habitat.

If we do a good job in this critical area, it will be easier to start conservation programs and they will be even more successful.

I am confident that these issues will be thoroughly discussed in the next two days. Through the understanding and knowledge gained from meetings like this, conservation will become an accepted means of resource management before our "well runs dry." Again, I want to welcome all of you to Denver and wish you success in this important conference.

Publicly Supplied Potable water conservation '81 A NATIONAL CONFERENCE

# Practical Applications/Local Experiences

# WATER LAW: IMPACT ON CONSERVATION

William R. Walker, Director
Virginia Water Resources Research Center
Virginia Polytechnic Institute & State University
Blacksburg, Virginia

## ABSTRACT

Laws with respect to water are unusual because they may vary depending on the form in which water is found. It is further complicated because the states do not have uniform laws for water in its various forms. Water with bed and bank in the western United States must conform to the prior appropriation doctrine which places emphasis on the protection of private property rights rather than maximum utilization. Water in this same form in the East is governed by the riparian doctrine which defines the water rights according to the place of use. Water under the ground may follow the English, American, or reasonable use rule. Diffused water which flows over the surface of the ground must be captured to establish a right. All of these laws evolved generally for historical reasons and have been modified slightly by statutes but not uniformly. None were designed to reduce consumption, promote efficiency or facilitate change to a higher beneficial use. The development of constitutionally protected water rights has made change more difficult. Yet these laws and the institutional structures which have evolved to implement them must be modified to promote greater use of a finite resource.

## INTRODUCTION

Common though it may be in nature, water is an unusual commodity in law. Often laws which apply to water depend on the form in which the water is found. Thus, one set of laws may govern water with bed and banks (streams and lakes), while another deals with water below ground and still another may apply to diffused water (water flowing over the surface of the ground). These water laws may be further complicated because the states do not have uniform laws for water in its various forms.

Water laws are the management tools for implementing water policy, and the many water laws found throughout the United States reflect many different, and often conflicting, water policies. Federal, state, and local governments all have water laws which reflect their varying roles and perspectives. The lines of demarcation among these jurisdictions are not clear and sometimes reflect concurrent responsibilities.

Water laws can have a significant impact on how effective a conservation program can be related to water supply. For the purposes of this paper I have defined conservation as those activities which 1) reduce the total consumption of water use for a given activity, 2) make more efficient use of a given water supply, or 3) encourage water to be put to its highest and best use as determined by the mores and values of the time.

Let's examine the laws related to surface water (those with bed and bank) to see to what extent they can encourage the conservation of water as defined above. In a general sense surface waters are governed by two doctrines: the prior appropriation doctrine which governs those states located west of the 98th meridian and the riparian doctrine which is reflected in the common law in most of the eastern states. It should be understood at the outset that in none of these states are the laws exactly similar.

PRIOR APPROPRIATION

The prior appropriation doctrine, which is the framework for the western law, allocates water in specific amounts for the use of the various appropriators on a stream. With very few exceptions this doctrine does not encourage or facilitate any form of water conservation, as defined above. Most of the problems under the prior appropriation doctrine are waste-related and result from the priority system of rights where uses are frozen in terms of the original amount, place, and purpose of use (1).

In the West, more than 85 percent of the water is used for irrigation. Since most of the water in surface streams has been allocated, additional water for public water supplies must come from the amount currently being used in agriculture. The first question is to what extent existing laws and institutions permit and/or facilitate a change from an agricultural to a public supply use. The second question is whether the existing laws encourage activities which facilitate this change in use without significant reductions in agricultural production. As will be seen, these questions are not separate and distinct but interrelated.

The problems of waste are easily identified with irrigation, but they are not peculiar to irrigation and can be classified in three very distinct and somewhat overlapping groups. First, given the place and the purpose of a particular use, the <u>amount</u> of the water diverted for it is frequently excessive and wasteful. Second, given the purpose of a particular use, its <u>location</u> is often such that the same purpose of use at another location would require a smaller amount of water. Third, even though the location and the amount used are appropriate for the particular purpose for which water is being applied, this purpose may be such that the same amount of water used for a different purpose would constitute a more beneficial use.

## Wasteful Amounts

The obligation to use only the amount reasonably necessary has been said to demand an unrealistic display of self-restraint. The problem and the difficulty of finding a workable solution is well stated in the 1938 Law Review:

> . . . while the [doctrine of appropriation] reads well on paper, it is based on an altruistic concept of human behavior which practice has shown to be grossly deficient. The appropriator is under a duty to take no more water from the stream than he can use, and he may under no circumstances waste or extravagantly use the water which he has appropriated. Yet, experience has shown not only that he may not be trusted in his own judgement to so confine himself, but that the enforcement of his duty against him is attended with extreme difficulty. Even today, enforcement rests largely in the individual initiative of fellow appropriators who are hardly in a position to inspect his use for waste (2).

Appropriators may be able to divert more water than is necessary because the maximum rate of flow covered by an appropriation right is usually greater than is actually necessary at many times of the growing season. Fear of forfeiture of the unused part of a right is likely a cause for unnecessary uses of water.

While irrigation techniques are continually improving to allow greater production per unit of water use, individuals are slow to change without an incentive. Since the change would benefit junior appropriators in the form of additional water, there is almost a disincentive present. Professor Stone in a recent article (3) argues that under Montana law there is probably no right to saved water (4).

As part of his water right, the appropriator's method of diverting water from the stream is protected if his method is deemed reasonable under the circumstances. This protection, however, can prevent another person from using apparently available water if a senior appropriator's method requires preserving certain flow conditions to propel his diversion machinery or to keep the water level within reach of his intake facilities. Whenever an inefficient method of diversion is deemed reasonable by the courts, a part of the stream flow will have to pass substantially unused.

## Wasteful Locations

A particular use may be so located that its value is relatively low in terms of the amount of water necessary to maintain it. Though changes in the place of use are generally permitted, an appropriator may often feel that changing an existing wasteful use would not be in his individual interest. The interdependency that exists where water is successfully used and reused by a number of appropriators frequently means that a change cannot be made because of the requirement that existing conditions of supply must be preserved and subsequent rights of supply cannot be impaired.

A change in the point of diversion whether the move is up- or downstream will affect other users between the old and the new points by altering the velocity, quantity, and level of flow reaching them. A change in the place of use may mean that the seepage water and the water flowing from the surface of the field will take a different course back towards the stream, perhaps cutting the supply of the person who was using the water along its previous route and perhaps waterlogging land along its new route. Because the soil at the new location of use or along the new route may be different, the unconsumed water may re-enter the stream at a different time or with a different content of dissolved solids--to the injury of the downstream user. A change in the place of use may be reflected in timing, velocity, quantity, level, and purity of flow and such a change may be especially disruptive to established conditions if the new purpose is more consumptive than the former one.

The earliest settlements of the western valleys frequently occurred in downstream areas, with the result that many senior appropriator rights are located in these areas today. In order to satisfy a senior's right to a certain amount of water at a downstream point, therefore, it may be necessary that junior upstream appropriators let several times this amount pass by them to allow for these channel losses. A fuller use of stream flows could often be achieved by a greater upstream use and a successive reuse by each lower appropriator of the water reaching him. Since irrigation is a relatively consumptive use, a considerable decrease in quantity could result from upstream junior appropriators' uses. Water that returns to the stream may be lower in quality and delayed in reaching downstream points--to the injury of senior downstream rights. The uses a junior upstream appropriator can make may therefore be quite limited by the existence of these downstream rights.

## Wasteful Purposes

An appropriation right allows water to be applied to the same purpose forever. The interdependency among users is likely to block changes to different purposes if existing conditions of supply are to be strictly preserved for the benefit of established users.

Whenever there is insufficient water for all the appropriators, their uses must be terminated in reverse order of priority until the entire supply gives senior appropriators their full entitlement. No allowance is made for the relative value or needs of different uses at that moment. In the case of irrigation, different crops or different fields of the same crop may require water at different times, and high value crops may be in critical need of water that goes instead to a low value crop (even, perhaps, in less immediate need of water) because the latter is irrigated under a senior right.

Several cases in Oregon have held that an appropriator may use water only to the extent needed for which it was appropriated and when not needed for that specific use, junior appropriators are entitled to such water (5). These cases all involved the circumstance where a senior appropriator was attempting to cover additional uses with his existing right.

There appears to be a tendency for the appropriation system to freeze the initial patterns of resource allocation. The West has been warned in strong language that "it may soon decide whether its future must be sacrificed by its antiquated priority system in water use." (6)

Water Rights Appurtenancy

In some states the water right is appurtenant to the place of use. Thus the transfer to a "higher and better use" is dependent upon the water being able to be used on the land to which the water right attaches. In addition, junior appropriators who rely on return flows are usually fully protected and in some states, such as Nevada, specifically protected by statute. In South Dakota, water is appurtenant to the land and cannot be transferred unless it can be shown to have become impracticable to use economically. Query, is water "saved" no longer economically necessary and thus eligible for use on other land?

A review of the western state laws shows two fundamental reasons are apparent for the ostensible "anti-conservation position of the majority." The first is a strict adherence to the notion of "water rights appurtenancy." The second is the very real and complicated problem of potential impairment to water users who rely on the transferor's return flow. The Arizona Kavocovich case is a classic example of the former. In this case the irrigators concrete-lined their ditches and were able to save sufficient water to irrigate additional adjacent land. A legal battle ensued over whether they could apply this "saved water" to new adjacent land. The Arizona Court of Appeals rejected this procedure, relying in part on "impairment" but mainly on the notion of traditional appurtenancy of water to a particular piece of land:

> ". . .this court is of the opinion that the doctrine of beneficial use precludes the application of water gained by conservation

practices to the lands other than those to which the water was originally appurtenant." (7)

## Water Rights Impairment

The issue of "impairment" through transfer recognized in several states is clearly more important. Judicial attitudes regarding appurtenancy may be changed, but if conservation and subsequent use of conserved water actually hurts another water user, a much more serious problem exists. Since all western law protects persons relying on returned flows of water, a conservation practice which eliminates the return flow runs "head-on" into the basic foundation of western water law principles. The problem is further exacerbated by the court's and administrator's frequent inability to address the issue of return flows and to arrive at a good method of quantifying how much return flows would be "lost" to other right-holders if the water "saved" were transferred.

In theory, the owner of the water right is free to exercise it as any other freehold interest. In practice, however, no change in a water right is permitted if the change will injuriously affect the rights of other appropriators on the stream. It thus must be concluded that prior appropriation does tend to preserve existing patterns of water use.

## Integration of Tributary Ground Water into Priority System

Historically, the prior appropriation doctrine was based on the characteristics of water flowing on the surface. Groundwater has become a supplemental source, and today depletion of groundwater aquifers has occurred. This depletion in groundwater aquifers has an effect on the flow of natural streams. A conflict has thus developed between the owners of surface water rights (who are senior in the priority system) and groundwater users. The hydrologic interplay between tributary groundwater and surface flow, while extremely complex, is well acknowledged.

Some states such as Colorado have attempted to administer tributary groundwater and surface water on the basis of prior appropriation. The result sought by this integration is the maximum utilization of water resources. Despite legislative pronouncement coupling these two concepts, the two elements do not make a happy marriage.

Because of the constitutional protection of property rights in water, any system of integrated use of ground and surface water must cope with vested rights perfected pursuant to the doctrine on appropriation. Prior appropriation doctrine is based on the immediate (in a relative sense) availability of surface flow. Groundwater, however, has no immediacy of flow characteristics. In the case of surface water, when an adverse effect to a senior user is detected, the junior user is shutdown and the benefits to the senior are immediate. Groundwater, on the other hand, flows very slowly and in a complex manner. The adverse effect of a junior's well may not occur for months or years, and likewise the resulting benefits to a well shutdown will not occur for a corresponding period. Thus it is less likely that the benefits of a shutdown of a junior user will reach the senior in time for his need.

Prior Appropriation and Maximum Utilization

The goal in the management of a finite resource is the maximum utilization of the resource. Prior appropriation grants claimant private property rights on a first come, first served basis. Maximum utilization, on the other hand, would appear to involve a sharing of water among senior and junior appropriators to foster intensive and efficient use of water for the overall benefit of the state. It is not a quantity-of-use concept but a quality-of-use concept. Maximum utilization would appear to involve an analysis of the best means and patterns of allocation for the state and its people. Such a concept does not lend itself to a system designed to protect private property in the water where the protection of vested rights is the paramount concern.

In a 1973 Colorado case the Supreme Court upheld a decision of the state engineer who denied a permit for some wells located 13 miles from the nearest natural stream because there was no unappropriated water. In denying the well permits, the Supreme Court showed its determination to avoid use of wells so as to diminish the amount of water available to senior surface rights. It concluded that the doctrine of maximum utilization should not interfere with those vested property rights. One must conclude that no matter how desirable from an analytical point of view, maximum utilization does not lend itself to a system of prior appropriation.

RIPARIAN DOCTRINE

Under the riparian doctrine, the use of surface water from a stream is restricted to the owner of the land contiguous or riparian to the stream. Generally, the riparian status extends only to land lying within the same watershed of the stream from which it is taken. The right of a riparian owner to use the water is said to arise from the ownership of the land and the use of water is limited to the riparian land.

The amount of water a riparian owner may use and the purpose for which he may use it are not subject to exact determinations. Originally there was a "natural flow" rule which permitted each riparian to divert water to the extent of his domestic needs and which allowed him to demand that the natural flow of the stream reach his land materially unaltered except for the domestic uses of upper riparians. This rule has been modified in most jurisdictions in favor of the "reasonable use" rule. This rule permits each riparian to use water to the extent of his domestic needs and then, subject to the domestic needs of other riparians, he may use water for such purposes in such an amount as is reasonable in light of all other riparians having a similar right.

The restriction of water use only on riparian land is limiting since it presupposes that the best use of the water is always on land which is in immediate contact with it. Thus water may go unused because the law does not permit it to be transferred to lands which are not riparian to the stream.

This doctrine does not require that the water be used efficiently. The only requirement is that it must be "reasonable" in relation to others having a similar right. The number of people having similar rights varies with time and no riparian owner loses his right to use water through non-use.

A further restriction on the users of water under this doctrine relates to municipalities. In most eastern states municipalities cannot acquire riparian status. Cities or towns withdrawing water from streams do so 1) with an expectation of having to buy riparian rights in the future when someone is damaged, or 2) having acquired existing and future rights on a stream prior to withdrawing.

In general the riparian doctrine does not apply to groundwater. It would be applicable to groundwater if there were clear evidence that the water beneath the surface were in fact flowing in an underground stream. Most states have very strict rules as to how an underground stream must be determined and as a result most groundwater is considered to be percolating. As such they are subject to one of the prevailing groundwater doctrines--English, American or correlative rights.

GROUNDWATER LAW

The English rule has very few restrictions with respect to groundwater. There are no restrictions on places where it may be used; there is no liability for pumping activities which interfere with others using the underground water in the absence of malice. Dissatisfaction developed with this rule and after 1900 most cases applied a reasonable use rule or "American Rule." This rule says that one man can use thereon the water percolating through his own lands in a manner reasonable to the needs and necessities of his own tract of land, while also having due regard to the coequal rights of his neighbors whose lands overlie the same strata. The correlative rights doctrine is based on the theory of proportionate sharing of withdrawals among overlying landowners. Under this rule landowners of percolating groundwater have coequal and proportionate rights to their overlying ownership. Under this rule a landowner may not extract more than his share, even if it is to be used beneficially on his own land, when the rights of other overlying landowners will be impaired by his use. None of these rules are concerned with keeping water use to a minimum or ensuring that water is efficiently used in terms of its highest and best use. It is only when conjunctive use of surface and groundwater becomes a reality, that we can expect a uniform set of laws for managing surface and groundwater which are interrelated physically.

## CONCLUSION

Increased water supply needs in the future will have to be met by 1) decreasing the amount of water currently being used for certain activities, 2) being able to shift water from existing uses to new ones, 3) restructuring management strategy so ground and surface waters can be used conjunctively, and 4) recognizing that water supply and water quality are part of the same problem. Waste can no longer be tolerated because certain practices were historically acceptable, efficiency will have to be a serious criterion in determining how water is used from both a technical and economical perspective, and total resource management will have to become something more than a "catch phrase." The eastern states may need to restructure their total water codes to keep from operating on a crisis to crisis basis. Politically it may not be easy but vagrancies of nature and increasing population may force acceptable compromises. In the West the problem has been further complicated by the Federal Government's policy of providing "cheap" water and the reserved water rights of both Indians and the Federal Government. Both levels of government must work together to make more water available through conservation for water supply purposes.

In addition to existing laws, there are areas where there are no laws or they are very vague. An example is the status of underground storage: Who owns the rights? Can those who put water down be certain of their right to recapture from a legal perspective? These areas need to be examined in detail.

In my opinion, a patchwork approach will likely make the problem worse. As one area is addressed another one is aggravated. Unless all levels of government--Federal, state, and local--begin to recognize the seriousness of our legal and institutional problems, we are going to have some very critical water problems in the future.

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# MOTIVATING THE PUBLIC TO SAVE WATER IN THE ABSENCE OF A CRISIS

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## ABSTRACT

Managing municipal water demands on a regular basis can be an important tool in helping to balance the supply-demand equation. Various elements or techniques can be considered by the utility, i.e., consumer education, pricing formulas, devices suitable for retrofitting existing homes, devices suitable for new development, irrigation equipment, drought-tolerant plant materials, and codes and regulations. But how do you successfully implement these elements and induce consumers to save water when there is no spectre of a water shortage to help congeal public action? In this paper the author shares his experiences in implementing water conservation in the North Marin County Water District and provides some tips and advice that have evolved from this experience. The thrust is a "volunteerism" type approach that first seeks a commitment from the consumer, followed by education and supply of materials, and lastly, follow-through surveys to determine the effective penetration of the idea or technique. Much of the advice developed by the author parallels empirically derived criteria employed by successful advertising agencies.

## THE BASIC STRATEGY

Water conservation is one element of demand management which holds significant potential for optimizing our water resource delivery systems while reducing energy consumption. But how do we motivate water consumers to use water wisely and frugally? How do we implant the idea in their heads that conserving water is in the best interest of man and nature? How do we do this when, in all but a few years, most of our man-made systems function well and are supplied by abundant quantities of fresh water?

For a clue to the answer, let's harken back for a moment to a pronouncement of one of our greatest statesmen:

> "With public sentiment, nothing can fail, without it, nothing can succeed."
>
> Abraham Lincoln, August 21, 1857

Add to this, the wisdom of a now anonymous sage:

"What the public thinks is what the public hears."

Now we are shown a way - public education. By constantly and repeatedly telling the story about water conservation, we can achieve a public awareness - a sentiment - which in the balance, once favoring conservation, will result in conservation.

HOW DO WE IMPLEMENT THE BASIC STRATEGY?

It is, of course, easy to create public awareness in situations of drought. It is not so easy, in fact extremely difficult, to achieve awareness in the absence of drought. But to make water conservation an effective tool in optimizing water resource use, that's exactly the challenge we face.

Fortunately, we don't have to look far for help, for this same problem has faced many before us, only the context was different. What I speak of is the multitude of advertisers who must constantly struggle for a "piece of public awareness" in order to sell their wares and services. We can learn well from the techniques developed over the years in the field of hard knocks known as advertising. First, however, we must orient ourselves to this field, which to most of us is as mysterious and vague as the Pythagorean theorem when we first heard the ominous term in our geometry class.

Let's start at the beginning. What is advertising?

"Advertising is salesmanship in print."

John E. Kennedy

Specifically, effective advertising is the art of getting our message on water conservation, or more accurately, our claim about water conservation, into the heads of the most consumers at the lowest possible cost. Let me parenthetically note here that most of the concepts regarding advertising set forth here were derived from a book on the subject entitled <u>Reality in Advertising</u> by Rosser Reeves, Chairman of the Board of the successful advertising firm of Ted Bates & Company.

The measure of advertising effectiveness, simply put, is that upon hearing our claim, the consumer remembers it. To be effective, an advertisement must meet three requirements:

1) it must <u>make a proposition</u> or claim (i.e., state that if you conserve water you will enjoy some specific benefits);

2) the claim must <u>be unique</u> and clearly stated or purveyed; and

3) the claim must <u>be strong</u>.

If we achieve these three goals in setting forth our proposition, it will be remembered and, perhaps, even implemented.

A caution to bear in mind at this point is that we must respect some cardinal principles developed by advertising experts:

1) Remember that the consumer tends to remember just one thing from a given claim; therefore, provide the back-up detail needed but keep the basic message short and simple and focused on the key concept.

2) Use visuals to strengthen the claim and create a "feeling" for it and make sure the visuals let the consumer "see with his eye" what he is reading or hearing so that the effect is one of reinforcement - not the opposite.

3) Seek wide dispersion of your message, i.e., try to reach the greatest number of consumers in every feasible way - don't rely on only one avenue of approach. For instance, consider and utilize:

   - bill stuffers
   - newsworthy stories or press releases for local press, radio and television
   - paid advertisements
   - school education programs
   - commercial approaches, i.e., a poster contest sponsored by a local group of businessmen, displays in merchants' windows, working with commercial outlets on giving high profile to water conservation items (such as in the local hardware store setting aside a special area labeled "water conservation center,..." or a similar set-up in the local nursery(s) presenting water conserving plants)
   - a booth at energy conservation and other types of fairs
   - speeches before service clubs, seniors, and local organizations and groups
   - distribution of information materials at new business openings, supermarkets, etc.
   - community conservation efforts, such as organized retrofit programs, and repeat of such programs
   - activities aimed at new development seeking installation of water conservation devices or use of drought tolerant landscapes; consider connection fee discounts; also ordinances or regulatory requirements if you think it necessary

- special efforts to reach large customers and work with them by class or on a case by case basis in metering inplant use and performing water conservation audits
- special efforts to provide information to key segments of the development sector, i.e., informational materials for landscape architects regarding the use of drought tolerant plants
- seminars and distribution of information on appropriate irrigation systems and irrigation management
- water conserving plant demonstration gardens
- water conservation device displays.

4) Penetration - that is, the effectiveness of sinking the message home into the consumer's head - is achieved in part by "pressure" in the form of repetition. Tell the story again and again - at every opportunity. Try not to change it too often or unnecessarily, and check your progress with follow-up consumer surveys.

In the time permitted for this paper, it is not possible to go into detail on every aspect of our water conservation effort at North Marin, but I would like to share two of our experiences with you.

CASE EXAMPLE ONE - WATER SAVING DEVICES IN NEW RESIDENTIAL GROWTH

Facing a water shortage while awaiting an expansion project, North Marin County Water District introduced a moratorium on new connections. This triggered a lawsuit from the last developer eligible to receive water. The remaining supply was insufficient to serve the developer's project but, by implementing a water conservation plan including use of low-flush toilets, shower and faucet flow controls, faucet aerators, insulated hot water lines, appropriate irrigation equipment and special soils preparation, water demand for the project was reduced to fit the available supply. The plan was developed utilizing significant input from the developer's engineer, plumbing contractor, etc. A detailed description of the plan is contained in North Marin's Little Compendium of Water Saving Ideas, March 15, 1977 edition. The crisis quickly passed with approval of a bond issue and start of work on the expansion project. The water saving plan worked so well, however, that North Marin County Water District decided to encourage other developers to install water conservation devices. Public commendations and news stories were utilized to encourage developer participation. Help was solicited from engineering consultants serving residential development interests. We met with these engineers and pointed out the benefits of such a program given our dependency on periodic expansion of our overland aqueduct system. We modified the plan slightly, based on experience with the first project, and then strongly encouraged its use. With persistence, first one, then another, and another developer installed the devices. Soon, within about two and a half years, utilization was approaching 80 percent. At that point we proposed the program be made mandatory for all new residential development (except for individually constructed single family homes). A hearing was held, minor modifications made, and on August 17, 1976, the plan was implemented. Since that date, all agreements for water supply contain the following provisions:

> "Water-Saving Devices for New Buildings and Landscaping." Prior to the commencement of water service to the real property and project the Applicant shall, at Applicant's expense, install water conservation devices and materials required by the District's Regulation 15e as follows:
>
> (1) All interior plumbing in new buildings shall meet the following requirements:
>
> (i) toilets shall not use more than 3-1/2 gallons per flush, except that toilets and urinals with flush valves may be installed,
>
> (ii) shower heads shall contain flow control inserts, valves, devices or orifices that restrict flow to a maximum of approximately 3 gallons per minute,
>
> (iii) kitchen and lavatory faucets shall have aerators or laminar flow devices together with flow control inserts, valves, devices or orifices that restrict flow to a maximum of approximately 2 gallons per minute.
>
> (2) All new parks, median strips, landscaped public areas and landscaped areas surrounding condominiums, townhouses, apartments and industrial parks shall have a well-balanced automatic irrigation system designed by a landscape architect or other competent person and the system shall be operated by electric time controller stations set for early morning irrigation. Landscaping covering clayey soils and slope areas shall be equipped with low output sprinkler heads permitting a slow water application rate. Prior to installing the irrigation system, the landscaped area shall be scarified and covered with a mixture of not less than four to six inches of topsoil (preferably native topsoil) amended with at least four cubic yards of organic material (nitrolized redwood sawdust, rice hulls, or equivalent) per 1000 square feet, and other soil amendments in a quantity and type approved by the developer's landscape architect. The District's Board of Directors may on the written request of an Applicant, waive any part or all of the requirements of this subsection if it finds that the area to be landscaped is too small or does not otherwise justify the automatic irrigation system or soil preparation.
>
> The District will consider, and may approve, requests to substitute for any of the requirements of this section well-designed alternatives or innovations that will effect significant reductions of water requirements."

To sum up, I believe the key to the success of our program for new construction lay with the fact that, first, we designed the plan with input from the professional engineers and contractors who regularly service the development community in our area; second, we employed publicity helpful to the developer in marketing his dwellings; third, we relied on a spirit of volunteer cooperation on the part of the developer; and last, when the program reached 80 percent penetration, we converted to a mandatory plan to pick up reluctant participants - as much out of equity to the volunteer participants as for any other reason.

CASE EXAMPLE TWO - RETROFIT KITS FOR EXISTING RESIDENCES

During the drought of 1976-77, distribution of water-saving kits to existing residential customers became popular. Typically, these kits contained a displacement bottle(s) or bag capable of displacing about 0.7 gallons of water in the toilet tank, dye tablets with instructions on how to check for toilet leaks, shower head flow restrictor inserts of one design or other, and a general brochure or other information providing tips on things to do to save water.

In late Spring of 1976, although suffering no water shortage, North Marin County Water District notified its customers, via a simple bill stuffer, that free water saving kits were available. The kit consisted of:

1) two one-quart plastic toilet tank displacement bottles (4-1/4" x 1-3/4" x 8-1/2")

2) a flow-tube-type shower flow-control insert including an "O" ring to eliminate noise;

3) two dye tablets with instructions for conducting a toilet-tank leak test; and

4) instructions for installation, follow-up toilet leak trouble-shooting and repair, and tips and information on water conservation in general.

Each kit cost about $1.00. The bottles were weighted with the proper amount of gravel to assure submergence, and all items were placed in a plastic bag designed to be hung on a door knob. Customers were asked to join in an effort to "SAVE WATER TODAY...FOR TOMORROW!"

The first bill insert, mailed in Spring of 1976 with no rationing in effect, is shown in Figure 1. Parallel with distribution of the bill stuffer, media stories were released, a poster contest with prizes supplied by local merchants was launched, speeches were presented to local citizen groups, and notices were placed in the two local newspapers. Of the 12,350 connections existing at that time (most of these were residential connections), 58 percent responded that they would like to receive a kit. Volunteers were utilized to assemble and distribute the kits and all orders were filled relatively promptly. All this was a big job and it involved many children in the community - Girl Scouts, Bluebirds, Cub Scouts, Boy Scouts, etc., thus serving to increase penetration even more. The next year, 1977, the second year of the dry spell hit California, and most San Francisco Bay Area communities, including North Marin County Water District, were forced to reduce water consumption an average of 30 percent. Customers were again asked to participate in the kit program, and at the same time, customers were surveyed as to the fate of items received in kits distributed in the prior year. The second bill insert, mailed in Spring of 1977 with mandatory rationing in effect, is shown in Figure 2. Responses increased to 82 percent with this second mailing. Regarding the questionnaire which reflected penetration achieved in the first year, 8,900, or 72 percent, of the District's customers responded. Three thousand of these responses were selected at random for analysis. Taking into account the level of penetration and extrapolating results to the whole service area, the survey revealed the following:

1) 60 percent of all customers installed bottles.

2) 5 percent of those installing bottles reported unsatisfactory performance.

3) 43 percent of the customers performed the leak test.

4) 30 percent of the customers installed shower inserts.

Admittedly, the second year of this program occurred during a crisis. The first year, however, did not; yet amazingly high penetration was achieved.

We believe the high penetration achieved in the first non-crisis year was due to the following factors:

1) The program was accompanied by significant advertising (most of it free, incidentally) which was diverse in nature and which was repeated many times over the course of three months.

2) The claim was simple and understandable ("install a kit and help save one million gallons of water each day").

3) Kits were "engineered" to be easy to install.

4) Kits were supplied only to customers who had asked for them.

5) A plethora of volunteers was used - mainly children, thus saving money while at the same time increasing penetration and media interest.

By comparison, experience recorded in the San Diego area by the

State of California Department of Water Resources during 1977 and utilizing three different approaches to distribution, revealed much less satisfactory results (see Table 1). The author believes the three most important reasons for the higher penetration in the first year of the North Marin County Water District program were:

1) Customers were asked to make a commitment (request a free kit). We believe this commitment, be it ever so small, placed the customer in a "follow-through" frame of mind when the kit was delivered.

2) Program advertising was intense, diverse, and repetitive.

3) Volunteers from almost every childrens' group in town were involved in the distribution.

SUMMARY

To summarize, I believe there are ways to successfully motivate a community to save water - even in the absence of a clear and present drought. Some of our experience on the matter is included in the two case examples described in this paper. The means and knowledge to accomplish water conservation are available to us and stem from the tools of the trade plied by the traditional ad man. What is required is a sensitive yet practical, common-sense approach to the problem and a willingness to accept the hard work necessary to bring it off.

FREE ONE-TIME WATER SAVING OFFER

Please check box, fill in address, and return this card with your water bill.

☐ Yes, I wish to join with my neighbors and help save 1,000,000 gallons of water per day (and energy as well)! Please send me (without charge) the toilet water saving bottles, shower flow control insert and toilet leak test kit together with instructions.

My address is: ______________________________

Note: The water saving devices, contained in a plastic bag, will be hung on your door by a volunteer service group should you elect to participate in this water conservation effort.

WE MUST SAVE WATER TODAY...FOR TOMORROW!

A Public Service by North Marin County Water District
999 Rush Creek Place, Novato, California 94948

Figure 1. First Bill Insert (Spring 1976) - No Rationing in Effect

FREE WATER SAVING OFFER!

Last year North Marin Water offered a free water saving kit to its customers in a joint effort to save one million gallons of Russian River water per day. WE AGAIN MAKE THIS OFFER AND WILL DELIVER THE KITS TO YOUR DOOR PROVIDED YOU RETURN THIS INSTRUCTION LETTER TO OUR OFFICE BY NO LATER THAN MARCH 11, 1977. Even if you do not wish to receive a kit, we ask that you fill out and return this letter with your next water bill payment.

Did you request a kit last year? ☐ Yes ☐ No

Did you receive a kit last year? ☐ Yes ☐ No

Please check the following actions and observations as appropriate:

☐ I inserted _______ bottles in toilet tank(s).
☐ I installed _______ shower inserts.
☐ I performed the toilet tank leak test.
☐ I found 2 bottles per tank worked satisfactorily.
☐ I found I could use only 1 bottle per tank and maintain a satisfactory flush.

Any problems or complaints with kit materials: _______________

_______________________________________________

_______________________________________________

If you did not participate in this water saving effort last year or if you would like to receive an additional kit, check here. ☐

Enter address here _______________________________

_______________________________________________

In order to calculate water saved we ask that you tell us how many people live at the above address. __________ people.

A public service by North Marin County Water District
999 Rush Creek Place, Novato, California 94948

CONSERVATION MAKES GOOD CENTS

Figure 2. Second Bill Insert (Spring 1977) - Mandatory Rationing in Effect

TABLE 1

UTILIZATION AND RETENTION (PENETRATION) OF
WATER SAVING TOILET AND SHOWER INSERTS[1]
IN THE SAN DIEGO METROPOLITAN AREA IN 1977
(Program Sponsored by State of California,
Department of Water Resources)

| Households | Distribution Mode[2] | Initial Penetration[3] | | Retained[4] | | Net Penetration[5] | |
|---|---|---|---|---|---|---|---|
| | | Toilet | Shower | Toilet | Shower | Toilet | Shower |
| 270,000 | depot | 20% | 12% | 70% | 82% | 14% | 10% |
| 60,000 | mass | 30% | 16% | | | 21% | 13% |
| 40,000 | door to door | 23% | 11% | | | 16% | 9% |

[1] Different types of toilet inserts of principally either the water dam or displacement variety were distributed. Plastic orifices controlling flows to 11.4 l/min (3 gal/min) were distributed.

[2] Distribution mode key:

- Depot distribution: kits were made available in a variety of neighborhood locations such as shopping centers, fire stations, etc.
- Mass distribution: workers and volunteers hung kits on doorknobs without talking to residents.
- Door to door distribution: workers called at each home, explained the program, asked resident to participate and left kit if resident agreed.

[3] Percent of total households. Many households did not receive the kits. By distribution mode area, total households not receiving kits were: depot - 68%; mass - 33%; door to door - 56%.

[4] Percent of households that initially utilized devices based on statistically significant follow-up survey conducted approximately two years after distribution.

[5] Percent of total households.

# PROVIDING SECTION SERVICES IN TECHNICAL INFORMATION AND TRAINING*

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The American Water Works Association's (AWWA's) training and technical information programs have been undergoing a major evolutionary change over the past several years. The planning, development, and implementation of various programs administered by the education department have been a time-consuming process; currently, however, established programs are online and new directions are being examined to expand and improve member services.

What have been the primary causes that have brought about the dramatic changes in the Association's education services? Most visible has been the increase in staff from three to nine members in the past 5 years. The expansion of professional staff has been a building process of selecting persons with abilities in specialized areas of technical information retrieval, program coordination, and training materials development, who function as a team. The turning point, however, can be traced to two factors that have resulted in substantially changing the Association's posture and providing the impetus to move in new directions.

1. Several years ago, the Officers and Board of Directors made a commitment to establish a technical library. This commitment was one of underwriting long-term support for the library's development and growth as a repository of literature relating to the water supply industry. At that time, no one anticipated that what would emerge would be a technological breakthrough for the Association in providing instant, online literature searches.

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*Presented at the 1981 Annual Conference of the British Columbia Water & Waste Association, Penticton, B.C., April 22-28, 1981. Text prepared by AWWA Education Department staff: B. Haskins, K. Keeley, L. Janak, and D. Cooperider.

2. The attitude of the Association's leadership changed nearly 5 years ago with respect to accepting Federal assistance for the development of training materials. Since then, nearly $15 million has been funded by the U.S. Environmental Protection Agency (EPA) for a variety of training programs and implementation activities.

In part, recent accomplishments are the result of the Board's position on accepting supplementary program grants and commitment to supporting a relevant education program on an international level.

The education department is one of the few departments in the Association that has contact with sections on a regular basis. Because of the communication linkage with individual members and sections, staff view their primary role as serving members by providing information to the hundreds of questions received on technical literature, seminars, and types of training materials available.

My purpose today is to inform you about what we're doing and to discuss our plans for meeting the challenges of the '80s in responding to section interests and needs in the areas of technical library services, seminars, and the development of training materials.

## TECHNICAL LIBRARY SERVICES

The Technical Library was authorized by the Board of Directors in May 1977. By August, staff was hired to organize the technical information published by AWWA and establish a system for cataloging books and reports already existing at the Denver Headquarters. The primary objective of the library has been to provide information on the water utility industry to Association members and headquarters staff. This is currently being accomplished through three basic programs:

- Audiovisual Services
- Reference/Research Services
- Standardized Bibliographies

### Audiovisual Library Services

The Audiovisual Library Service has been one of the most visible member services for several years. The immediate collection contains approximately 100 different selections to supplement training programs and to provide media resources for use in public information presentations to schools and community groups. In an average year, the library receives approximately 700 circulation requests for various 16-mm films, 35-mm slide presentations, and videotape programs listed and described in the audiovisual catalog. When a request is received, the "show date" is confirmed in writing and the media is made available for a 3- to 5-day period. Costs for the use of media are nominal, and rental fees typically amount to $10-$25 for each type of media requested. This service charge covers handling, mailing, media repair, and replacement.

New titles recently added to the collection include:

- Sampling and Analysis of Trihalomethanes (Videotape)
- Vault Safety (Videotape)
- Managing the Water We Drink (Slide/Tape Presentation)
- How to Use the Chlorine Institute Emergency Kit "B" for Chlorine Ton Containers (Slide/Tape Presentation)
- Without Water (16-mm film)

There are very few good public information and training audiovisual materials produced each year, and the staff relies, to a large extent, on others for information concerning the availability of new media materials produced commercially or by various organizations. In the future, AWWA will be obtaining more videotape cassettes. There is evidence that a significant number of utilities now have the necessary videotape playback equipment. Also, we will be encouraging utilities to evaluate the feasibility of using videodiscs now entering the market as an adjunct to their inservice training programs.

## Reference/Research Services

One of the most recent services provided by the technical library is providing up-to-date reference and research information for members. The service is performed principally by computer searches, although staff still handles a limited number of reference requests through manual searches. Computer data bases provide us with instant access to water supply information throughout the world via several major computer online reference bureaus subscribed to by the Association. Library staff have the capability of tapping more than 50 information banks, or data bases, that store more than 30 million published articles, reports, books, proceedings, and other technical documents.

Here's how the system works. The client provides staff with key words or phrases on the topics being researched. From terminals located at the Association, key words are transmitted to data bases and matched with key words coded with the titles of articles stored in computers. The search takes only minutes. What the client receives within days is a bibliography containing all reports, articles, and books related to the search topic. Almost all bibliographic citations contain two to three-sentence abstracts. Another phase of the reference service is to assist the client in obtaining the search document in hard copy. Many utilities and consulting firms are finding the Association's reference and document delivery service more efficient and time saving than using their own people to manually locate important references.

Computerized information retrieval is a relatively new library technology. Most data bases cover literature published since 1970, and the data files are updated monthly. The cost for a computer search typically runs $50-$75, depending on the type of bibliographic search requested. AWWA has advanced the data base concept one step further and is now entering and testing what we call "AWWA INFO." When this project is completed, we will have developed a private, composite data base that will cross-reference all Journal articles since 1976, all Water Quality Technology Conference papers since 1973, all Annual Conference and Preconference Seminar papers since 1975, and all AWWA Research Foundation publications since 1977.

## Standardized Bibliographies

Standardized bibliographies are gaining in popularity and use since their inception 2 years ago. They were compiled in response to frequently asked reference questions on specific topics of water treatment, distribution, and management. For example, the standardized bibliography on "Softening and Iron-Manganese-Color Removal" contains bibliographic references to 15 articles, each containing a three- to five-sentence abstract. Standardized bibliographies listed below currently appear in the Publications Catalog and sell for $3.50 each, member rate.

- Asbestos/Asbestos Cement Pipe and Drinking Water
- Cast Iron Pipe Corrosion
- Connection Charges, Tap Fees and Main Extension Financing
- Cross Connection Control and Back Siphonage/Back-Flow Prevention
- Data Processing/Automation in Water Systems
- Energy Conservation
- Giardiasis
- Leak Detection and Unaccounted-for Water
- Metering/Telemetering/Meter Repair & Testing
- Rates and Cost of Service
- Softening and Iron-Manganese-Color Removal
- Water Hardness and Health
- Water Main Replacement - Water Main Breaks

Staff is in the process of preparing 10 new standardized bibliographies, which will be available in August.

- Chlorine Resistant Bacteria in Distribution Systems
- Diatomaceous Earth
- Direct Filtration
- Disinfection Alternatives
- Drought
- Home Water Treatment Units
- Regionalization
- Sludge Disposal
- Taste & Odor Control
- Trihalomethanes

## SEMINAR PROGRAMS

As most of you know, for many years we have offered seminars to improve the technical, professional, and managerial skills of personnel employed in the water industry. We view the program as a forum for the exchange of ideas and technology among our members and nonmembers alike. Many of you have been participants and found that the program gave you the opportunity to share experiences and ideas with others who were doing similar work and facing many of the same challenges.

Currently, there are eight types of seminars, including Chlorination, Cost of Service, Cross Connection Control, Customer Service, Emergency Planning, Taste and Odor Control, Safety, and Water Loss Reduction. Seminars cover a wide variety of topics ranging from current technical procedures used in water treatment to handling irate customers and establishing equitable rate structures.

As needs of the industry change, new programs are developed to provide training and educational opportunities that will meet those needs. Our goal is not to duplicate training provided by vocational/technical schools, colleges, and universities, but to bridge the gap between formal education and on-the-job experience.

In 1976, the Association offered only five seminars. Most were directed toward water utility operators. Recently, however, certain pressures have forced utilities to examine their internal operations and improve efficiency in providing services.

A program for customer service representatives was piloted in 1977 in response to the growing demand for assistance to improving customer relations by providing training for employees who had daily contact with customers. Prior to the development of the Customer Service Seminar, there were no programs available to customer service representatives, billing clerks, or meter readers. The seminar has proved so successful that, to date, nearly 75 programs have been presented to over 2,000 seminar participants.

The Cost of Service Seminar--an introductory course for managers, planners, and consulting engineers--was developed in 1979 to address concerns related to the process of setting and managing rate levels and allocating costs of services.

The newest seminar, piloted in late 1980, is the result of the need for utilities to reduce lost and unaccounted-for water. It is estimated that 30 Water Loss Reduction Seminars will be presented in 20 sections of AWWA this year. Developed for managers and water distribution system personnel, the program provides practical suggestions for reducing revenue losses by repairing meters, locating and repairing underground leaks, and improving billing systems. This is the first program that brings both management and operations together with a common goal. The response to this approach has been extremely positive, often resulting in more effective interdepartmental communications.

We recognize that the success of the seminar program is directly attributable to our sections. Section Education Committees play a vital role in identifying training needs within the section where the Association can supplement their training activities. A major goal of the education department is to involve the sections more in planning educational activities. Steps have already been taken with Section Education Chairmen, Safety Chairmen, and Newsletter Editors to improve communications between sections and AWWA training staff.

Last year, Section Education Chairmen were furnished with updated procedural guidelines for scheduling seminars with headquarters. Systematically, twice a year, Education Committee Chairmen are contacted by letter and telephone by our Training Programs Coordinator, who works with sections on seminar arrangements. When a seminar request is received from a section, every effort is made to ensure the program's success. Seminar promotion, student materials, instructors, speakers, and adequate meeting facilities are arranged by the department's coordinator. There is no cost whatsoever to the sponsoring section, and every effort is made to avoid burdening the section with seminar arrangements. Generally, an interested member in the city where the seminar will be held is asked to provide information on hotels with meeting rooms, and to receive and distribute student materials at the seminar. This person is designated the Local Arrangements Chairperson (LAC), and in exchange for his/her assistance, he/she attends the seminar as a guest of the Association.

While the Association is not a certifying agency, Continuing Education Units (CEU's) earned by those attending seminars are applied toward certification renewal in many States and provinces. A permanent record of CEU's has been maintained by the Association on persons attending seminars since 1976.

For several years now, we have been introducing sections to the concept of "contracting" for seminars. Many utilities, government agencies, and training organizations have found this approach to providing training successful. For example, a section or utility may request a seminar for 30 persons. The cost is negotiated on the basis of services performed and materials required. There are many options, but the more services performed by the contracting organization, the lower the cost. Since the sponsoring organization or section has "purchased" the seminar, the registration fee (if any) is set by the sponsoring organization. Many sections have contracted and fully subsidized the program by offering the course at no cost. Others have used this method to generate revenue, in which case everyone benefits. Sections earn a moderate profit and students receive the training at a lower cost, since fees set by sections are usually less than the fee charged by the Association.

Contracting for seminars is a method whereby sections or utilities can retain responsibility for the program without having to develop materials or recruit instructors. Moreover, they become actively involved in the training process.

In the past 5 years, over 7,500 water utility personnel, regulatory officials, and consultants have attended more than 250 seminars. That amounts to approximately 90,000 person-hours of training.

Water utility management, increasing costs, water quality, and improved service were major concerns in the '70s. The challenges of the

'80s will undoubtedly include financial considerations related to growth, new sources of supply, facilities expansion and replacement, and water conservation practices. Already, many utiltities are experiencing revenue short-falls as a result of voluntary and enforced water conservation measures. Inflation, population growth, and migration compound the very difficult task of planning and developing adequate drinking water supplies for the future.

The Association must be prepared to offer training that is geared toward helping utilities cope with these new challenges. Through systematic evaluation, statistical interpretation, and reporting, the education department will respond to section needs by expanding and upgrading seminar services.

## TRAINING AND PROGRAM MATERIALS DEVELOPMENT

Perhaps one of the most recent and significant changes in program direction has resulted from a reorganization of the education department and the assignment of staff to a materials development section. This group of people is responsible for the preparation and recent publication of a Chlorination Training Package. The training package concept is a new thrust for the Association in providing training alternatives that have not existed before. The chlorination package has been prepared in 10 individual modules of instruction and offers the user several options for conducting inservice training sessions on a short- or long-term basis.

The various instructional components that make up the package include:

- Instructor Guide, 110 pages illustrated
- 35-mm slide illustrations (80) correlated with discussion topics
- 16-mm film entitled "Safe Handling of Chlorine"
- Slide/tape presentation on "Chlorine Residual"
- Water Chlorination Principles and Practices, Manual M20, AWWA
- Chlorine Manual, the Chlorine Institute
- Handbook of Chlorination,, Van Nostrand Reinhold Company
- Standard Methods, 15th Edition, AWWA/APHA/WPCF
- Water Quality and Treatment, McGraw-Hill Book Company
- Water Treatment Plant Design, AWWA/ASCE/CSSE

The instructor guide has been organized in a way that each module of instruction contains an overview, training objectives, methods of instruction, supplemental materials, selected references, lesson outlines, and instructor notes. Instructors are encouraged to prepare data using local examples and to draw upon their experiences to supplement course notes.

As we have seen before, in periods of spiraling inflation and administrative budget pressures, it always seems that training funds are the first to be cut. We believe the training package concept will provide a way of conducting training at a substantially lower cost per student.

The use of packaged program materials is not only an efficient method of providing training and improving operating performance, but probably the most cost-effective. It is more economical than paying registration fees, transportation costs, and per diem expenses for outside training. Here are some advantages that should be evaluated in considering the purchase of a packaged training course:

- Training expenses can be shared with neighboring utilities.
- Training can be adapted to deal with inplant operating problems.
- Instruction can be paced to the learning rate and interests of plant operations staff.
- Course materials can be taught at a time most convenient to the work schedule.
- Instructional materials are reusable. They will be around for a long time, providing opportunities to hold refresher courses or train new employees.

As fewer and fewer dollars are appropriated for training at the national level, it will become increasingly important that AWWA sections as well as local utilities provide the necessary training for their employees.

Over the years, the Association has been engaged in a number of training projects that have been funded by EPA and the Indian Health Service (IHS).

- Two excellent slide/tape presentations on <u>Chlorine Residual</u> and <u>Turbidity Analysis</u> were produced in conjunction with various SDWA publications. The presentations emphasize proper sampling and testing procedures as well as how test results are calculated.
- A Five-Volume Operator Training Program Series has been under development for the past 3 years. Each volume focuses on a specialized segment of water supply operations from source to tap. Titles in the series include:

  Volume 1, Introduction to Water Sources and Transmission
  Volume 2, Introduction to Water Treatment
  Volume 3, Introduction to Water Distribution
  Volume 4, Introduction to Water Quality Analyses
  Basic Science Reference Handbook (an applied supplement to Volumes 1-4)

  Volume 1 and the reference handbook are presently in print, and Volumes 2-4 are scheduled for publication in 1982.
- Most recently, the Association has been preparing training materials for EPA and IHS on the operation and maintenance of

sanitation facilities on Indian lands. As a spinoff from the project, the Association is preparing a book on Management of Small Water Systems, which is scheduled for publication late this year.

Work is currently in progress on the development of another comprehensive training package on safety practices. The training course will emphasize topics identified by a needs assessment survey mailed to member sections last year. Particular attention is being devoted to safety and distribution operations, where 70 percent of all accidents in the industry are reported to occur.

Future plans for program development include packaging existing AWWA seminars, such as Cross Connection Control, Customer Service, and Water Loss Reduction. In addition, a number of course topics have been identified that deal with the operation and maintenance of ground water systems.

## CONCLUSION

As the '80s unfold, there will certainly be many more issues confronting our industry than we contemplate today. The consequences of the years ahead will demand that new ideas be applied to traditional approaches, that new technology and procedures replace obsolete ones, and, perhaps most important of all, that we have access to information to enable us to resolve unfamiliar situations. To accomplish these tasks, we need your help in identifying how our education, training, and information services can serve your interests and needs most effectively. We ask for your continued cooperation and support in this joint endeavor.

# WATER-SAVING PLUMBING: A Flow Control & Maintenance Program To Reduce and Control Water Use In Multi-Housing Properties

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## ABSTRACT

Evaluation of water consumption at multi-housing properties often reveals excessive and costly water use. The challenge to reduce and control water flow is being successfully met by a program designed to modify plumbing fixtures and provide management of water consumption.

## INTRODUCTION

Management responsible for budgeting operating expenses at apartment and condominium communities has expressed increasing interest in devices to save water and energy as utility costs have increased rapidly in recent years. In far too many cases, however, management failed to put forth an effort toward reducing water consumption equal to their interest. Unfortunately, many efforts directed towards saving water produced results far inferior to what can be expected from a water conservation program.

As a manufacturer and supplier of flow control devices, we have supplied numerous projects for the past ten years. Many times we have delivered quality devices which, instead of achieving significant reductions in excessive water use, find their way to the supply room to await installation during a vacancy or turnover. When complete installation is immediate the job is sometimes carelessly performed. And even when installation is as complete and professional as one could hope for, the consumption analysis which follows is often incomplete or incorrect. These problems are usually compounded by the fact that other important water management responsibilities are completely overlooked. Any effort to conserve water in a multi-housing environment will encounter a number of obstacles, any one of which can adversely affect the result of the program.

Being absolutely certain that flow control devices can provide a significant reduction in consumption, Metropolitan Watersaving decided to market devices through a program of water management, thus guaranteeing results over which we previously had little or no control. Instead of delivering products to be used or abused at the whim of maintenance personnel, we would deliver results through a professional program of water management.

A complete retrofit service is offered to modify existing showers, faucets and toilets to perform at more efficient flow rates.

Shower: Overgenerous showerheads (5-6 gpm) are changed to a water/energy-saving model that uses less than 2.5 gpm. Several models are tested to confirm efficiency and to permit selection of preferred spray pattern.

Faucet: Kitchen and lavatory faucets are fitted with flow control aerators to govern flow to under 2.75 gpm. Aeration offers benefits such as non-splash flow and better sudsing action.

Toilet: Conventional tank-type flush toilets consume an average of 5.2 gallons per flush. Toilet tank dams are installed to modify existing tanks to use 3.5 gallons per flush for an average reduction in water use per flush of 1.7 gallons. Careful installation and minor adjustments when necessary assure adequate flushing action. Toilet is carefully checked to assure fixture is leak free and water level is at proper height.

In addition to the hardware phase, other phases of the program include:

a) analysis of water use
b) survey of building/unit fixture
c) installation service to assure standardized flow rate on a per unit basis
d) monitoring service as follow-up

Several recent job consumption figures illustrate the benefits of flow control devices when used as part of a complete water management program:

Job Number: 0073-0050
Units: 128
Location: Silver Spring, Maryland

| Meter Reading Period | Consumption Daily/Unit (gallons) | |
|---|---|---|
| 1/18/80 - 2/19/80 | 251 | |
| 2/19/80 - 3/18/80 | 234 | |
| 3/18/80 - 4/18/80 | 221 | |
| 4/18/80 - 5/19/80 | 220 | |
| 5/19/80 - 6/24/80 | 242 | |
| 6/24/80 - 6/30/80 | 230 | |
| 6/30/80 - 7/21/80 | 271 | |
| 7/21/80 - 8/22/80 | 232 | |
| 8/22/80 - 9/22/80 | 229 | |
| 9/22/80 - 10/17/80 | 207 | --- implement flow control |
| 10/17/80 - 11/21/80 | 154 | |
| 11/21/80 - 12/19/80 | 156 | |
| 12/19/80 - 1/21/81 | 132 | |
| 1/21/81 - 2/23/81 | 134 | |
| 2/23/81 - 3/19/81 | 135 | |
| 3/19/81 - 4/20/81 | 132 | |

Average reduction: 102 gallons daily per unit

Dollar savings annually: $14,272.50

235 gal x 128 units x 365 days @ 2.33/1,000 = 25,581.54
133 gal X 128 units x 365 days @ 1.82/1,000 = 11,309.04

annual savings = 14,272.50

Implementation cost: $1,996.80

Expenditure recap period: 1.7 months

Job Number: 3701-3705
Units: 936
Location: Bailey's Crossroads, Virginia

| Meter Reading Period | Consumption Daily/Unit (gallons) | |
|---|---|---|
| 1/11/79 - 4/12/79 | 142 | |
| 4/12/79 - 7/11/79 | 150 | |
| 7/11/79 - 10/15/79 | 155 | |
| 10/15/79 - 1/12/80 | 166 | |
| 1/12/80 - 4/11/80 | 171 | |
| 4/11/80 - 7/17/80 | 144 | --- implement flow control |
| 7/17/80 - 10/10/80 | 142 | |
| 10/10/80 - 1/19/81 | 105 | |
| 1/19/81 - 4/10/81 | 101 | |

Average reduction: 66 gallons daily per unit

Dollar savings annually: $47,576.79

66 gal x 936 units x 365 days @ 2.11/1,000 = 47,576.79

Implementation cost: $11,033.75

Expenditure recap period: 2.8 months

Job Number: 0408-6000
Units: 1200
Location: Alexandria, Virginia

| Meter Reading Period | Consumption Daily/Unit (gallons) | |
|---|---|---|
| 4/24/80 - 5/22/80 | 179 | |
| 5/22/80 - 6/23/80 | 189 | |
| 6/23/80 - 7/25/80 | 191 | |
| 7/25/80 - 8/25/80 | 199 | |
| 8/25/80 - 9/23/80 | 202 | |
| 9/23/80 - 10/22/80 | 196 | |
| 10/22/80 - 11/19/80 | 205 | |
| 11/19/80 - 12/22/80 | 190 | |
| 12/22/80 - 1/22/81 | 191 | |
| 1/22/81 - 2/21/81 | 157 | --- implement flow control |
| 2/21/81 - 3/23/81 | 133 | |
| 3/23/81 - 4/22/81 | 127 | |

Average reduction: 70 gallons daily per unit

Dollar savings annually: $53,655.00

70 gal x 1200 units x 365 days @ 1.75/1,000 = 53,655.00

Implementation cost: $18,369.00

Expenditure recap period: 4.1 months

# LANDSCAPING ALTERNATIVES AND IRRIGATION CONSERVATION

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## INTRODUCTION

I would like to make a few general comments concerning the subject of water conservation and what we in the home building industry are doing about that important subject. First, for the last 2 years the home building industry has been the recipient of a voluntary effort on behalf of the plumbing industry to provide water-conserving devices as standard equipment. New homes in Colorado have been receiving low-volume, 3-1/2-gallon toilets; low-volume showerheads; and faucet aerators. This is a dramatic case where voluntarism through private enterprise has moved at a faster pace than any government codes. Second, the trend toward smaller, more dense housing, which has primarily been motivated by issues of affordability, certainly has been a positive factor relative to water conservation. Outside irrigation demands are reduced by this trend toward more density. Third, I would hope that this audience would find the most recent National Association of Home Builders Consumer Survey very interesting. The historic main reasons for people buying new homes have been the need for moving to a larger home and moving to a nicer neighborhood. Energy has now become the number one subject of concern. Although the current main concern of energy is heating, the subject of water conservation also is included in the broad concern for energy-conserving homes.

## DENVER LAWN WATERING PROGRAM

Now I would like to discuss a very exciting 1981 Denver lawn irrigation program that will be using mass media to change the existing patterns of overwatering in our area, but first a word about the supply problems in the Denver area. Currently, we are operating with a treatment limitation until a new plant can be completed next year, which means that we operate with an every-third-day watering schedule to assist in the lowering of that peak demand. In addition, we also have a raw water supply problem. This means that this region of the country is very interested in long-range conservation efforts that could alleviate, to some degree, the necessity for developing as much raw water as is currently being contemplated. As a result of the negotiation that led to the permissions required to proceed with the construction of the new treatment facilities, a Citizens Advisory Committee was formed for the purpose of providing citizen commentary and input to the Denver Water Department. This Citizens Advisory Committee, which has been in existence for 2 years, has several Task Forces. I am Chairman of the Task Force for Landscape Water Conservation. Other Task Forces include: the Home Water Conservation, Water Metering, and Long-Range Planning Task Forces. Serving on a Citizens Advisory Committee can be a very frustrating experience due to lack of mission, undetermined goals, poor attendance, lack of staff support, and ineffective leadership. Recognizing these liabilities, our Landscape Conservation Task Force set up an operating philosophy that included the following points: One, the Chairman personally solicited key members via telephone; he explained the purpose and assured them that the meetings would be brief and to the point, and that the Task Force would be disbanded after completing its mission. The membership included sod growers, sprinkler company representatives, savings and loan and mortgage bankers, conservation officials from neighboring cities, landscape architects, garden store owners, consulting civil engineers, and other interested citizens. Two, we sought and expressly recruited key members of the Denver Water Department staff to attend our meetings and to participate. This included members of the Community Affairs Department as well as the Conservation Officer. The theme of this strategy was working together toward a common cause. Three, meetings were held, no more than monthly, at the Denver Water Department; they started at 4:15 p.m., making it more convenient for all people to attend on a regular basis. The meetings for this program started in October 1980, and continued through April 1981. Four, our meetings were devoted to getting outside local speakers to cover the subject of new technology, mass media communication opportunities, and a market program to unite the two.

As Marketing Vice President for Sanford Homes, Inc., which builds 400 homes per year, my skills are in the field of marketing. Therefore, the prime strategy was to seek out the areas of greatest marketing potential (in this case, existing bluegrass lawns in the Denver metropolitan area) to review the existing knowledge base, which turned out to be the one at Colorado State University at Fort Collins; and then devise a plan whereby these concepts could be "sold" to the consumer utilizing contemporary marketing and public relations techniques.

Our Conservation Task Force focused on lawn watering as an area of high potential. During periods of hot weather of over 90° F in July and August, approximately 80 percent of all water used in the Denver system goes into the irrigation of bluegrass lawns. Another way of expressing this high consumption is to note that on an annual basis Denver has a usage of 150 gallons per day per person. This consumption rises to over 500 gallons per day per person during maximum day conditions, which in Denver can occur back to back for several days at a time. With the cooperation of the Denver Water Department staff and other neighboring communities, we attempted to learn how much people were actually watering their bluegrass lawns. We now have some evidence that it may be as high as 1.9 inches of water per week. Other data indicate that typical watering in our area ranges from 1.5 to 2.0 inches of water per week through the 22-week growing season, which is from May through early October. Some of the information from Colorado State University indicates that very attractive lawns only require 0.9 inches of water on the average throughout the growing season. If people are willing to accept an option of a lawn appearance that is satisfactory but somewhat less green, then the watering requirement can be decreased to 0.7 inches of water per week. Our Task Force saw that this could be an area of high potential savings for the Denver area if the consumers could be informed, educated, and motivated to apply this information.

The Task Force felt it advisable to do some basic research about consumer attitudes. A common theory stated by conservation-interested individuals was that "the public really does not care about conservation and therefore it is unwise to spend a great deal of resources on educating the public when the demand is not there." The Task Force asked the Metro Poll Survey, a division of the Denver Consulting Group, to do a February 1981 survey to test these assumptions. The survey, performed as a public service, generated some very encouraging and startling results. First, over half of the consumers were vitally interested in saving water through better methods of lawn irrigation. Second, the citizenry was extremely informed about the necessity for water restrictions in the Denver area, which are due to growth, limitations on plant treatment capacity, and the present drought conditions.

From a marketing viewpoint, the gasoline energy crisis and shortages, the escalating utility bills that relate particularly to natural gas and electricity, and the nationwide drought with its excessive publicity have contributed greatly to the public awareness that was verified in this survey. The Task Force recommended that the Denver Water Department hire a public relations firm to undertake the coordination of these programs. At one of our early sessions, we heard a presentation from a Vice President of Public Affairs from Channel 9, our ABC affiliate, who was most enthusiastic about our ability to gain major commitments on the television stations relative to free public service announcements, talk shows, and other support commitments. At our meeting, Ms. McKinley committed 26 spots per week during the summer. A second major commitment was received from the News Director of Channel 9 relative to supporting our watering forecast system. A few years ago, the Denver Water Department had produced the very excellent "Water Folly" cartoon educational announcements. We are planning on expanding this series to better emphasize outside lawn irrigation. A new brochure will be prepared in four colors with distribution through Channel 9, the Denver Water Department, and major retail outlets and local garden stores. It will be designed to better explain the system of bluegrass watering, which ties into the daily watering forecast.

The Denver Water Department also intends to install a telephone call-in system whereby a customer could phone in and get various taped messages on a timely basis that would explain many aspects of water conservation and current weather conditions as they relate to the watering forecast. For many years, the Denver Water Department has used a newsletter with its billing process. The Task Force recommended that the newsletter be reviewed from the viewpoint of increasing readability through more contemporary graphics and formatting.

For the Colorado State University information, I wish to express my gratitude to Dr. Jack Butler and his staff. For many years, horticulturists have been provided with evapotranspiration (ET) rates for agricultural crops. Dr. Butler has expanded this information to include bluegrass lawns. The accompanying table describes three quality levels of lawns: country club, which is 80 percent of ET and is a very attractive, good-looking lawn; meadow, which is 60 percent of ET and is mostly green but includes some brown and still overall has a very attractive appearance; and prairie, which is mostly brown and perhaps not appropriate for an urban environment. The table was prepared using average conditions in the Denver area; it shows the various options the consumer might select. In reviewing the table, it is important to recall that our data indicated that the average consumer in Denver watered 1.5 to 2.0 inches of water per week, but country club only requires 0.9 inches of water per week and meadow only requires 0.7 inches of water per week throughout the growing season. The accompanying figure from Colorado State University indicates the importance of adequate lawn fertilization in this program. As can be seen, a reduction of 30 percent in applied water for a lawn that has adequate nitrogen or is properly fertilized only shows a drop in appearance level of 1, on a scale of 1 to 10, whereas the lawn that is improperly fertilized shows a dramatic drop in lawn quality as the water is reduced.

The scope of our program for 1981, therefore, included a Denver Water Department daily calculation of ET data, including daily information about solar radiation, wind, temperature, and local precipitation, if any. This information will be provided to a major television channel for inclusion in the weather forecast as well as to The Denver Post, which has made a commitment to include not only the 3-day watering schedule but the watering forecast for the next day. The special four-color brochure will be prepared as previously discussed, and we will be supporting this program with articles by our public relations consultant for the newspapers and speciality magazines within the Denver area. We also hope to have several of our experts from the Task Force as well as local horticulture experts go on various local talk shows. I am pleased to report that this program, in its entirety, was presented to the Denver Board of Water Commissioners and received their total endorsement as to its viability and priority.

As to future plans for improving the conservation potential of bluegrass in the Denver area, we hope to offer a consumer kit that could be available for about $18. It would include some simple measuring devices to better determine the output of sprinkler systems; the four-color informational brochure describing the various options of lawn quality that might be selected; a probe specially designed for lawns, very much like the watering probe that is now being used for indoor house plants, indicating when to water; and a special watering permit that could go in the homeowner's window, exempting those homeowners from 3-day watering. This kit would give the above information along with the daily ET watering forecast, allowing the homeowner to select the kind of lawn desired and to water only when the lawn needs it. There is no question that excessive water waste occurs during the 3-day cycle, since many homeowners water each third day because they feel their lawns cannot go 6 days without water. If they were allowed to water only as needed (as indicated by the probe), they might stretch out the time period to 4 or 5 days, which would greatly enhance the root growth of the lawn.

## SUMMARY

I can say with a great deal of enthusiasm that we have a high potential coalition of lawn experts, Denver Water Department staff, mass media, and interested parties who have worked very hard to pull together some specific information that can help the average consumer reduce dramatically his water use during the summer. We are fortunate to have an excellent program and a consumer demand that makes the marketing of this program a very viable prospect. We look forward to reporting our success with the summer 1981 Denver lawn watering program.

TABLE

Average climatic data and recommended average daily irrigation levels for urban lawns to provide lawn quality ratings of prairie, meadow, and country club.

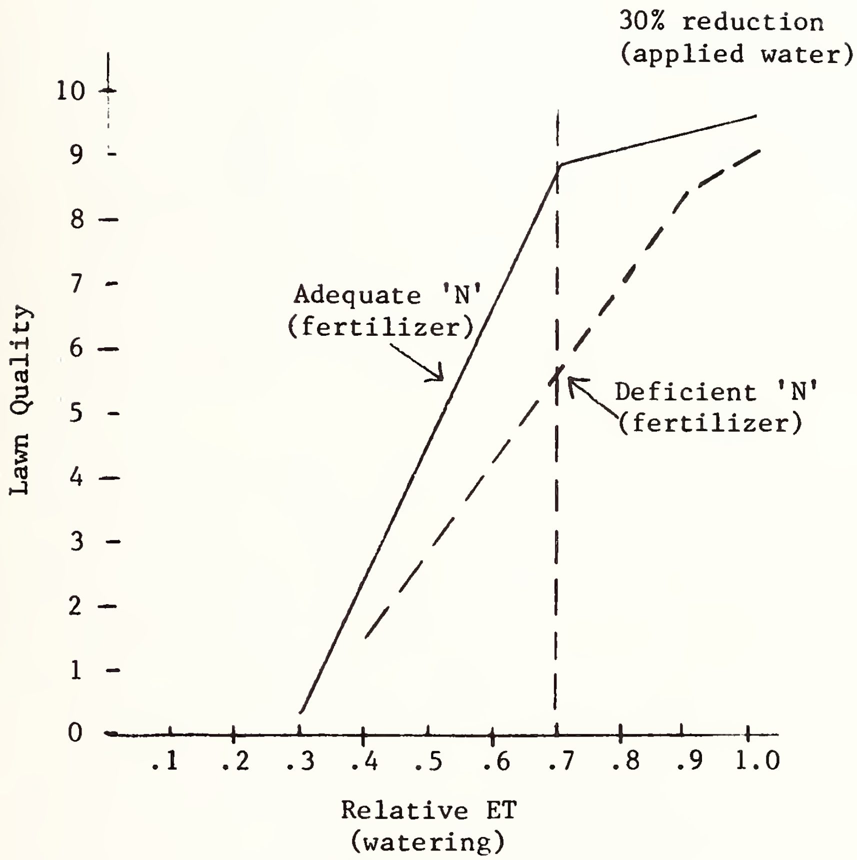
City: Denver, Colorado

Elevation (feet): 5,280

| Month | °F | Average Precipitation in/week | Potential ET in/week | Irrigation in/week Lawn Quality Prairie | Meadow | Country Club |
|---|---|---|---|---|---|---|
| May | 60° | 0.60 | 1.38 | -- | 0.39 | 0.66 |
| June | 68° | 0.45 | 1.91 | 0.16 | 0.88 | 1.27 |
| July | 76° | 0.40 | 2.09 | 0.28 | 1.07 | 1.49 |
| August | 76° | 0.29 | 1.82 | 0.30 | 0.99 | 1.35 |
| Sept. | 68° | 0.26 | 1.32 | 0.17 | 0.66 | 0.91 |
| October | 52° | 0.26 | 0.77 | -- | 0.28 | 0.41 |

FIGURE

Adequate Lawn Fertilization




Colorado State University

04/81

# WATER CONSERVATION: THE LEAKS IN IMPLEMENTATION

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It is a pleasure today to address such a distinguished body which represents a field so vital to our future. America, for the first time, is beginning to realize that water, like energy, minerals and other natural resources, is a limited commodity which it can no longer afford to waste. America has experienced droughts, water shortages, and facility failures in almost every region of the country. Water Conservation is no longer a new idea. It has been successfully applied in enough situations and under different circumstances, that it should no longer be the subject of blind skepticism. Many of the people taking part in this conference bring ideas and results gained from the actual field rather than from studies and hypotheses as was the case in the past. Water Conservation is no longer a new idea. However, while it is considered the answer to future water needs, its future is not tomorrow, but today.

In a conference such as this, it is important not only to look at where we are going, but also to analyze where we are. The Environmental Policy Institute (EPI) is currently conducting a project which in part will do just that. EPI is presently developing a model water conservation program for the state and local level. The first step was to find out what presently exists in our systems. Our initial process was to review all of the 50 state water codes for existing water conservation laws. Second, we surveyed all state governments or Departments of Water Resources. Using a questionnaire, we asked these agencies what the states had in terms of a water conservation program, conservation statutes, proposed water conservation programs, or individual conservation elements. In addition, the project is surveying the state university systems and land grant colleges in much the same manner, as well as reviewing successful water conservation programs on the local level.

While the EPI study has not yet been completed, there are trends developing that are worth noting. When reviewing the state codes, we found that under Montana State code 85-1-203:

> State water plan shall set out a progressive program for conservation, development, and utilization of the state's water resources and propose the most effective means by which these water resources may be applied for the benefit of the people, with due consideration of alternative uses and combination uses.

When we contacted Montana, however, we were told that there is no water conservation program.

The State of Florida, under State code 373.016(1)(2b) states:

> The waters in the state are among its basic resources. Such waters have not heretofore been conserved or fully controlled so as to realize their full beneficial use. It is further declared to be the policy of the legislature: To promote the conservation, development and proper utilization of surface and ground water.

In actuality, Florida has nothing resembling a Water Conservation effort.

The State of Delaware, currently experiencing the northeast drought, under code 6001 states:

> In view of the rapid growth of population, agriculture, industry, and other economic activities, the land, water and air resources of the State must be protected, conserved and controlled to assure their reasonable and beneficial use in the interest of the people of the State.

Yet all Delaware has is a maximum flow requirement in their plumbing code for new construction.

The State of Mississippi, under code 51-3-20(3) states:

> The council shall develop an annual statewide plan for implementing works of improvement for the purposes of drainage, prevention of flood water damage or the conservation, development, utilization, and disposal of waters for recreation, beautification, welfare, and other beneficial use.

When we asked for a copy of their annual statewide plan, Mississippi replied: "As is often the case in legislation no funds were made available for carrying out these provisions."

It is not my intent to single out any one of these states for any other purpose than to show how representative they are of the conditions in most of our states.

When analyzing our state survey we developed minimum criteria by which we judged if a state has a water conservation program. To qualify, highly residential states must have:

- a comprehensive public education program
- a residential retrofit distribution program
- progressive rate structure reform (where local law permits)

High agricultural or rural states must have:

- an agricultural conservation program
- a ground water management program
- a public education program

I would like to stress again that these are minimum guidelines and not all of the elements needed for an overall comprehensive program. It should be also noted that state water situations and conditions vary; are not easily comparable to each other; and not all reported water conservation elements are equal to each other in scope, funding or results.

According to our survey, only one state comes close to having a state water conservation program: the State of California. While we felt their program did not extend far enough in such areas as rate structure reform and agricultural and ground water management, California is progressively and agressively moving ahead in most other conservation areas. It is most likely only a matter of time until they address these weaker points.

Our survey recorded six to eight states as having partial state programs. A partial program would have several water conservation elements such as a progressive plumbing code, a leak detection, leak repair program, and a metering requirement program. While this would not meet our criteria for a full program, it is certainly going in the right direction.

Twenty states possess one or two conservation elements such as a metering requirement or a progressive plumbing code. Often these elements were instituted for reasons other than water conservation. These states do not appear to be moving toward a program.

Approximately five states have proposed state water conservation programs designed for future legislation or implementation. These states presently have little or no conservation elements in practice. Several of these proposed programs are quite impressive; however, they still must be subjected to the legislative and agency process of review, some of which may never be passed or enacted.

Finally, sixteen states do not presently have, nor do they foresee having, any form of a water conservation program. The apparent reasons for this are quite diverse in nature. Most of these states tend to be in the Northwest, Midwest, and Southeast regions of the country.

One early assessment that can be made from this survey is that a gap exists. There is a gap between the state water codes and their implementation, a gap between local water conservation and its state counterpart, a gap between studies and proposed plans and their implementation.

These gaps are not new nor are the reasons for them few in number. However, one of the older and primary reasons for this gap is the variety of definitions attached to water conservation. In too many areas of this country, conservation still means structural approaches such as the building of dams, reservoirs, innerbasin transfer networks, and desalinization plants. This misleading interpretation addresses only increasing supply and storage capability. This has usually been in spite of the consequences. The consequences have meant devastation to our prime farmlands, wetlands, wildlife, water quality, towns, and generational family way of life.

The consequences also mean enormous cost overruns that the taxpayer and local resident must bear. The Stonewall Jackson Dam in Lewis County, West Virginia, has produced such problems. While water supply is only one of the minor purposes for the project, Stonewall Jackson Dam offers a good example of the enormous costs and effects that a project can incur. The Dam will displace approximately 1,800 residents and destroy 400 farms. The original cost of the project was estimated by the Corps of Engineers to be $34.5 million. The current costs have run up to $225 million. Now the non-federal share of that payment is $58 million. This $58 million must be assumed by the West Virginia residents and taxpayers. The State of West Virginia has no water conservation program.

Another example is the City of Boston, which is reported to be leaking approximately 76 million gallons of water per day. Instead of repairing its leaky system, Boston has proposed to transfer the same amount of water out of the Connecticut River into the Quabbin Reservoir through the construction of the "Northfield Diversion." The Quabbin Reservoir is another result of Boston's desire for more water. Its construction resulted in inundating four towns, displacing 2,500 residents, and the exhumation of 7,500 bodies from 34 cemeteries.

Politics and political favoritism are additional barriers against conservation implementation. For years water rate structures have benefitted the large consumer at the expense of the small consumer and federal taxpayer. These rates have encouraged overwatering, waste, and the growing of high water consumptive crops in non-native regions. Cotton, for instance, which is native and essential to the economy of the Southeast, is now grown in abundance in the Southwest. Until this federal and state subsidy of water to favored regions and consumers is ended, and the price of water is set at its true value, there is no reason for the consumer to conserve.

Another factor that hinders implementation is that the public is still largely uneducated about the benefits of water conservation. Most of the public views conservation as only to be practiced during a water crisis. As a whole, they have failed to understand the long- and short-term benefits and the public and private savings that it offers.

Our government leaders and elected officials also remain ignorant and apathetic to water conservation. Towards the end of 1980, when the present Northeast drought first began to develop, it was shocking to find that most state and local governments involved didn't know what direction to take. It was as if the California program, the Washington Suburban Sanitary project, and the Tucson, Arizona experience had never happened. Aside from an outdoor use ban, the threat of water rationing, and an occasional public education effort, what is the Northeast's plan for solving their problems? They are still trying to develop one.

A final major reason for the lack of conservation implementation is the anticipated start-up and operational costs. In actuality the investment returns on these programs can be enormous. Not including the cost of labor or the cost of retrofit kits, the City of Tucson, Arizona, spends approximately $3000 annually on its water conservation project. They have reduced their peak demand by 1/3. Elmhurst, Illinois, during 1977, reduced their maximum daily consumption rate by 30 percent and their daily consumption rate by 5 percent. The cost of their program is $1.00 per capita.

In older cities, capital improvement programs such as metering a non-metered system or repairing a badly leaking system can require huge capital investments. These cities, often financially strapped, find it hard to justify or produce funds for such programs, regardless of the long-term returns and benefits. Technical and financial assistance must come from the states. The State of Massachusetts, for example, has a $10 million, 50 percent matching fund program with the local level for leak repair programs. However, this type of innovative funding proves to be more the exception than the rule.

The problems hindering water conservation are large and complex. The solutions, however, are amazingly basic in nature. One solution is education: the public must see that water conservation is more than just an <u>alternative</u> solution to a water problem. It is the most sound and economically feasible solution which must be applied to a problem before any other action is taken. The public needs to understand this and demand it. We must educate our government leaders and elected officials. Once educated, we must urge and pressure them into adopting water conservation as an operating policy. This is by no means an easy task, but until our leaders do so, conservation will remain only sporadically in test projects around the Nation.

Innovative funding programs are essential, especially now that the present Federal administration is cutting Federal programs in these areas. Such agencies such as the Office of Water Research and Technology, and other technical and financial aid sources are being abolished. This more than ever puts the burden on the states. Matching funds, rate structure changes, and tax incentives are just a few areas than can make up the difference. Much more, however, is needed.

The problem of implementation is real. Failure to address the problem will mean that our studies and proposals will continue to sit on the shelves of libraries rather than being put into action in solving our water problems of today and tomorrow.

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Potable
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'81 A NATIONAL CONFERENCE

# Resources: Manuals and Handbooks

# DEVELOPING AND TESTING A WATER CONSERVATION HANDBOOK

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## ABSTRACT

How do we "sell" water conservation?

The advertising community would suggest that we begin by educating the residential consumer. "Easy Ways to Save Water, Money, and Energy at Home," a 32-page booklet produced by the Potomac River and Trails Council, was designed to do this.

What follows is the distillation of experience gained by the Environmental Protection Agency (EPA), which commissioned the booklet, and the Potomac River and Trails Council (PRTC), which designed and printed it.

We also describe "Project Water Watch," a program undertaken by PRTC in Frederick, Maryland, a small but developing city of 30,000 where there is no perceived water supply problem. With a small EPA grant, PRTC has been testing the attitudes of local residents about water conservation, and about the booklet "Easy Ways to Save Water, Money, and Energy at Home."

## EASY WAYS TO SAVE WATER, MONEY, AND ENERGY AT HOME

To improve water quality and reduce the cost of wastewater treatment, Congress, in the 1977 Clean Water Act Amendments, charged EPA to encourage less costly alternatives to conventional wastewater treatment systems. Recognizing that public education was essential if "alternative" and "innovative" systems were to gain acceptance, Congress also charged EPA to develop "a continuing program of public education" on these topics, and on "methods for the reduction of wastewater volume."

"Reduction of wastewater volume," or "flow reduction," is probably the cheapest way to reduce the cost of treating wastewater. In addition, it can relieve overloaded treatment systems; extend the life of existing facilities; and in some cases permit towns to build smaller new plants than they might have thought necessary.

It can also bring inexpensive relief to homeowners with failing septic systems,and to communities faced with building major sewage facilities to cope with septic failures in rural towns and subdivisions.

We planned "Easy Ways to Save Water, Money, and Energy at Home" to make it useful in the EPA Construction Grants Program, which requires communities planning new wastewater treatment facilities to address water conservation as an "alternative" in sizing plant capacity. But we also wanted a booklet that would be suitable for anyone - town or household - who was interested in saving water.

Given these "target groups," we decided the diction and graphics should be informal, non-technical, and <u>fun</u> to read and look at - but <u>not</u> "corny" or patronizing. And since we didn't want to produce a forbidding tome, we thought 35 or 40 pages would be about the right length (the printed version comes to just 32 pages).

Over the year and a half it took to get the booklet from concept to printed page, we learned that developing such a "simple" booklet was <u>anything</u> but simple!

On the production side, the writer thought: "Well, all I've got to do is review the 'literature' on the subject, condense it down to what I need, and start writing. And then find someone to do the graphics and layout."

And the project officer at EPA thought: "Gee, since I've dug up all sorts of material for the writer to review, and since we're just talking about 30 or 40 pages, in two or three months I'll have the book!"

No one anticipated how <u>hard</u> it would be to get <u>just</u> the tone of voice we wanted, or how difficult developing a theme - a common thread that tied things together - would prove. And once we decided that line drawings would be a lot more "informal" than photographs, we could not forsee that the artist (whose sketches were "perfect") would get cold feet and back out of the project - which set us back about four months.

The "education" of the writer was perhaps the most difficult (and time consuming) aspect on the production side: for he soon learned that reading about water conservation was not enough. To make the booklet "informal" required him to put it in his own words (and not words borrowed from the experts), and this, as it developed, required many weeks of tinkering and record keeping at home.

And as the tinkering and data collecting progressed, the book went through draft after draft, and a shift in narrative from third person ("he, they") to the first person ("I, we") - which, we thought, would enable readers to identify with the writer as a person like themselves, and not think of him as an outside "expert" preaching to them.

Basing the text on what was learned at home enhanced this effect by enabling the writer to take the stance of a "layman"; and say to the reader: "I'm in the same boat. But what I've tried at home has saved a lot of water <u>and</u> money - and here's what I've learned."

Eventually we saw the relationship between a gas-guzzling car and the water-guzzling plumbing that most of us inherit with all but the newest homes; and the really large energy savings that ride piggy-back on <u>hot</u> water conservation.

This, after many false starts, gave us the theme: "We're all stuck with water-guzzling plumbing fixtures, but by retrofitting with good low-flow devices now on the market, we can save a lot of water, energy, and money - and, incidentally, reduce the need for costly new water and sewage facilities that we pay for through rate increases."

While the author felt strongly about the environmental benefits that water conservation can bring to local rivers and streams, he also assumed that few householders would invest $25 or $30 in flow-reduction devices just to "save the environment." While the book includes a few references to environmental quality, they are low-key and not insisted on.

We approached the illustrations with several biases:

(1) Drawings are more specific and can show a lot more detail than photographs.

(2) Even the simplest plumbing fixtures are a mystery to Harriet and Harry homeowner. Clear illustrations,

keyed to the text, are the most effective tool we have to motivate people to do something about water conservation.

While it's easy enough to remove an old showerhead and replace it with a good low-flow model, unless the illustrations show this a lot of readers will never make the attempt.

As it was, finding the right illustrator to do what we wanted turned into a nightmare. To get the range of technical and humorous drawings that we wanted, we finally settled on three artists: a woman who was just right for some of the imaginative "fun" drawings could not do good plumbing illustrations, for example. Since we didn't want to sacrifice her successful drawings, we decided to get another hand to do the plumbing fixtures. We even incorporated a few sketches by our first artist, who backed out when it came time to do some finished art.

The work of three hands may not be wholly compatible, but we think there is a lot of life to the illustrations even so. We also learned that with proper guidance we don't always need "professional" illustrators: imagination and dedication to the job are equally vital qualities. For several "professionals" who submitted sketches, it was obvious to us that this was "just another job," and that we'd get polished but lifeless work from them.

Some of our best drawings are by a young woman just out of college - who had no published work in her portfolio, but who had a fertile imagination and a genuine interest in the subject of water conservation.

For anyone embarking on a project like ours, in which a government agency encourages the production of an illustrated booklet (either in-house or out), we have the following additional tips:

(1) Ideally, try to find a project director who really understands and believes in your cause or program.

(2) Time spent by the director in interviewing writers and illustrators is well worth it. By all means get samples of their work, and in the case of illustrators have them try their hand at sample sketches. In our case, we had them sketch faucets, toilet fixtures, etc.

(3) Don't be fooled by flashy studios or portfolios full of

published articles or illustrations. Will the person invest the time and energy to learn about this subject and audience? If you don't think so, forget the person's reputation and look elsewhere.

(4) The writer and illustrator should work together. Once the text is taking shape, have them begin to decide on the number and kinds of drawings that will be needed - and on the appropriate treatment.

We didn't start with an illustrator until the text was finished; and then compounded the problem by failing to give her a clear idea of just what drawings we wanted. "You look over the text and tell us what you think needs illustrating," was our approach - and so it was probably inevitable that this person back out of the job.

(5) The project director (or the firm you choose to direct production)must give you realistic estimates of the time and money it will take to do the job.

In our case, we greatly underestimated the difficulty of the job, and the budget that was needed. The typography, for example, cost the PRTC a lot more than had been budgeted.

Neither EPA nor PRTC expected such a lengthy project; the booklet was produced with a very low budget largely because both EPA and PRTC believed in the "cause"; but a case like this will be the exception rather than the rule.

(6) Allow plenty of time for drafts of the text (and artwork) to be sent around for review.

We sent drafts to about 10 or 15 "expert" hands, and to 20 or so "laymen" (members of PRTC). Many of the comments were important ones, and led to needed revisions of the text. The writer and project director are often so "close" to the subject they overlook important points.

In our case, we sent out about three sets of drafts before we were satisfied, and the process took about three or four months.

(7) Get an imaginative, creative person to do the layout. The best of texts and illustrations will be "wooden"

in a poor layout.

Layout is a time-consuming job so be sure to budget properly for it. In our case, it took about a week to get the "right" cover design.

PROJECT WATER WATCH

The Potomac River and Trails Council has been trying to test people's attitudes and perceptions about water conservation in a city of 30,000, where there has never been a problem with water supply, and where water and sewer rates are quite low.

We also thought it would be an interesting place to test our booklet "Easy Ways to Save Water, Money and Energy at Home." Since Frederick, Maryland is in a humid climate, and did not feel the 1980 drought that troubled other communities in the East, we wanted to see what the "selling point" would be for water conservation.

We began with a market survey of plumbing, hardware, and other stores that carry even a modest number of plumbing fixtures. We found, in Frederick, that:

(1) The most common items offered for sale are faucet aerators. Very few stores handle low-flow shower heads, and only <u>one</u> sells toilet dams.

While clerks and store managers agree that water saving might be a good idea, they were unanimous that there was no market for low-flow plumbing devices in Frederick.

In a store that carries a few low-flow shower heads the manager said, "We've sold one low-flow shower head in the last two years. And it will take about that long to sell another one."

(2) <u>None</u> of the store managers was interested in stocking additional low-flow devices.

(3) The chain stores, generally, do not order their own supplies. Virtually all of them carry a trade-name plumbing line, and orders are placed for them by a regional or national office.

(3) We bought and tested four brands of shower heads. <u>All</u> were just a standard shower head (most of them plastic) with a plastic washer inserted to make them "low-flow."

None gave a satisfactory shower.

After meeting with the Mayor and head of the city's Public Works Department, we decided to develop a slide show that would teach city residents where their water came from; how it was treated to make it potable; how Frederick handled its wastewater; and how the city billed residents for water and sewer service.

We also added a section on water meters for people who wanted to check out their home water use; and about 30 slides that show how low-flow plumbing devices work and how to install them.

Finally we developed two questionnaires: one to find out what Frederick residents know about the city's water supply and their own household water consumption, and a second questionnaire to get their evaluation of our booklet.

Our idea was to have meetings in discrete parts of town: in the black community, the downtown historic district, in several new subdivisions, etc. To date we've had six public meetings, all but one poorly attended. We've met in a church basement, local homes, and a downtown community center.

Since we are testing attitudes as well as people's responses to our book,we decided to advertise the meetings through "normal" channels: the newletters and channels of communication that each group normally uses. In other words, we haven't gone out of the way to "drum up business"; and, indeed, the one downtown meeting that we scheduled for a general audience (and so advertised through radio spots and in the newspaper) had <u>no</u> attendees.

At the other five meetings we followed a similar format: administer the water supply quiz (respondents do not sign it or identify themselves); give our slide program (which answers questions raised by the quiz); answer questions, and then have a general discussion about low-flow devices. Each participant gets a free copy of "Easy Ways to Save Water..." and an evaluation form about the book that we ask them to return in a self-addressed stamped envelope.

We also loan out low-flow shower heads and toilet dams to people who want to try them.

What we have learned so far is about what we could have predicted: without a water-saving campaign backed by the city government the level of interest and application in water conservation will remain low - except where there is a dynamic community leader to influence his neighborhood or civic group.

And we think that only a prolonged drought or maybe a massive population influx that would strain existing water supplies would bring the city to start the kind of campaign that will get results.

Or perhaps if Frederick had to make extensive capital investments in water and sewer facilities that led to big rate increases, the new rates themselves might trigger an interest in conservation. (Interestingly, this has just happened in a large subdivision a few miles from Frederick.)

Even if the city launched an extensive campaign - which included increasing block rates to reward conservation - a lot would depend on the availablity of good low-flow plumbing devices. After our program, for example, everyone asks, "Where can I get toilet dams or low-flow showerheads?" And we have to tell them, "These things aren't available at stores in Frederick."

So either the city would have to supply reliable devices, or induce local merchants to stock them

Our other findings I'll sketch briefly:

(1) People will <u>not</u> return evaluation forms, even when the envelope has a stamp and return address. To date, we've given out 70 of our booklets around Frederick and had just <u>six</u> evaluation forms returned.

As a "control," when we were asked to give our program at a National Conference on "Water Programs in the Reagan Administration" (sponsored by the American Rivers Conservation Council), we brought along our booklets and evaluation forms. At this conference, attended by citizen leaders from all over the United States, we gave out 40 booklets and evaluation forms - but, in the intervening months, not <u>one</u> evaluation has been returned.

(2) Frederick residents, new and old, know next to nothing

about their city's water and sewer system. Over half the people we quizzed thought the city's sewage is treated and discharged into a river 25 miles from town!

Less than a quarter knew the source of their drinking water.

(3) Not surprisingly, town residents knew as little about their household water consumption. The pattern was to consistently <u>underestimate</u> the amount of water used by various household appliances - especially the bath and shower.

Most respondents were about 50 percent <u>low</u> in their estimates of the water used in an average bath or shower.

(4) Willingness to try low-flow shower heads and toilet dams varied from group to group. We found that a <u>lot</u> depended on the group leaders.

Two examples: not one town-house resident in a new subdivision was willing to try a shower head. And we noted that our host, who was chairman of their civic group, was especially cool toward the idea.

Two weeks later we met with a well-organized civic association from single family homes in the same subdivision. Their president was a dynamic, knowledgeable person who welcomed us warmly and asked a lot of lively questions.

By the end of the meeting, <u>all</u> <u>15</u> participants wanted to try (even buy) our shower heads and toilet dams.

(5) So far, low-income residents have shown little interest in our program. In three meetings at churches and public places in a lower income part of town, we've had a total of 15 participants.

A church minister in this part of town seemed the most hopeful contact for us. But when it came to testing a low-flow shower head in his home, he wanted none of it.

(6) The moral - for readers who may be interested in establishing a water-saving program - is obvious: identifying forceful and concerned citizen leaders should be one of the first priorities.

Another is to coordinate with your local government and water utility. We received outstanding cooperation from Frederick city officials: indeed, to help us prepare our slide show, the head of the Public Works Department drove us to all of the city's water facilities, dug up typical water meters for us to photograph, etc.

In the event that Frederick ever wants to launch a water-saving campaign, we will have done a lot of the spadework for them.

City officials were also grateful that we contacted them. Had we tried to "go it alone," we might well have earned their enmity.

(7) As another "control," we took our program to a new community called Fountaindale, about 10 miles from Frederick, a subdivision that has exorbitant water and sewer rates. (These are now about $800 a year for a family of four.)

Given the long-standing battle the community had fought with their local water company, and the attendant newspaper publicity, we thought that here, surely, the residents would have more knowledge and interest than in Frederick.

Our idea was to do about 30 door-to-door interviews at houses chosen at random: give them a water-use quiz (modified to meet conditions in Fountaindale); discuss the economics of water saving; and leave a flier advertising "Easy Ways to Save Water...." (We were curious to see how many residents would order a free copy of the booklet; but so far, after 30 interviews, we haven't received <u>one</u> order.)

While we were very well recieved in Fountaindale, and found that everyone wanted to <u>talk</u> about the water system, to our <u>surprise</u> the residents <u>knew</u> as little about the workings of their public and household water systems as Frederick residents! One example illustrates this: 20 of the residents we interviewed believed their water came from reservoirs, when, in fact it comes from a large public well. Except for a few respondents, estimates on home water use were also <u>low</u>, comparable to estimates made in Frederick.

Most surprisingly, few Fountaindale residents had a clear idea of what they were paying for water and sewer service: estimates ranged from \$150 to \$800 a year. Several new residents thought their bill would be about \$75 a year!

CONCLUSION

Since late January, when "Easy Ways to Save Water..." was published, we've received orders for about 16,000 books (including one large order from a water utility). We've also had many favorable comments from readers all over the country.

Most of our orders have come from people and communities in dry climates, or from humid areas in the East that were hard hit by the 1980 drought.

But even in Frederick, where there is little interest in water conservation, a few key assumptions we made in producing the booklet have been reinforced:

(1) Barring drought or disaster, economic motives are the main way to interest people in conserving water. Only a few are swayed by appeals to "good citizenship" or to "save the environment," etc.

(2) Where water and sewer rates are low, and there is little money to be saved by conserving water (as in Frederick), people have to see the relationship between saving HOT Water and saving ENERGY; and that wasting water in the shower or tub will add a significant increment to their annual energy bill.

(3) Even with exorbitant water and sewer rates (as in Fountaindale) we shouldn't assume that people know much about their public and household water systems.

We found that Fountaindale residents <u>wanted</u> to save, but had little idea how much water they were using or how to begin saving.

So even with a motivated audience, a good public education program is vital.

(4) Talking to people in Frederick and Fountaindale reinforced another idea that was central to our booklet: most of us would rather rely on a good low-flow device than change a habit. "I'm not about to take a shorter shower," one man said, "but I <u>will</u> change to a low-flow

shower head if I can find one that will give me a decent shower."

So the effectiveness of a water-saving campaign will depend in great measure on the availability of effective low-flow plumbing devices. A person who gets "turned-on" to water saving may soon get "turned-off" if he can't find low-flow shower heads and toilet dams; or, worse, if he buys a slipshod model that gives a lousy shower.

(5) Where water is concerned, don't count on people to mail in requests for booklets, water-saving devices, etc.

Meetings and door-to-door interviews work best.

# FLOW REDUCTION: METHODS, ANALYSIS PROCEDURES, EXAMPLES

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## ABSTRACT

Increasing numbers of communities across the nation are realizing the benefits of flow reduction in managing their wastewater treatment facilities. Among these benefits are savings in wastewater treatment, water supply and energy costs, as well as the ability to meet a greater portion of future needs with existing treatment capacity. <u>Flow Reduction: Methods, Analysis Procedures, Examples</u> (1) was prepared for the Environmental Protection Agency (EPA) to assist communities in developing cost-effective flow reduction programs. The manual's flexible, yet structured step-by-step procedure is a useful guide to developing program alternatives, analyzing program benefits and costs from a community viewpoint, providing for adequate public participation, and selecting a recommended program based on the analysis results. The manual also provides detailed information on flow reduction measures and specific devices, including their associated costs and water and energy savings, as well as examples of how to calculate a program's net monetary benefits. Two additional volumes will supplement Parts I and II of this manual. Part III will demonstrate the manual's procedure using two real-world communities; Part IV will provide additional guidance and material for developing flow reduction public information programs.

## WHAT IS FLOW REDUCTION--AND WHY CONSIDER IT?

As its name implies, flow reduction refers to ways of reducing or slowing the growth of the quantity of wastewater flowing to a wastewater treatment facility. It is essentially a subset of water conservation. Whereas water conservation focuses on reducing water use in general, flow reduction focuses more directly on reducing water used indoors since this is the water which enters sewer lines and flows to the treatment plant. Selected water conservation measures applied to the residential, commercial, public and small-scale industrial setting form the core of any flow reduction program.

There are two principal motivations for communities to consider flow reduction. First, communities can reap substantial benefits from an effective flow reduction program. Using relatively common water-saving measures, indoor water use can easily be reduced by approximately 25 percent (see Table 1). The corresponding reduction in wastewater flow may allow communities to either delay building new components of treatment facilities or to size certain facility components smaller. This of course will save the community and its water users money over the long term. Similar savings may result on the water supply side. In addition, individual water users will realize savings on energy bills, since a large portion of the indoor water saved will be hot water. Spiraling costs of water supply, wastewater treatment and energy will continue to make these potential benefits increasingly difficult to ignore. Many communities have already been successful in reducing wastewater flows through conservation efforts. To cite just a few:

- Oak Park, California reduced dry weather wastewater flows through a retrofit program by about 25 percent (2).

- Springettsbury Township, Pennsylvania reduced average wastewater flows to its eight-million-gallon-per-day (mgd) treatment plant by about 30 percent through flow reduction and infiltration/inflow programs (3).

- Oakland and Berkeley, California have reduced dry weather wastewater flows by 10 percent. During the 1977 drought, flows were reduced by 28 percent (4).

- Elmhurst, Illinois reduced its average flow by nine percent and its peak day flows by 14 percent (5).

The second main motivation for flow reduction is that EPA now requires any community planning a wastewater facility through its Construction Grants Program to do a flow reduction analysis (6). Only communities with populations under 10,000, with an average daily base flow less than 70 gallons per capita per day (gpcd), or which already have an approved program are exempt from doing the analysis. As shown in Figure 1, while the major tasks in facilities planning are progressing, three additional tasks are performed to refine the community's wastewater flow projections: a flow reduction analysis, an industrial flow analysis (to reduce flows from specific, large industrial water users), and an infiltration/inflow analysis (to reduce the amounts of groundwater and rain water entering the wastewater system). Refining projected wastewater flows through these three efforts may enable a community to adjust the sizing or staging of its treatment facilities, thereby saving on construction and operating costs.

## FLOW REDUCTION ANALYSIS

Flow Reduction: Methods, Analysis Procedures, Examples was prepared for EPA by INTASA, Inc. of Menlo Park, CA, to assist communities in performing the flow reduction analysis and in developing cost-effective community flow reduction programs. The manual develops a step-by-step procedure as a guide to carrying out the analysis.

Table 1. Indoor Residential Water Use and Potential for Water Savings with Conservation

| Indoor Water Use | Total Indoor Use (percent) | Without Conservation[a] (gpcd)[c] | With Conservation[b] (gpcd)[c] | Reduction (percent) |
|---|---|---|---|---|
| Toilet flushing | 40 | 25 | 17.5 | 30 |
| Bathing | 30 | 20 | 16 | 21 |
| Lavatory sink | 5 | 3 | 3 | - |
| Laundry & dishes | 20 | 13 | 9.5 | 27 |
| Drinking & cooking | 5 | 4 | 4 | - |
| Total | 100 | 65 | 50 | 23 |

a. Based on data in U.S. EPA. 1979. (2).

b. Assumes use of toilet dams, plastic shower head inserts and water-conserving dishwashers and washing machines.

c. Gallons per capita per day.

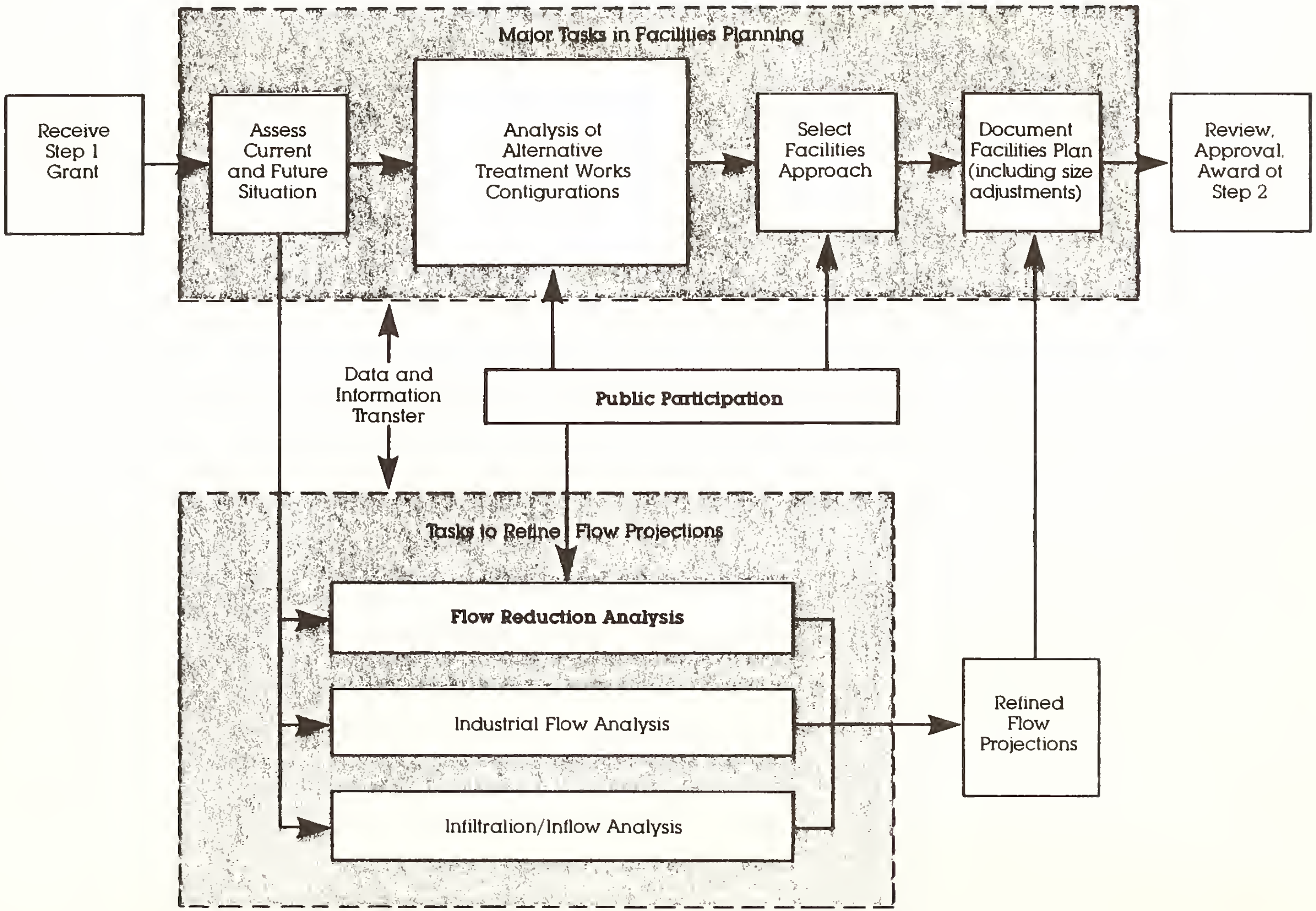


Figure 1. Flow Reduction Analysis within Facilities Planning

Figure 2 portrays this sequence of steps. Briefly, the approach involves:

- Determining whether, under EPA's criteria, the analysis is required for the given community.
- Projecting the community's water supply and wastewater treatment needs without flow reduction to establish a base condition.
- Developing a first-cut flow reduction program.
- Evaluating the program's monetary and nonmonetary benefits and costs.
- Repeating the evaluation for reasonable alternatives.
- Obtaining the public's views on potential programs.
- Selecting and documenting a recommended program.

Each step is described individually in the manual with emphasis on the information and specific analytical tasks needed to carry out the step. Where useful, examples are provided to indicate how certain tasks may be performed.

Developing a Community Flow Reduction Program

A large portion of the manual focuses on Step C--developing a first-cut flow reduction program. Three distinct but related components comprise an effective community program:

- a set of flow reduction measures selected from four broad categories: structural measures (e.g., retrofitting existing residences with low-flow devices); economic measures (e.g., changing water rate structures); legal/institutional measures (e.g., changing building or plumbing codes); and education measures (e.g., promoting water-saving habit changes).
- a public information program which supports the set of flow reduction measures by informing the public about these measures and the benefits they and the community at large can expect from implementing them.
- an implementation plan which sets forth the budget and manpower requirements of the program, the timing of the different program elements and provides for needed coordination and cooperation from other agencies and groups.

Since many community planners will not be familiar with available flow reduction measures, the manual supplies substantive information to aid communities in selecting a set of measures to include in a program.

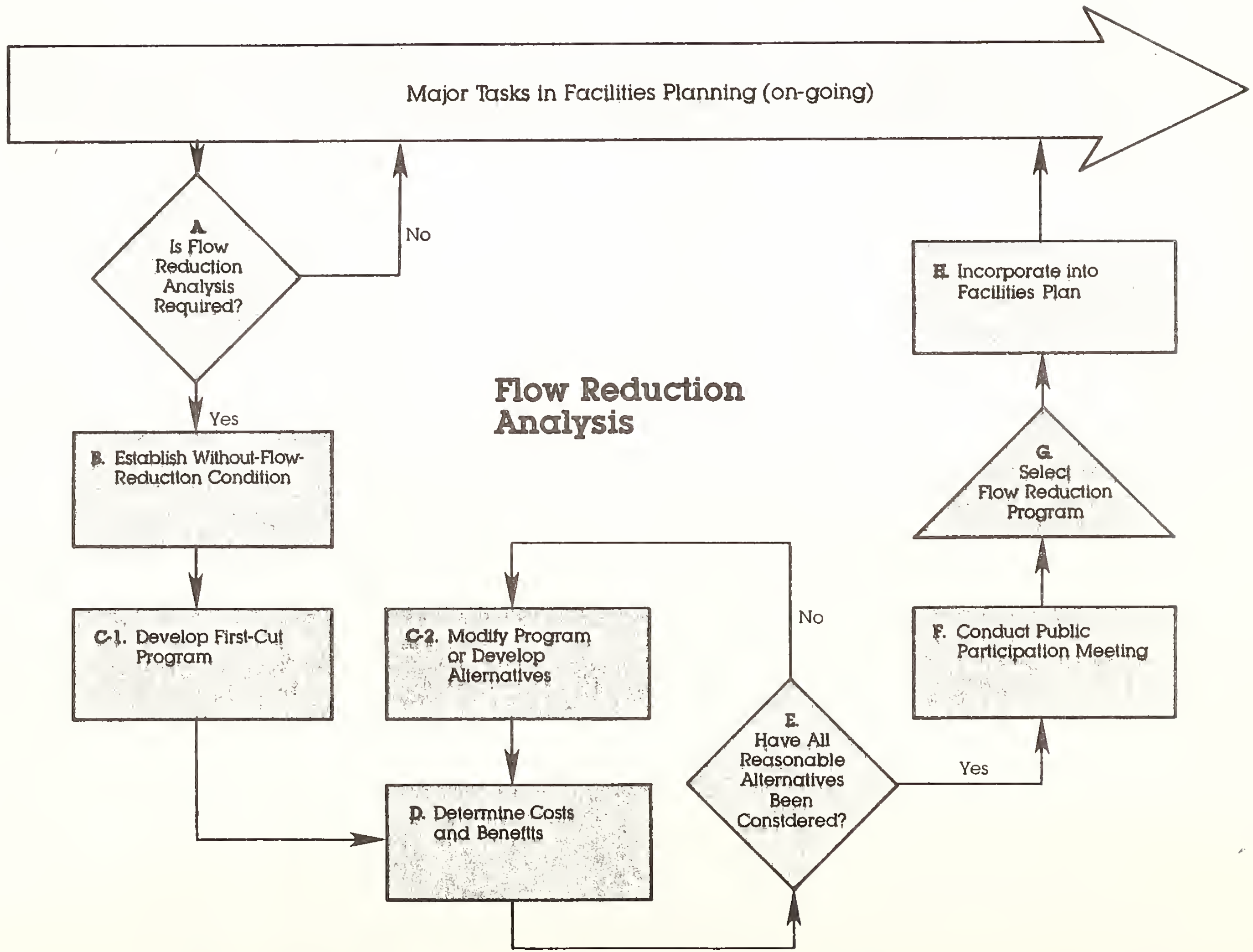


Figure 2. Flow Reduction Analysis

For example, the manner in which retrofitting programs are carried out (e.g., door-to-door distribution of devices without professional installation versus device distribution with installation) greatly affects the results achieved. Thus, the manual describes these different retrofitting strategies and indicates the results obtained by various communities which have used them.

Detailed attention is also given to specific water-saving devices and appliances that can be included in a flow reduction program, including retrofits for toilets, faucets and showers, low-flow fixtures for new construction, pressure reducers, and water-saving appliances. Along with descriptions and pictures of devices, the manual gives a first-order comparison of their relative cost-effectiveness taking into account typical community savings in water costs, wastewater costs and water users' hot water energy costs. The significant assumptions used in developing these comparisons are clearly stated so that communities can develop comparisons using numbers reflecting their own particular circumstances.

## Evaluating Program Benefits and Costs

A flow reduction program will result in both monetary and nonmonetary costs and benefits to the particular community in which it is implemented. To provide a basis for selecting a program alternative which is economically beneficial and environmentally sound, a comprehensive evaluation of the program's full effects is needed. To avoid double-counting either program costs or benefits, a community viewpoint is maintained throughout, simultaneously considering effects on three community entities: the wastewater utility, the water supply utility, and water users.

A flow reduction program's monetary costs consist only of the direct costs of the program, and include: (1) the cost of purchasing and installing flow reduction devices, (2) the costs of the public information program, including such things as printing flyers and developing exhibits, and (3) the costs of implementing the program including, for example, needed staff time.

The monetary benefits of the flow reduction program consist of the total savings in costs to each community entity. Specifically, these monetary benefits will include cost savings to:

- the wastewater utility due to net reductions in capital and operations and maintenance (O&M) costs resulting from the projected reduction in wastewater flows.

- the water supply utility due to net reductions in capital and O&M costs resulting from the projected decrease in water demand.

- water users due to decreased energy costs resulting from savings of hot water.

The monetary benefits to the two utilities are determined by comparing the projected capital costs and O&M costs (expressed in terms of present worth) without the flow reduction program to the capital and O&M costs with the flow reduction program. The difference between these costs throughout the planning horizon represents the program's monetary benefits to each respective utility.

Figure 3 portrays a simplified hypothetical example for a wastewater utility. In this case, the reduction in projected peak wastewater flows resulting from the flow reduction program allows the utility to adjust downward the sizing of certain facility components. These would include unit processes which are hydraulically determined--those sized according to the volume of flow. The monetary benefits to the utility would include the savings in capital costs from building smaller facility components and any savings in annual O&M costs which result from the reduced average daily flow to the treatment plant. It must be noted that the occurrence and magnitude of variable O&M cost savings from reduced wastewater flows will vary depending upon the particular characteristics of the wastewater treatment plant, the collection system and the wastewater flow itself (7).

A similar procedure is followed to determine the capital and O&M cost-savings to the water supply utility. The present worth of the cost-savings to the utilities along with the present worth of the water users' hot water energy cost-savings together comprise the total monetary benefits to the community from the flow reduction program.

Subtracting the direct program costs from these total monetary benefits yields the program's net benefits to the community. When this determination has been made for all program alternatives and the public's views have been obtained (Step F), a sound basis exists for selecting a program that will be cost-effective, supported by the public, and able to be implemented.

## DEMONSTRATION CASE STUDIES AND ADDITIONAL MATERIALS

The procedure developed in the flow reduction manual is purposefully flexible to allow communities to tailor the analysis to their particular circumstances. INTASA is now working with EPA to actually demonstrate the manual's methodology using two real-world communities. One west coast and one midwestern community have been selected as the demonstration sites. The results of these two case studies, to be published as a separate volume (Part III), will demonstrate not only the manual's methodology, but the tangible results that can be obtained from a flow reduction program.

In addition, a third volume (Part IV) will provide additional guidance on developing flow reduction public information programs as well as

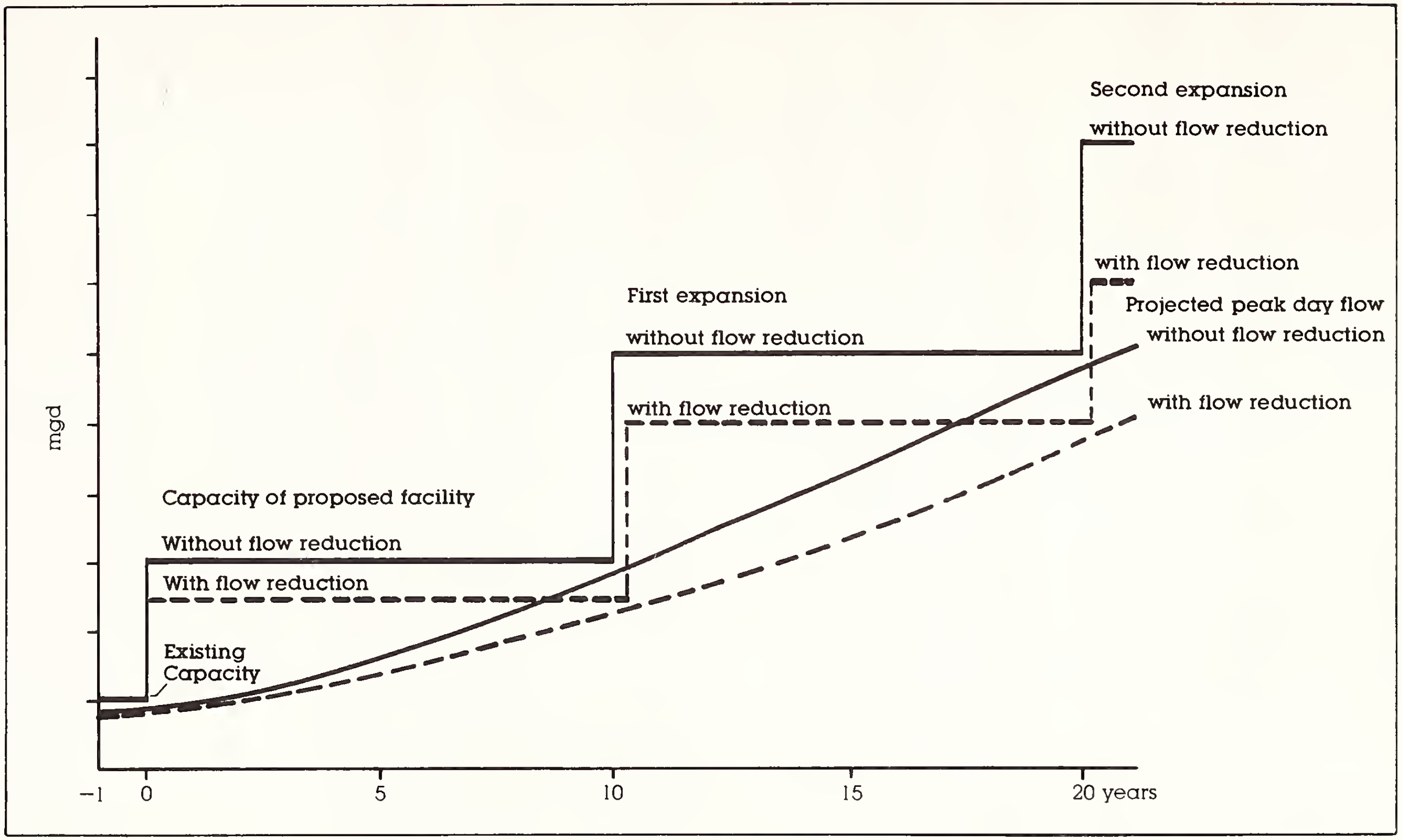


Figure 3. With and Without Flow Reduction Conditions for Hypothetical Wastewater Facility

general materials communities can actually use in their public information programs. Together, these three volumes will provide the practical rationale and guidance needed to realize flow reduction's potential in various community settings.

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# STATE WATER CONSERVATION PLANNING GUIDE

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## ABSTRACT

The U.S. Water Resources Council, under the authority of Title III of the Water Resources Planning Act of 1965, provides grants to States for the development of comprehensive water and related land resources plans. Through the water policy initiatives of President Carter in 1978, agencies were directed to emphasize the integration of water conservation in the implementation of water resource management programs. Acting upon these initiatives and the directives of the President, the Water Resources Council emphasized the integration of water conservation in State programs.

To assist States in this endeavor, the Council developed the State Water Conservation Planning Guide. The planning guide is to be used primarily by State water planners in establishing and implementing a water conservation program. The guide details many of the necessary actions to implement an effective water conservation program. A prime objective of this guide is to bridge the gap that exists in many States between State and local water planning and implementation efforts. It is imperative that the participation and support of local utilities, municipalities, and other water purveyors be solicited during plan development and extended into implementation. The philosophy and objective of the planning guide, the proposed implementation guide, and the Water Resources Council grant program were always to extend Federal assistance, both technical and financial, down to the States, and through the States to local water purveyors. To accomplish more efficient water use, Federal efforts must be carried down to the local level.

## INTRODUCTION

The U.S. Water Resources Council was established by the Water Resources Planning Act of 1965 (P.L. 89-80) as an independent executive agency. The membership of the Council was established under Title I of the Act to consist of the Secretaries of the Interior, Army, Agriculture, Energy, Transportation, Housing and Urban Development, Commerce, and the Administrator of the Environmental Protection Agency. The

Council's responsibility under the Act is to encourage, through the cooperation of the States, the conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis.

Title II of the Act authorizes the President to declare the establishment of a river basin commission upon request by the Council, or a request addressed to the Council by a State within all or part of the basin or basins concerned if the request: (1) defines the area, river basin, or group of river basins for which a commission is requested, (2) is made in writing, and (3) is concurred in by the Council and by not less than one-half of the States within which portions of the basin or basins concerned are located.

Under Title III of the Act, the Council is authorized to provide grants to States to assist them in developing and participating in the development of comprehensive water and related land resources plans. Since Fiscal Year 1967, the Council has provided such assistance on an annual basis. For the first 13 years, Congress authorized $5 million annually to be appropriated for the program, and for the past two years $10 million have been appropriated. Due to recent revisions in the Federal budget, however, future appropriations for the program remain uncertain.

## THE STATE WATER CONSERVATION PLANNING GUIDE

### Purpose of the Guide

From the water policy initiatives of President Carter in 1978, Federal agencies were directed to develop procedures for integrating water conservation into existing programs, and to emphasize water conservation in the development and implementation of water resource management programs. In response to these directives, the Water Resources Council amended the implementing guidelines for the planning grant program under Title III by including water conservation as one of five major program areas which were to be addressed by States while participating in the program.

As a means of providing technical assistance to States developing or modifying water conservation programs, the Council initiated preparation of the State Water Conservation Planning Guide. First, it was concluded that most States had instituted water conservation programs to one degree or another. Many, however, were not adequately equipped with the necessary tools for developing a comprehensive water conservation program. Some States were actively involved in water conservation activities, but did not have a comprehensive or well-defined program that incorporated clear water conservation objectives. In developing this planning guide, the major goal of the Council was to prepare a document that would be of optimum benefit to all the States, both those with very modest efforts in water conservation and those with well-defined programs. The major objective of the guide is for it to be used selectively by each State to apply those elements of the guide which are most appropriate to each State's specific conditions and needs.

By no means was this planning guide ever conceived as a panacea for all water supply problems, or as a mandate to States that they must institute a water conservation program or publish a water conservation plan. The planning guide was intended as a guide and nothing more. President Carter emphasized the need for increased attention to water conservation and the Water Resources Council responded by developing a document that can be used to whatever extent a State may choose or feel is necessary. It is designed to provide the basic essentials for assessing the feasibility of water conservation and for developing and implementing a water conservation program should such action be considered necessary.

## Development of the Guide

Development of the planning guide was begun in early 1980 by the J. B. Gilbert Division of Brown and Caldwell, a consulting engineering firm of Sacramento, California. Mr. Jerome B. Gilbert, Vice President, directed the preparation of the guide and Mr. James A. Yost, Principal Engineer, was the project manager.

An initial draft of the planning guide was completed in March 1980 and was distributed to all States and territories for their review. In conjunction with this review, a series of workshops were scheduled in Boston, Washington, D.C., Atlanta, Chicago, Denver, and Seattle. The Council requested that States review the draft guide and prepare to discuss their comments at these regional workshops. The States then were asked to submit any additional comments in writing upon completion of the workshops.

The regional workshops were conducted in July and August of 1980. Forty-eight States and Territories participated in the workshops and provided valuable input to the project. The recurrent theme of the comments revolved around the need for including implementation strategies and contingency planning in the guide.

It is recognized that implementation strategies and contingency planning are extremely important to water conservation planning and need more attention. However, it became clear they could not be adequately addressed in the guide without interrupting its basic purpose. It was decided that these issues, particularly implementation strategies, should be handled in a separate document. A condensed chapter on contingency planning has been added to the final version to provide a limited amount of information on this subject. It is expected that a document exclusively directed toward implementation strategies will be developed as a logical follow-up to the planning guide.

All comments received on the planning guide were carefully analyzed and, to the extent possible, were incorporated into the final draft of the document. An extensive amount of time and effort was expended by State personnel in commenting on this planning guide. It goes without saying that these efforts were extremely helpful and greatly appreciated. The document was published and distributed to all States, to all workshop participants, and to other interested individuals.

## Scope of the Guide

The definition of water conservation for the purposes of this planning guide does not implicitly exclude storage as a means of water conservation. However, the guide is not necessarily useful in planning for storage projects. Generally, planning and development of water projects may be more appropriately handled in water supply planning rather than including it as an element of a water conservation plan or program. This does not suggest that water conservation planning should be instituted independently of water supply planning or independently of any aspect of a State's water management program.

The Council's definition of water conservation, which is included in the final guidelines for the State Water Management Program, is:

> "'Water conservation' means activities designed to (1) reduce the demand for water, (2) improve efficiency in use and reduce losses and waste of water, or (3) improve land management practices to conserve water."

In some States, water resources management is a function of an agency which has broad environmental concerns. In others, water management may be divided among several agencies with a separation between water quality and water quantity concerns. Because of these institutional differences, as well as geographical ones, there are varying definitions of the term "water conservation." Each State's definition of water conservation will also depend on the State's overall water management goals.

This guide describes water conservation practices that fall within the Council's concept of water conservation at the time it was prepared. This may limit the guide's usefulness for States which define conservation more broadly. Nevertheless, the guide can still be used to the extent applicable.

## Content of the Guide

The planning guide is divided into five major sections: the introduction, developing water conservation priorities, State program development, water conservation plan elements, and implementation of the State program. These sections are followed by two appendices, one of which provides a comprehensive water conservation bibliography and the other which lists those individuals which participated in each of the regional water conservation workshops.

Section 1 of the guide is an introduction to the guide and gives a brief background discussion on the purpose of the guide. It provides a discussion of the existing water conservation goals, policies and regulations at the time, beginning with President Carter's Water Policy Message. It follows with the purpose of the guide, the development of the guide, and the scope and content of the guide.

In Section 2, the various considerations for establishing particular water conservation goals and objectives are discussed in greater detail. This section emphasizes regional differences that may affect water conservation priorities in different parts of the country. Considerations such as water use patterns, energy requirements and sources of supply are discussed. This section also includes many of the benefits as well as problems which may be expected from increasing efficiency in water use.

Section 3 describes suggested procedures for developing a State water conservation program, including a State water conservation plan. Program development activities include:

- an initial assessment of the value and feasibility of water conservation in the State
- coordination of conservation efforts among concerned agencies
- development of a State plan
- public participation
- plan implementation

Each State can review the steps in program development and selectively combine those that apply to its specific circumstances into an approach to program development. These program development procedures should help each State integrate water conservation into its continuing water management program.

Section 4 describes the elements of a comprehensive State water conservation plan. Each element can be provided either by the State in consultation with water users, or by local and regional agencies and then composited into a State plan by the responsible State agency.

Suggested chapters or sections for organizing a State plan are:

- Summary
- Introduction
- Projections of Water Demand
- Water Supply Inventory

- Supply and Demand Analysis
- Description of Long-Range Water Conservation Practices
- Institutional and Legal Factors
- Evaluation of Long-Range Water Conservation Practices
- Emergency Conservation Plan
- Plan Recommendations

The recommended plan should detail actions to be taken by interstate, regional, and local agencies. Each water purveyor should have a plan specific to the supply and demand situation.

Section 5 includes State activities which are dependent upon the stage of development of the water conservation program. For the purposes of the guide three such categories for the development stage were established:

- Assessment Stage -- no State program defined.
- Planning Stage -- primary activities devoted to planning.
- Implementation Stage -- primary effort in program implementation.

This section provides general guidance on program procedures for each of these States. These procedures are general and must be adjusted accordingly by each State to satisfy individual needs.

Appendix A is a water conservation bibliography that contains many references that provide useful information for all phases of a water conservation program. The bibliography is arranged in the following general subject headings:

- Water Use
- Water Conservation Planning
- Water Conservation Practices
- Pricing and Revenue Planning
- Institutional/Legal
- Public Participation
- Public Education
- Energy Assessment
- Wastewater Reuse
- Emergency/Contingency Planning
- Water Conservation Impacts

Appendix B to the guide provides a list of all individuals who attended and participated in the regional water conservation workshops held prior to final publication of the guide.

STATE ROLE

One of the major requests raised by State planners participating in the workshops was for more specific suggestions on implementation of procedures defined in the guide. Specific information and guidance were requested for program development, plan preparation, and program implementation.

## Program Development

Additional guidance was requested on:

- Procedures to quickly assess the potential benefits of a water conservation program and to interpret planning results.
- Involvement of local utilities and municipalities in program development.
- Selection of the best planning approach to suit specific conditions in a State including how to prepare a plan, who should be involved, method of financing the planning effort, staffing requirements (estimates of levels of effort), and scheduling.

## Plan Preparation

The planning guide suggests procedures which are broadly applicable to varying conditions and needs across the United States. It was suggested by State water planners that more specific data, procedures, and examples of their application would be quite helpful. Specific items identified at the workshop included:

- More specific information on importance and use of various types of data in planning and implementation decision making.
- Nationwide data on water use by category.
- Advice on resolving problems with water rights.
- Procedures for defining the factor of safety in the analysis of the risk of source deficiency during drought conditions when the supply and demand relationship has been tightened through water conservation.
- Costs, effectiveness, public acceptability, operational characteristics, and environmental considerations for various conservation practices.
- Impact of water conservation on utility revenues.
- Guidelines on the feasibility, costs, and effectiveness of leakage surveys.
- Energy relationships of water conservation practices.

## Program Implementation

The planning guide was expanded following the workshops to provide additional assistance on implementation. Resultant revisions are presented below.

### Integration of Planning Results

Other ongoing activities in the State that are sensitive to the results of the planning efforts should integrate appropriate plan elements. Examples include:

- Facility planning for water supply and wastewater management systems.
- Statewide energy conservation programs.
- Agricultural, technical, and financial assistance programs.

Integration or coordination efforts should extend to the Federal, State, regional, and local levels.

Implementation of Action Programs

There are many possible actions which can be implemented soon after adoption of the conservation plan as shown in Table 1. The role of individuals, agencies, and companies should be identified in the plan.

There are a number of ways that the State could assist in financing these actions including, for example:

- Developing tax incentives comparable to those in energy conservation programs of the State and Federal Government.
- Instituting a program to surcharge water utility bills to develop a fund for water conservation activities.
- Instituting public utility commission requirements for the development of plans and inclusion of the costs thereof in rate determinations (such as those that have been developed in California).
- Making direct appropriations.
- Utilizing pass-through to local agencies of some of the State's assistance under the Water Resources Council Title III Program.
- Participating in other Federal grant programs, including those under the Clean Water Act.

Development and Adoption of Legal/Institutional Changes

Most State programs will probably be based on an existing institutional and legislative framework. However, changes in legislation, regulations, or administrative procedures may be necessary to effectively implement conservation practices. Examples of possible implementation activities include:

- Drafting and assisting in adoption of legislation requiring water-efficient appliances and plumbing fixtures in new construction.
- Developing legislation to provide incentives for implementation of a conservation program such as (1) tax credits, subsidies, or other similar incentives to homeowners, utilities, farmers, commercial establishments, and industries for implementation of conservation practices, or (2) allocation of priority points in water supply grant or loan programs for incorporation of water conservation measures.

Table 1. Possible Actions by Individuals, Agencies, and Companies to Implement Water Conservation Programs

| Water conservation measure | Individuals | Utilities/local government | Businesses and Industries | Areawide agencies | State | Interstate areas | Water equipment manufacturers |
|---|---|---|---|---|---|---|---|
| Retrofit devices | Install/provide devices | Provide/install devices | Install devices | Encourage installation | Encourage installation | Encourage installation | Provide/develop new technology |
| Devices for new construction | Install/provide devices | Require installation as condition of service | Install devices | Encourage installation | Encourage/require installation | Encourage installation | Provide/develop new technology |
| Regulatory code changes | Comply | Suggest/adopt changes | Comply | Suggest changes | Direct changes in regulations and building codes | Suggest changes | Comment on proposed building code changes |
| Metering | — | Install meters | — | Encourage metering | Require metering | Encourage metering | Provide equipment |
| Pricing | — | Change pricing to encourage conservation and compensate for any lost revenues due to less water use | — | Encourage conservation-oriented pricing | Encourage/require conservation-oriented pricing | Encourage conservation-oriented pricing | — |
| Leak detection | Promptly repair leaks | Increase electronic leak detection and repair programs | Promptly repair leaks | Encourage leak detection | Encourage leak detection | Encourage leak detection | Provide equipment, develop new technology |
| Water reuse | Local reuse where safe and appropriate | Study/implement cost-effective reuse projects | Evaluate potential for using reclaimed water | Study reuse on regional scale | Sponsor regional reuse studies, provide funding for construction | Sponsor interstate reuse studies | Provide equipment, develop new technology |
| Share water supplies | — | Develop interagency agreements as a drought contingency | For self-self-supplied industries, develop agreement where appropriate | Form utility committees to study regional water supply allocation and develop exchange agreements | Sponsor regional water studies | Sponsor interstate water studies | — |
| Public participation | Participate and implement applicable new practices | Provide exhibits, speakers bureau, school programs, public information | Participate and implement applicable new practices | Coordinate separate utility programs | Encourage/require utility programs, sponsor seminars and demonstration programs | Sponsor seminars, conferences, and exhibits | Assist water utilities and provide materials for exhibits |

- Amending administration of the States' water rights procedures to encourage more efficient water use without jeopardizing future water entitlements or priorities. This could require special legislation in some States, or changes in administrative policies and procedures in others.
- Requiring conservation practices to meet lower water duties in future water rights permits.
- Working with State and local planning agencies to help remove social impediments to more efficient water use such as development policies and standards that encourage landscaping with low water-use plants.
- Mandating leak detection programs or leakage surveys as a condition of the allocation of any Federal or State assistance in water system rehabilitation or expansion.
- Requiring gradual conversion of water rate structures to a form that encourages more efficient water use.

Continuation of Planning and Demonstration Projects

Additional planning may be required to address specific problem areas which were revealed but could not be adequately addressed during plan development. Examples could include methods for providing incentives for agricultural water conservation, detailed evaluation of the impacts of water rights procedures on water use, and investigation into the applicability of water banking.

It may also be necessary to conduct research and demonstration projects to provide data on conservation practices. One expressed concern is the effect on existing multi-story building plumbing systems of retrofitting with low water-using plumbing fixtures and appliances. Results of these planning and demonstration projects can be integrated into the program during future plan updates.

Conduct of Public Education Program

A key to successful program implementation is an informed and enthusiastic general public. Use of channels of communication established in the public participation element of the plan development should be continued into implementation. Techniques which can be used by the State to supplement the ongoing public participation program can include:

- Special seminars or workshops to draw attention to the conservation program and its goals.
- Technical assistance and encouragement to local agencies to implement their own public education efforts. The State can greatly enhance these efforts by providing educational materials (bill inserts, technical pamphlets, movies, materials for educational programs in elementary and high schools, etc.) at a lower rate when produced on a statewide volume.

- Public information displays at fairs or other major events.
- Speakers bureau.
- Hotline with a widely publicized number where local agencies and individuals can obtain advice and technical information.

Assessment of the Effectiveness and Updating of Program Elements

The water conservation program, particularly the plan, should be viewed as dynamic and subject to modification as to the effectiveness of various measures is determined and as water demand and supply conditions vary in future years. The State should adopt a series of priorities for implementation of the plan emphasizing the least costly, most readily accepted measures and deferring large-scale action on new practices until demonstration projects have shown positive results or until evidence from other areas of the country has been accumulated.

## LOCAL GOVERNMENT ROLE

It is clear that the planning guide is to be used primarily by State water planners in establishing and implementing a water conservation program. The guide details much of the necessary actions to bring about an effective program. However, as one can readily conclude, there is only so much that a State can do in implementing a water conservation program, albeit this can result in truly significant results. The real success of a water conservation program can be measured through local action. The distance between the State government and individual citizens can be a barrier to achieving optimum results in water conservation efforts. The hands-on experience of the local water supplier and the ability of local officials to determine the need for water conservation are invaluable for establishing an effective water conservation program.

Most States indicated that they are working or will be working closely with the local governments and local water purveyors in establishing and implementing their water conservation programs. Beyond statewide institutional and legislative changes to effect water conservation, local government and water suppliers possess the most effective means of implementing water conservation programs. For example, the planning guide discusses a number of possible actions that can be taken by individuals, agencies and companies to implement water conservation programs. The State can require changes in the construction codes or rate structures for the purposes of water conservation. However, local governments can require water conservation devices as a condition of service, they can adopt changes in the code, or require meters, increase leak detection programs or take any number of actions without the benefit of any State action. Most important, they are better able to implement programs tailored to their own specific needs as opposed to applying their situation to a statewide mandated water conservation program. Any statewide program in water conservation is only as effective as the local governments can make it.

## IMPLEMENTATION GUIDE

After completion of the workshops and incorporation of comments into the draft planning guide, it was evident to the Council that more specific information on many of these topics could be quite helpful to the States. It was intended at that time to prepare a follow-up guide for implementation that would provide more detail on the above items and present methods for coordinating State and local efforts. Water use reduction is accomplished at the local level. It is, therefore, imperative that the participation and support of local utilities, municipalities, and other water purveyors be solicited during plan development and extended into implementation. A prime objective of this guide was to bridge the gap that exists in many States between State and local water planning and implementation efforts. Methods which have been successfully applied in some States to maintain long-term contact and cooperative implementation between State and local agencies include water resources centers to provide technical assistance and water supply/demand data. Other States have provided retrofit devices to local agencies at low unit costs which the States can obtain through large-volume purchases. Public education materials can also be purchased at large volume by the State and provided at low unit cost to local water purveyors.

The philosophy and objective of the planning guide, the proposed implementation guide, and the Water Resources Council grant program were always to extend Federal assistance, both technical and financial, down to the States, and through the States to local water purveyors. To accomplish more efficient water use, Federal efforts must be carried down to the local level.

# THE ROLE OF LAND USE PLANNING IN WATER CONSERVATION

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## ABSTRACT

Land use planning and the regulatory controls that grow out of this process influence demand for water. Land development policies are formulated in the planning process and implemented through land use regulations. These regulations, especially zoning and subdivision controls, influence how much water a municipality will need by regulating the types of buildings that are built, their location, and the way open space is used around them. This paper examines how this influence can be used to conserve water. Water conservation elements in comprehensive plans are considered along with patterns of development that conserve water. Land use regulations that can serve to implement water conserving residential development are also examined.

Land use planning can be important to water conservation. It can help conserve supplies or reduce demand. Traditionally, land use planners have not played a direct role in water supply planning, but for some time they have helped communities manage and protect watersheds or aquifer recharge zones that are threatened by urban growth. In recent years, a growing number of local planning agencies have recognized the potential for land use planning to reduce the need for urban water. Some communities are now including water conservation elements in their comprehensive plans, which identify both opportunities for water conservation and implementing strategies. A few communities have also built water conserving principles into their zoning and subdivision regulations.

## WATER CONSERVATION ELEMENTS IN COMPREHENSIVE PLANS

The Proposed General Plan for Los Angeles County, California, calls for the protection of both water supply and quality:

> <u>Conserve Water Supply and Protect Water Quality</u>
>
> The supply and quality of local water must be conserved and protected. Otherwise the County could face critical shortages in the future.

Policy

Protect ground water recharge and watershed areas, conserve storm and reclaimed water, and promote water conservation programs.

Encourage the maintenance, management and improvement of the quality of imported domestic water, ground water supplies, natural runoff and ocean water.

The plan recommends the following measures to implement its water conservation policies:

1. Require the installation of low-flow or restricted-flow plumbing in all new construction.

2. Make available lists of native and domestic vegetation classified by the demand of plants for water.

3. Require the installation of dual water systems when and wherever feasible to achieve the maximum use of reclaimed water.

4. Investigate the potential for greater use of reclaimed water by industry and residences as well as for ground water replenishment wherever such use will not endanger public health.

The proposed plan also calls for concentrated development rather than low densities. This pattern of development requires less landscaping than lower densities and, in turn, less exterior water demand.

Water is a prime consideration in Santa Fe County, New Mexico's proposed General Plan. One of the plan's three major policy recommendations has to do with water demand:

> The growth and density of future development is to be related to availability of water resources given a recognized need to accommodate some future growth.

To implement this policy the Plan introduces a procedure to determine appropriate lot size of new residential developments in relation to water availability. The Plan explains:

> The lot size determination involves several steps. The first step is a calculation of water availability and demand:
>
> 1) The amount of ground water in storage is determined for each aquifer by using available data regarding geologic conditions and well characteristics;

2) The amount of ground water recharge is estimated by using precipitation data and geologic and topographic considerations; and

3) The annual amount of water demand is estimated based on population projections, on historic and projected water usage for typical residential households, and on known or projected irrigation, mining and other needs.

The second step is to determine the basis for water management in a given area. Three different policies have been recommended.

1) In areas where municipal water services are relatively accessible (metropolitan areas), it is the policy of the Plan to deplete ground water in storage over the period of 40 years;

2) In the remaining areas underlain by the Santa Fe Group aquifer (basin and basin fringe), the policy is to deplete ground water over the period of 100 years; and

3) In areas with little ground water in storage (mountain and homestead), a steady-state policy is proposed, where water consumption is balanced against recharge on a long-term average basis.

The population capacity of each area is determined by comparing the projected demand against the available supply, for a mining or steady state, as appropriate. This population capacity divided by the area of each aquifer gives the acceptable residential density.

The base densities so calculated assume that the annual water use per household will be approximately one acre-foot including both indoor and outdoor usage. In practice, many rural households utilize less water; with careful conservation measures it is easily possible to limit annual water to one quarter acre-foot per household, or even less. Therefore the plan proposes to permit higher densities wherever a proposed development includes provisions which will reduce water use below the one acre-foot per year value. A restriction on water use may occur through any or all of the following:

1) Conservation measures, such as installation of low water-use bathroom fixtures or other construction techniques, and water covenants, such as restrictions against swimming pools and large lawns;

2) Clustering of up to four houses on one metered well, with annual meter reading reported to State Engineer, or construction of a metered community system; and

3) The use of cisterns to collect water on the site, which thereby reduces demand for well water.

In these cases, where water conservation measures are instituted and where a cluster of as many as four homes are served by a community water system, as much as a fourfold increase in density is allowed. This applies to all rural and metropolitan areas.

In addition to allowing increased densities where water conservation measures are implemented, the Plan provides that densities may be altered if well tests and hydrology reports demonstrate that the water available to a particular development exceeds the conservation estimates used by the Plan.

## WATER CONSERVING PATTERNS OF RESIDENTIAL DEVELOPMENT AND HOUSING TYPES

Patterns of residential development that use less water are touched upon in both the Los Angeles County Plan, which encourages concentrated development and moderate rather than low density, and the Santa Fe County General Plan, which encourages housing clusters of up to four dwelling units per well. The broader concept of clustering, involving a clustered site design for an entire subdivision, represents the most efficient pattern of residential land use from a water conservation standpoint. Similarly, small lot developments and single family attached housing requires less water than large lot, single family detached developments.

### Cluster Developments

A growing number of communities are offering developers the option of reducing residential lots in single family detached subdivisions, and concentrating or clustering housing units on the most buildable portion of the tract. These cluster subdivisions usually require much less water than conventional large lot subdivisions with substantially larger lawns. The cluster option allows the developer to develop lots smaller than those specified in the zoning ordinance provided the land saved is reserved for permanent common use, usually in the form of open space, and often in its natural state. Many of the communities that offer the cluster option in subdivision design allow for up to a 50 percent reduction in the size of lots in their most restrictive large lot districts. Such reductions allow for comparable reductions in yard or lawn size. In regions where outdoor use accounts for a substantial portion of total residential demand--40 percent to 50 percent--clustering can mean significant savings in water over conventional subdivision design, especially when open space assembled in the subdivision for common use is kept in its natural state. The cluster subdivision plan (B) in Figure 1 allows for over 30 acres of land to be assembled as common open space.

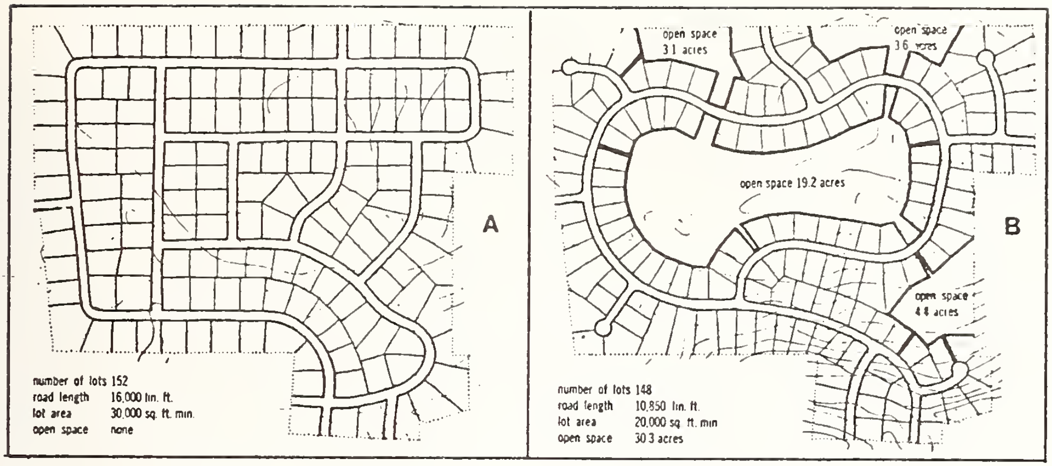


Figure 1. Comparison of Conventional (A) and Cluster (B) Subdivisions. Source: New Hampshire Office of State Planning, Concord, NH. Handbook of Subdivision Practice. Technical Planning Associates. 1972.

In addition to its water conserving potential, clustering is an environmentally sound form of site design. The well-planned cluster subdivision is cost effective, requiring less pavement and shorter utility runs, preserves natural drainage systems and open space, and other significant natural features that help control stormwater runoff and soil erosion.

Even greater water savings can be realized when attached housing units, like townhouses, are clustered or mixed with single family detached units in the same subdivision. Most side yards are eliminated when housing units are attached, allowing for further savings in outdoor watering. Figure 2 below demonstrates the dramatic difference in private open space or lawns in single family detached and attached units.

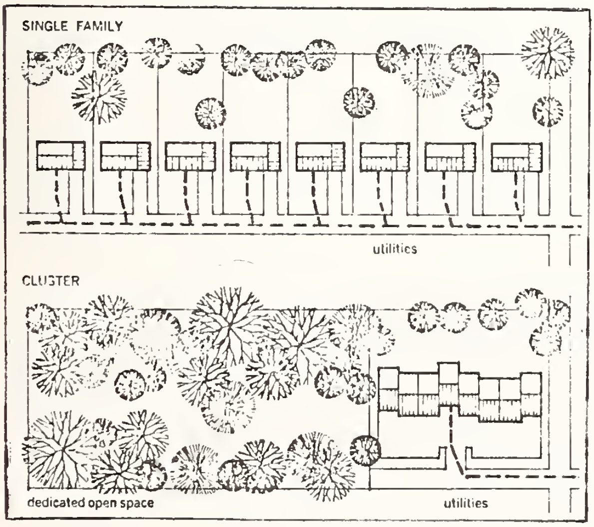


Figure 2. Comparison of Single Family Detached and Attached Housing.
Source: "Citizens, Computers, Clusters: A Way to Parks and Housing." John Rahenkamp and Andrew Wolffe, Landscaping for Living, The Yearbook of Agriculture. United States Department of Agriculture. 1972.

## LAND USE REGULATIONS FOR WATER CONSERVATION

Water conservation policies identified in the planning process can be implemented through zoning and subdivision regulations. These controls regulate features that have a direct bearing on the level of water demand that a given land use will require. Zoning regulates density and use, by establishing requirements for lot size; the type and location of buildings; and yard and open space requirements. Subdivision regulations regulate the conversion of raw land into building lots. These regulations ensure that new development is consistent with zoning requirements and establishes requirements for streets, drainage and storm sewers, water and sewerage facilities, utilities, and site design. Building water conserving principles into land use regulations must begin by removing barriers or regulatory provisions that waste water or allow for unnecessary water losses.

### Removing Barriers to Water Conserving Land Use

Conventional land use regulations waste water. For example, conventional large lot zoning, requiring one or more acres of land per lot, means large areas that must be irrigated as well as a sprawling pattern of development that requires longer utility runs and greater opportunity for water loss in the system. Water conserving alternatives to this pattern of development, such as clustering and higher density developments, have been discussed earlier. From a regulatory standpoint, clustering can be easily achieved by an amendment to the zoning ordinance that allows reduction in lot size when the land saved is assembled as common open space. Many communities also allow clustering under the Planned Unit Development (PUD) process. PUD is a much broader concept involving mixed uses--increased density in return for additional project amenities and relaxed public improvement standards in return for better design. In either case, the more concentrated cluster approach to land development allows for a more efficient use of water than conventional zoning and subdivision practice.

Conventional zoning usually also requires that single family detached dwellings must have setbacks from four property lines, allowing for two side yards and a front and rear yard. Side yards provide access to the rear area of the dwelling, can prevent crowding of buildings, and can allow for greater privacy. It is questionable, however, that two side yards are absolutely necessary to achieve these ends. Some communities have taken a less rigid approach and allow what is known as Zero Lot Line Developments (ZLL). This concept allows buildings to abut one or more of the property lines, usually a side lot line. This placement eliminates one of the side yards, thus reducing lawn area that can require irrigation. Sometimes, the house is sited on the corner of a lot so that it abuts both the rear and one side line. This arrangement allows each dwelling unit to concentrate its yard in one continuous space rather than the small yard areas allowed by the traditional pattern of four setbacks.

The well-designed zero lot line development can be a cost-effective way of providing single family detached housing. Higher density and less lawn area requiring irrigation make this pattern of residential development more water efficient than conventional single family detached housing. At the same time, the amount of usable yard space is maintained. Two styles of zero lot line development are presented in Figure 3.

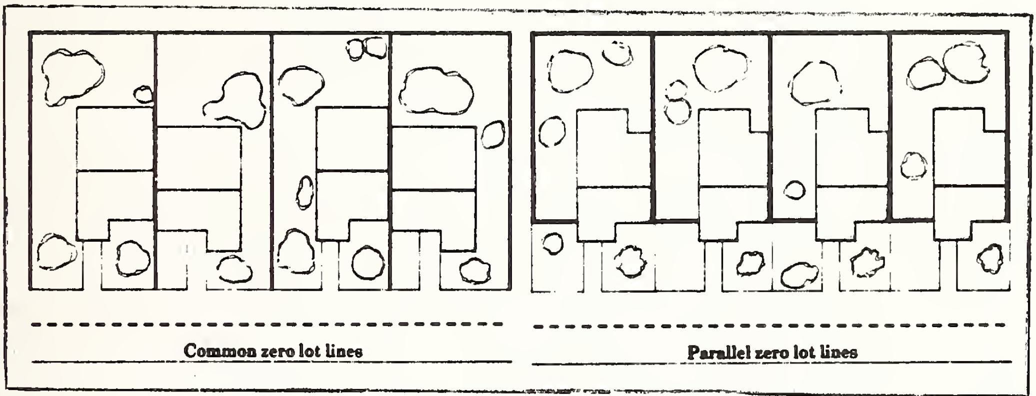


Figure 3. Two Styles of Zero Lot Line Development.
Source: American Planning Association, Chicago, Illinois. "Zero Lot Line Development." Teresa Zogby. PAS Memo. 79-9. 1979.

Another zoning concept that offers greater flexibility than conventional zoning practice is the performance approach. Unlike the essentially prescriptive, traditional zoning provisions which specify what can or cannot be done with a parcel of land, performance controls specify minimum or maximum levels of performance for various land use features. For example, a specification standard for water conservation might require that outdoor area in a residential development which requires irrigation must be limited to a given size. The reasoning is simple, of course--less lawn areas will require less watering. A more flexible performance approach could establish a maximum volume of water that can be used for outdoor irrigation, leaving it up to the developer to select the most appropriate way of handling outdoor areas. He could limit lawn size or use native vegetation, or a combination of both. Any design solution that does not require more water than the established maximum would be acceptable. Ideally, the land use ordinance could recommend design solutions that would limit outdoor watering to a preestablished level, but the developer would be free to propose any method that he could prove would perform properly.

Santa Fe County, New Mexico's proposed General Plan, discussed earlier, calls for a performance approach to implement its water conservation policy. This approach offers residential developers the option of either adhering to preestablished density standards or building at higher densities when the proposed development includes water conserving features which will reduce water use below a prescribed level.

Building Water Conservation Principles Into Subdivision Controls

The subdivision process offers an excellent opportunity for incorporating water conserving techniques in new residential development. The use of tried and proven water conservation techniques, such as the use of native vegetation for outdoor areas or the proper soil preparation for lawns, can be made a condition of subdivision approval. Ideally, subdivision regulations can require that all new residential developments must be designed to conserve water. One example of how water conservation requirements may be structured in subdivision regulations is found in the subdivision regulations for El Paso County, Colorado. The ordinance states:

> All subdivision design shall take into consideration the importance of water usage for the well-being of the region and the development of effective aquifer recharge capabilities. Planners and subdividers shall consider the applicability of non-potable water as an irrigation source, the development of ponds and catchment basins, and the effect of groundcover modification on aquifer recharge capability.
>
> 1. Use of large areas of artificial groundcover or groundcover not indigenous to the region shall be discouraged except in cases where a plan is submitted to use non-potable water as a primary irrigation source or in cases where such groundcover can be proven to be suited to the pre-existing natural conditions.
>
> 2. Subdivision design, lot design, and site design shall incorporate, whenever possible, the use of vegetation suited to the natural climatological and soil conditions of the area in which the subdivision is located.

El Paso County has also enacted Revegetation Specifications which identify native vegetation that developers can use to satisfy the requirements outlined in the subdivision regulations. These specifications also establish standards for finished slopes, soil preparation, fertilization, planting, and irrigation.

The city of Santa Fe, New Mexico, has taken a less elaborate approach, involving enactment of a water conservation ordinance that establishes certain requirements for new construction. This ordinance requires that:

> Irrigated areas shall be no more than 1,000 square feet per dwelling unit except for native vegetation requiring only initial irrigation.

SUMMARY

Land use planning and regulations can have a significant impact on residential water use. Patterns of development that use less water can be identified in the comprehensive plan and implemented through the land use controls that grow out of the plan. To be most effective, land use regulations must be flexible, allowing for subdivision design that includes clustering, attached housing, zero lot line, water conserving landscaping and other patterns of residential development that conserve water. Most communities are only beginning to understand the importance of land use planning to water conservation. Future progress in this area will undoubtedly depend upon greater awareness among land use planners of water supply planning principles and greater understanding on the part of water supply planners as to the important role that land use planning can play in this area.

This paper is based on a larger study designed to develop a guidebook for city planners on current local experience reducing demand for urban water and the role of land use planning in water conservation. This project is sponsored by the Office of Water Research and Technology, United States Department of the Interior. The guidebook will be distributed directly to local government planning offices through the American Planning Association's Planning Advisory Service.

# AURORA, COLORADO: RATIONAL LANDSCAPE ALTERNATIVES

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The City of Aurora, Colorado, lies starkly on the high plains at an elevation of 5,400 feet, with an annual precipitation of about 15 inches. It's a place where the Indian and Buffalo once roamed, Buffalo and Grama grasses thrived, and Soapweed Yucca, Sage, and Rabbitbrush still persist.

Aurora, Colorado, the fastest growing city over 100,000 population, has given way to the plowing and bulldozing of the native short grasses only to be replaced by highly cultivated Kentucky Bluegrass lawns. The clayey and sandy soils characteristic to Aurora, lacking organic matter found in areas of greater rainfall, are susceptible to wind and soil erosion; and are consistently forced to grow plants by the simple addition of water.

Water . . . water comes to Aurora by transmountain diversions from relatively distant areas in the Rocky Mountains west of Denver. With a population of 166,400 people, Aurora competes with Denver for water rights. Water rights in Colorado are based on the appropriation doctrine, and water close to Aurora and Denver is fully appropriated. Thus, rights with a high enough priority to provide a firm yield during droughts must be purchased from previous owners which often had agricultural uses. The total length of the Aurora network is about 135 miles.

The realities are the higher costs of transporting water and the increasing competition for water rights have created some political and environmental constraints for expanding existing utilities' capabilities to supply more water. The test of what will happen is underway. The drought of 1977-78 only slightly forced Aurora to reckon with nature. The drought of 1980-81 may be the "day" of reckoning.

In 1979, Aurora put into action a water conservation program which has the potential to really conserve water. The goal is to reach every person with the best contemporary knowledge of environment, design, grasses, plants, soil, and watering techniques, in order to achieve a beneficial reduction in water use or in water losses.

One of the major steps has been the compilation of local information about landscaping into a book entitled, Landscaping for Water Conservation in a Semiarid Environment. Written for the homeowner, the book has received metropolitan-wide support and acceptance. With the help of Colorado State University professors, CSU Extension Horticulturist Dr. Jim Feucht, two planning consultant firms (THK Associates and Carl Worthington Partnership), and a Soil Conservation Service District Office, Aurora became publisher of a thoughtful, thorough document on rational landscape alternatives. This publication has filled a gap in desperately needed reading material for the resident and professional who want to create a landscape that fits the environment. The philosophies expressed in the landscape handbook are those of the author and those who assisted the author. The book was put together by people, for people to use; and the City was the sponsor. The stereotype of the typical suburban community was replaced by Aurora leading the way to change. The endeavor has been a learning experience for all--a risk well taken.

## Planning: Designing a Thoughtful Landscape

The design chapter is particularly exciting for the designer, as well as being very practical for the homeowner. It encourages the homeowner to design landscapes with a master planning approach. Once the plan is completed, priorities can be set; and landscape development can be phased over several years to spread out the cost. However, when using a phased approach, the landscape planner should carry out landscape construction in the proper construction sequence. Landscape components are defined listing concepts, uses, advantages, and disadvantages. The eight components are plant materials, structures, mulches, irrigation, grading/contouring, soil, lighting and water (as a design feature). For instance, under "Structures" there are the concepts of fences, retaining walls, walls, overhead structures, surfaces, buildings, and sculpture. The use of a retaining wall would be to create useable level areas, i.e., terraces, to prevent water runoff. The "Mulches" component defines organic, inorganic, ground fabrics, and plastic concepts listing advantages and disadvantages of each. Using the landscape components and their various concepts and uses, four prototypical designs (older home, new cluster home, new suburban home, and older farmstead) are illustrated.

The Older Home demonstrates how an existing landscape can be renovated to make use of the following components and concepts: remove existing walks to permit creation of lawn and deck areas; pavement and decking in high activity areas to reduce amount of irrigated areas and to create more useful areas; remove unused lawn areas; planting beds to replace lawn to reduce water requirement and maintenance; water-conservative planting in parkways to replace lawn; large canopy deciduous trees for summer shade; planting masses for privacy screening; and flower beds as visual focal points.

The New Cluster Home is on a small lot 40'x75' and specifically addresses patio development. Landscape components and concepts are: fences to provide a high degree of privacy and containment of views inside the courtyard; variety of hard surfaces for intensive use areas; overhead structure for shade; automatic irrigation system to reduce maintenance; extensive plantings to create more comfortable outdoor room with good views; large canopy deciduous tree for summer shade and "ceiling effect"; and lack of lawn area to reduce maintenance and conserve water.

The New Suburban Home is a large lot 100'x170' and has no existing vegetation. The suburban home landscape utilizes the following components and concepts: hard surfaces for intense active use areas; overhead structure for shade; dry creek bed to channel runoff around home and active use areas, for visual interest, and to create an edge between differing landscape types; plantings along dry creek bed edge to utilize runoff; lawn areas for active uses such as play, games; dryland plantings for non-active use areas to reduce water requirement and maintenance; fence and plants as windbreaks to lessen impact of winds; fence, berms, plants for greater privacy; berms for good drainage and visual interest; irrigation system to reduce maintenance and for efficient distribution of water; play area for children located adjacent to lawn area in clear view from house (kitchen); and large deciduous trees for shade.

The Older Farmstead is several acres, very open and exposed to winds, and has a surrounding prairie landscape. This rural residential landscape makes use of the following components and concepts: most intense landscape use adjacent to house; transition landscape between the outdoor intense activity area and the natural prairie; natural prairie landscape in outlying areas and covering the greatest amount of area; planting windbreaks to lessen the effect of the winter winds; channelization of the summer breezes for cooling effect; retaining wall to eliminate steep slope to create a level terrace for the outdoor activity area and to create an edge between differing landscape types; gravel surfaces for driveway and footpaths; and irrigation system to reduce maintenance and for efficient distribution of water.

## Grasses: An Alternative

A new landscape ethic and esthetic consciousness needs to be developed. By learning anew or relearning what it means to live in a semiarid climate where water is a precious, limited resource, a new consciousness can be developed in planning the landscape.

A Colorado style can be unique by the use of native and adapted grasses. However, residents need to prepare themselves for the different esthetic quality this will create. Native grasses are softer and gray-green; and they cannot be compared to turf grasses because they are not a lawn substitute. Native grasses should be thought of as a design component.

Jack Gilcrest, a landscape architect who assisted with the book, has a three-year-old Buffalo grass lawn. Buffalo grass needs at least two seasons in order to establish a good cover. It needs full sun, clayey soil, gets to a natural height of four inches, and has seed heads to about six inches. Jack mows his lawn in the spring and fall and watered it once during the 1980 summer. The edges are occasionally trimmed to give a somewhat more manicured look. The grass has a gray-green color for about six months during its growing season and is a light brown in color during dormancy, the other six months. Jack mixed wildflowers into the seed mixture when he sowed the seed to create a naturalized meadow.

Gary Powell, another landscape architect who assisted with the book, has a six-year-old Buffalo grass lawn in his front yard. He's planted it with Aspen. Gary mows his grass more frequently, however. When Buffalo grass is kept mowed, it immediately gets compared to Kentucky Bluegrass and naturally does not hold up to the test because it is browner and less dense.

To do away with Kentucky Bluegrass would not be appropriate either, for it is the most efficient ground cover in terms of weed control and the ability to withstand traffic. Bluegrass is quite drought-resistant and can endure long periods without water, providing there is good soil preparation first and it is watered properly. The care of Kentucky Bluegrass is very important and can reduce water requirements. The Aurora landscape book settles some old arguments concerning lawn care:

(1) Mowing height should be two inches or more.

(2) Grass clippings should be left when mowing; however, grass should need frequent and consistent mowing if leaving the clippings.

(3) A thick layer of thatch less than 1/2 inch is beneficial and should not be removed.

(4) Aerification should be done on a regular basis, especially on compacted soil.

(5) Low-nitrogen fertilizers should be used which contain a phosphorus and potassium to increase the ability of the turf grass to survive drought stress.

## Plants: Native and Adapted

The third chapter lists many native and adapted plants that are effective and distinctive, which are suitable for a residential landscape; and choices should not be limited to native plants alone. Choosing plants with the same water requirements in a mass planting can be fun and creative. Proper use of mulches goes hand-in-hand with mass plantings, and plants with mulching can require less water. Creating a berm of eight to ten inch smooth river cobble with Sedum and Aspen is an interesting planting for a front yard.

Soil: The Most Important Part

Soil is the most important consideration in developing a water conserving landscape. Most soils in the Denver metro area lack organic material. Adding soil improvement can save the homeowner money in the long run because it will save water. The gardener should learn what an ideal soil is, and soil tests should be taken prior to planting. Terracing is an important consideration. If the slope is so steep that water commonly overtops the ridges left by tillage, terraces are needed at intervals to intercept the run-off.

Watering: The Final Meeting

Knowing when and how to water is the goal of proper irrigation. Automatic sprinkler systems are the most efficient way to water. Whether the choice be automatic or portable sprinklers, it is important to understand the lawn's requirements and signals. One must be very familiar with his sprinkling equipment. The rates at which the water is applied and the pattern of water distribution will vary. The homeowner is encouraged to measure patterns of water distribution.

Drip irrigation has gained more attention in recent years because of its potential for decreasing water requirements. Drip systems cannot be used where it is desirable to provide mist. A combination of overhead sprinklers for lawn areas and drip for shrubbery and trees provide an ideal system.

For watering trees and shrubs and along driveways and sidewalks, a deep-root irrigator is the best method to avoid runoff or evaporation. Hand watering dry spots can allow the rest of the lawn to go unwatered several more days. Runoff water should be captured and channeled to direct water flow toward planting areas where it can be used.

Knowing when to water is just as important as knowing how to water. Give plants some credit for hardiness. Stop watering by the calendar. Take a shovel or screwdriver into the garden and turn one blade of soil. If the soil is dry, water it. Learn to recognize a plant's way of telling when it is thirsty. If footprints show when walking on bluegrass lawn, it is thirsty.

The following are some basic guidelines to improve water application:

(1) Have the land in good condition. Level land makes it

possible to apply water more evenly to all parts of a yard.

(2) Have a good irrigation system.
(3) Determine water intake rate.
(4) Check soil moisture before irrigating.
(5) Check depth of water penetration.

The results of efficient water application are uniform growth and maturity and savings in water and labor.

Other Measures

The City of Aurora has not only published a landscape booklet but has created the Aurora Water Conservation Office to better serve and educate residents. By the formation of this office, the City committed itself to a long-range public education water conservation program.

The City has recently passed a lawn ordinance too. The ordinance restricts the amount of Kentucky Bluegrass lawn a homeowner can install based on the total square footage of the lot and requires soil preparation before planting. Anyone installing a new lawn must obtain a lawn permit, and must have proof they installed organic matter.

Since the Aurora Water Department was established in 1949, all water services have been metered. All billings are made on a metered basis including useage for parks, schools, and other public facilities. All Aurora water users pay a monthly service fee based on meter size. In addition, all water used is billed at a uniform rate which varies by customer class. This is a straight line rate which adds an economic incentive to conservation.

Present Aurora plumbing code requires the installation of certain water saving fixtures on all new and remodeled construction. Customers can purchase low-flow showerheads, toilet dams, and faucet aerators from the Aurora Water Conservation Office to retrofit homes constructed prior to 1977 when the plumbing code went into effect.

Some people are comparing the drought of 1980-81 to the dust bowl days of the thirties. The measures that Aurora will be taking because of the emergency situation of the drought are every third day watering beginning May 1 and a penalty rate structure allowing 15,000 gallons per month per household at the current rate of $1.03 per thousand gallons; at a usage of 15,000 to 30,000 gallons, the rate would be $2.06 per thousand, and above 30,000 gallons, the rate would be $4.12 per thousand. Customers will receive computer printouts in April and May showing the previous usage for their households so they can monitor usage and try to reduce their consumption, and beginning in June customers will be billed monthly rather than bimonthly. In addition, in June, the Aurora City Council will decide whether or not there should be a new lawn moratorium depending on reservoir levels.

The City of Aurora is facing reality. Whether it be in a drought year or a plentiful year, change is needed. It's time to look at the real necessities of life: water, air, soil, and light. When water is placed at the top of the list, everything else falls into place.

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water conservation
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# Impact of Low Flows on Wastewater Collection Systems and Treatment Facilities

# WATER CONSERVATION AND WASTEWATER FLOW REDUCTION - IS IT WORTH IT?*

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## ABSTRACT

This question was the subject of a recent research study largely funded by the Environmental Protection Agency (EPA). Two study reports were prepared: a detailed report published by EPA and a summary report published by the California Department of Water Resources. This study of indoor water conservation and resulting wastewater flow reduction arrived at one main conclusion: There are overwhelming benefits to be derived from community water conservation programs and they should be vigorously promoted.

I would like to share with you today:

- The study background.
- The study approach.
- Key findings of the study.

## THE STUDY BACKGROUND

During the last 10 years, urban water conservation has attracted much attention and has come to be considered an essential part of the effective management of our water resources. Urban water conservation not only saves water but also saves precious energy. While saving water has become increasingly popular across the country, the most intensive water conservation effort probably took place in Northern California during the acute drought of 1976-77. The drought is not the subject of this study, but it did provide a good opportunity for measuring some of the effects of water conservation.

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* This paper is based upon a detailed report, "Effects of Water Conservation - Induced Wastewater Flow Reduction -- A Perspective," EPA 600/2-80-137, August 1980, published by EPA, and a summary report with the same title, dated June 1980, published by the California Department of Water Resources. Both were written by this author.

During the drought, Californians were encouraged by governmental and water resources management agencies to conserve water both outside and inside their homes. In most critically dry areas, mandatory controls were applied to conserve water. Some of the common practices included cutting back on or eliminating landscape irrigation, and installing low-flow faucet aerators; low-flow showerheads or flow restrictors; and "water dams," plastic bottles, or plastic bags in toilet tanks to reduce the amount of water used for flushing. These and other measures, however, were often undertaken without a full knowledge of the positive and negative aspects of conserving water, particularly with regard to reduced wastewater flows. Questions raised then are still being asked:

- What are the effects of water conservation on wastewater collection and treatment systems?

- What are the effects of any changes in the quality of the treated wastewater on wastewater reuse?

- What are the positive and negative aspects of water conservation, and is water conservation still worthwhile after both aspects have been considered?

This study was made to answer those questions.

## STUDY APPROACH

During the 1976-77 drought, numerous local agencies in Northern California experienced reductions in wastewater flows and nearly all of the major communities there were under some form of mandatory conservation. Data were collected from these agencies primarily to measure any significant effects of flow reduction on their operation. Various local agencies were contacted to obtain actual data concerning:

- Reduction in wastewater flow.

- Changes in wastewater quality.

- Specific operational problems encountered in collection and treatment facilities.

To answer the question "Is conservation in indoor water use worthwhile?", its primary benefits and costs were analyzed and compared. This was done by choosing conditions for analysis to represent what could be expected in the future on a statewide basis if indoor water conservation measures were taken.

The next 20-year period, 1980-2000, was used as the basis for analysis. This time span represents a period for which expanded or new wastewater facilities would be sized for capacity. Two cases were examined in small, medium, and large wastewater systems.

Under Case I conditions, existing sewer systems are enlarged to cover a larger service area and existing treatment plants are expanded to receive a larger flow due to new population growth. Thus, since water conservation-induced reductions in wastewater flows from both existing and new building constructions affect the sizing of new wastewater facilities both types of conditions were considered.

Under Case II conditions, new sewer systems and treatments are constructed to serve the new population growth independent of the existing facilities. Thus, water conservation induced reductions in wastewater flows from new building construction only affect the sizing of new wastewater facilities, so only these new facilities were considered.

The conceptual reduction in the new wastewater system capacity, when wastewater flows are decreased due to indoor water use reduction in existing and new building constructions, is depicted in Figure 1.

Benefits resulting from savings in water, energy, and wastewater facilities costs were examined.

The amount of water saved was treated as the amount of water that would not be needed in the future. The cost of supplying that water, which otherwise most likely would be incurred in the absence of water savings, was used as a measure of water supply benefits.

Two types of energy savings were considered: one, the savings due to less use of hot water and two, the savings due to less water needed for treatment and conveyance in the local water supply distribution system.

The extent to which future construction of wastewater collection and treatment facilities could be sized smaller and construction costs saved were examined. Any savings in the operation and maintenance (O&M) costs due to reductions in wastewater flow were also taken into account in the benefit analysis.

The negative effects, or costs, of water conservation measures and their impact on wastewater reuse also were examined.

The cost of various scenarios of water conservation measures at different levels of water conservation efforts ranging from minimal to potential were examined.

The negative impact on wastewater reuse due to increased salt concentration in the effluent was assessed. Three major uses of wastewater, namely crop irrigation, landscape irrigation, and industrial use, were examined to determine how much they are affected by changes in wastewater quality as a result of flow reduction.

The net worth of water conservation was measured by determining its "net benefits," which is the difference between all its benefits and costs. Stated in another way, it is the excess of benefits over cost. The point where the maximum excess benefits occur is the point of optimum development.

KEY FINDINGS

Effects on Wastewater Facilities

- Some agencies experienced two years of flow reduction, in 1976 and 1977, while others experienced only one year, in 1977. In the first year of reduction, the average flow reduction was 17 percent. In the second year, the average flow reduction was 39 percent.

- One-half of the 17 wastewater systems surveyed encountered operational problems during periods of flow reductions. In general, however, the problems were not severe enough to greatly affect the system operations. Common problems in the sewer system were solids settling and odor. Common operational problems in the treatment plants were odor in the primary and secondary clarifiers, and bulking in secondary clarifiers due to excessive growth of filamentous bacteria.

- Remedial measures were taken to resolve the problems, and there were no documented cases where the wastewater facilities could not continue to be properly maintained.

- Changes in wastewater quality during periods of flow reduction did not generally result in more frequent treatment plant violations of biochemical oxygen demand (BOD) or suspended solids (SS) discharge requirements.

- The BOD and SS concentrations of the wastewater entering the treatment plant generally increased while the concentrations leaving the plant generally decreased during years of flow reduction. The efficiency of treatment plant removal of BOD and SS generally increased slightly.

- Energy and chemical uses were the primary items affected by wastewater flow reduction.

- As shown in this graphic (Figure 2), the overall O&M costs for the wastewater collection system decreased slightly, with a maximum of 3 percent cost reduction at 50 percent flow reduction. Most of the reductions in cost resulted from decreased energy use for the lift pumps.

- The decrease in energy use for the treatment plants amounted to a maximum of 20 percent at 50 percent reduction in flow due to lower pumping requirements for the hydraulic load. Use of chemicals ranged from a decrease of 30 percent to an increase of 50 percent. As shown in the next graphic (Figure 3), the overall O&M costs ranged from a decrease of about 5 percent to an increase of about 4 percent. For treatment plants that experienced higher costs, increased use of chemicals was the major factor.

Water Conservation Benefits and Costs

The findings are listed separately for the two cases analyzed.

Case I - Where the new wastewater facilities are additions to or expansions of the existing facilities to take care of new population growth. Thus, wastewater flows from both existing and new building constructions were considered.

- Indoor water use reduction for the water conservation measures examined ranged from 10 percent with minimal water conservation effort to a potential of 35 percent.

- As shown in the next graphic (Figure 4), savings in capital cost of treatment plants ranged from 12 percent at 10 percent indoor use reduction to 22 percent at 20 percent to 35 percent indoor use reduction.

- The annual cost of water conservation measures increased from $0.20 per household at 10 percent reduction in indoor use to $30 per household at 35 percent reduction.

- As shown in the next graphic (Figure 5), the major benefit is energy savings due to less use of hot water in homes. Other benefits are cost savings in water supply and cost savings in municipal wastewater systems.

- As shown in the next graphic (Figure 6), there are considerable excess benefits over costs (net benefits). The optimum level of indoor water use reduction is nearly 30 percent and the benefits are about three times as great as the costs.

- The optimum level of indoor water use reduction would require a strong water conservation effort.

- Water conservation in existing buildings is responsible for generating about 70 percent of the total net benefits.

Case II - Where the new wastewater facilities serve new population growth independently of existing facilities. Thus, wastewater flows from new construction only were considered. The findings for Case II are similar to Case I, except for the following major differences:

- Indoor water use reductions for the water conservation measures examined ranged from 30 percent with minimal water conservation effort to a potential of 40 percent.

- The annual cost of water conservation measures ranged from $0.10 per household at 30 percent reduction in indoor use to $10 per household at 40 percent reduction. The costs are lower than those for Case I. The reason is that water-saving toilet, shower, and faucet fixtures, which are responsible for most of the reductions, are mandatory in new construction in California and would cost less than retrofitting existing buildings.

- As shown in the next graphic (Figure 7), the net benefits for Case II are considerably less than those for Case I. The comparison of net benefits for Cases I and II reflects the dramatic beneficial effect of water conservation in existing buildings.

Effects of Changes in Wastewater Effluent Quality

- The impact of increased salt concentration (as a result of flow reduction) on wastewater reuse for crop irrigation, landscape irrigation, and industrial uses has no noticeable effect on the "net benefits" (gross benefits minus costs) of water conservation. Thus water conservation is not counterproductive to wastewater reuse.

- "Penalty costs" reduce the net benefits only slightly. Penalty costs are borne by consumers as a result of increased salt concentration in its water supply and are associated with use of home water softeners, soap and detergent, bottled water, and water heaters.

- Desalting and blending of the effluent would mitigate any increased salt concentration. However, the cost of desalting would be considerably greater than the penalty costs.

Savings in Future Capital Expenditures for Secondary Treatment Plants

At the optimum level of indoor water use reductions in new and existing building constructions, the expected savings in capital expenditures of secondary treatment plants proposed for new construction and enlargement in California is on the order of $210 million (1979 dollars).

I have described to you the study background, the study approach, and the key findings. Before concluding my remarks, I would like to briefly address the issue of "What Should We Do Next?"

WHAT NEXT?

The positive results of this study, positive conservation statements, federal regulations for cost-effective analysis, and existing policies, which all promote water conservation, do not necessarily cause a community to undertake concerted water conservation efforts in a non-crisis water supply situation. This is indicated by the sudden increase in the amount of wastewater flow in California during the year immediately following the drought. This increase averaged 34 percent even though the flow quantity did not reach pre-drought flows. The tendency for the community to revert to old habits points out a need for an understanding of the "incentives" of water conservation as viewed by different elements within the community. In urban water use, a variety of interested parties are involved with water supply development, treatment, and delivery; consumer use; and wastewater treatment disposal. Although water conservation may result in a net economic gain to a community, when viewed as a whole system as was done in this report, the financial impact is different for each party.

The solution approach is to investigate the primary economic gains or losses of water conservation from at least three points of view -- those of the water suppliers, the consumers, and the waste discharger.

When individual interests understand the benefits to themselves as well as to the total community, they will generate a willingness to take action leading to the development and implementation of a workable plan to conserve water.

ACKNOWLEDGEMENT

Credits

This study was largely funded by a grant from the U.S. Environmental Protection Agency (EPA). Terry Bursztynsky of the Association of Bay Area Governments, Berkeley, California; Wen H. Huang of EPA, Washington, D.C.; and Takeshi Asano of the California State Water Resources Control Board, Sacramento, California, assisted in the study analyses.

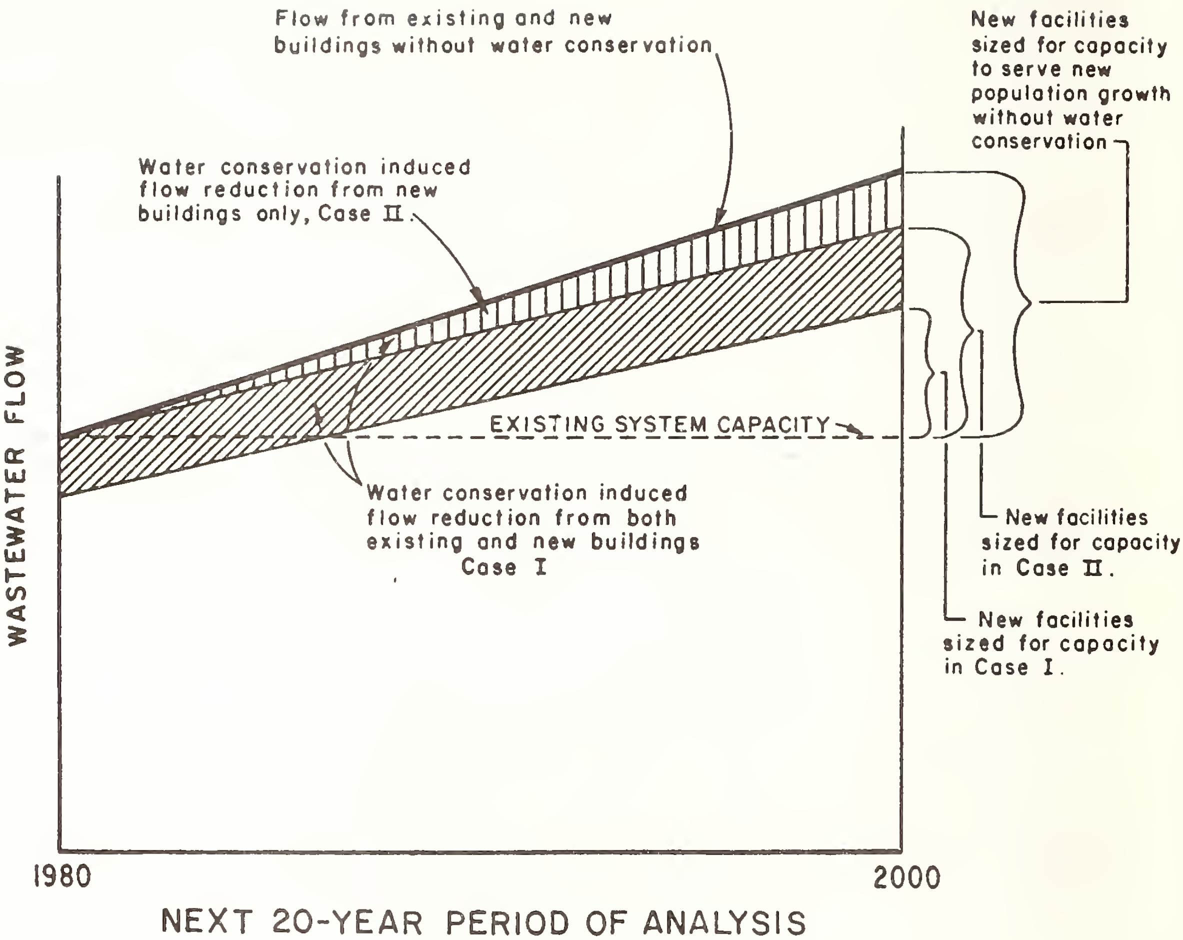



Figure 1. Effect of wastewater flow reduction on new wastewater system capacity.

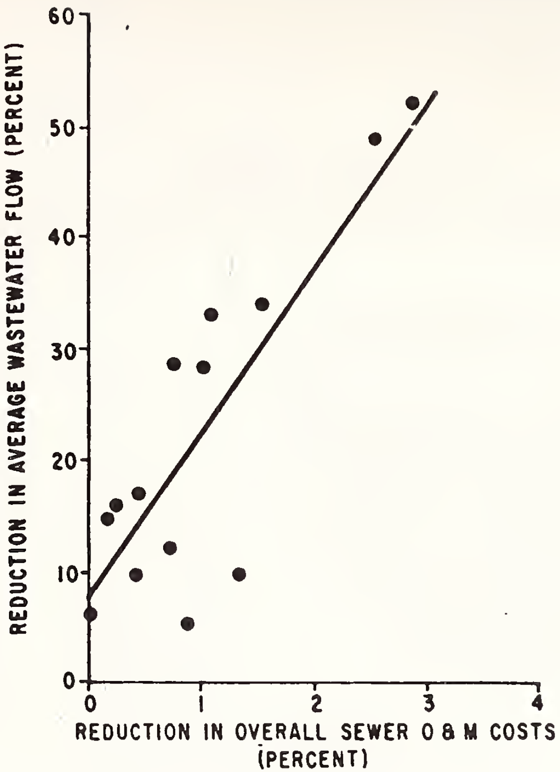



Figure 2. Reduction in sewer operation and maintenance (O & M) costs.

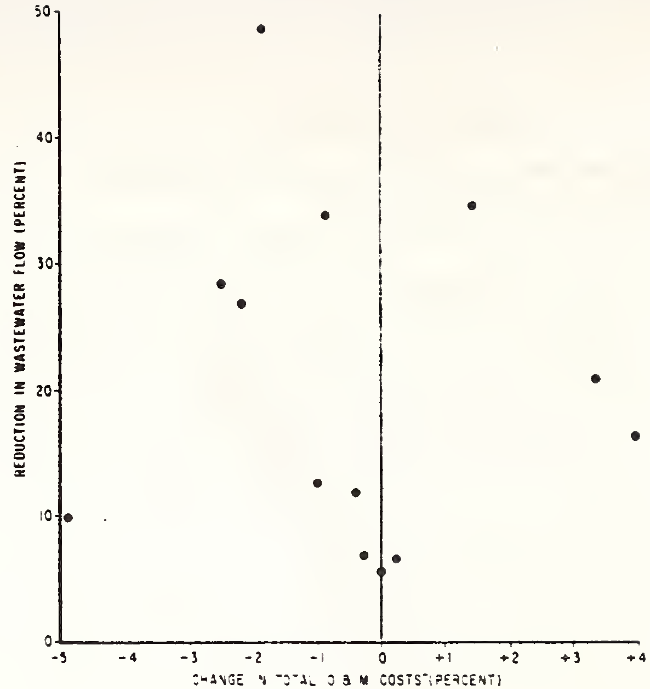



Figure 3. Change in operation and maintenance costs of secondary treatment plants.

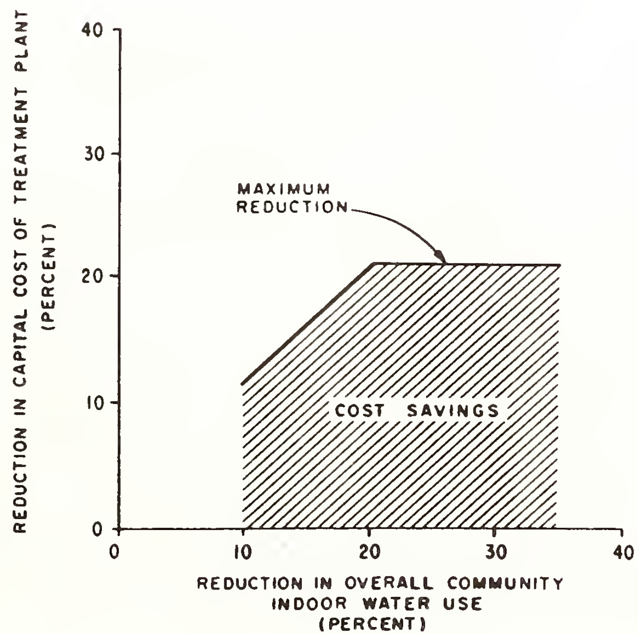
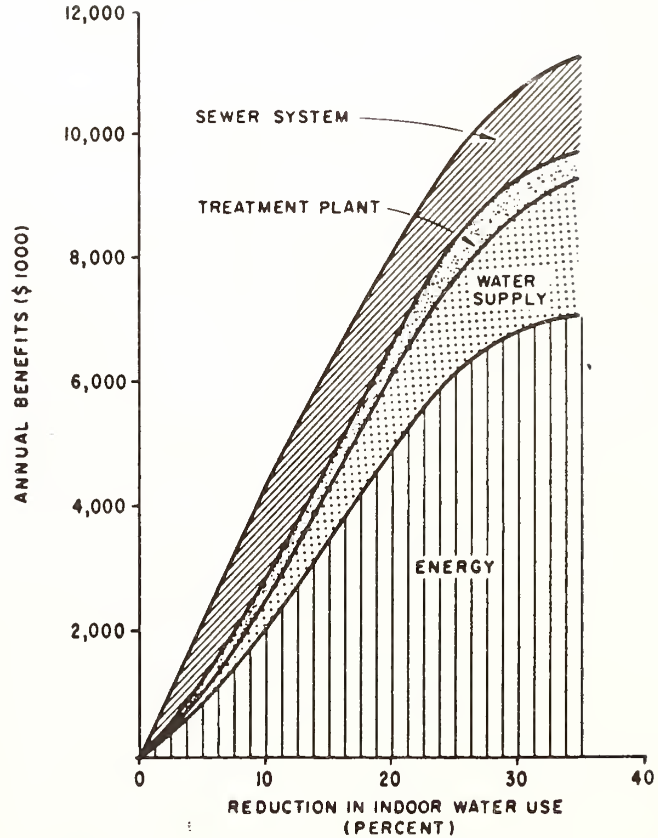
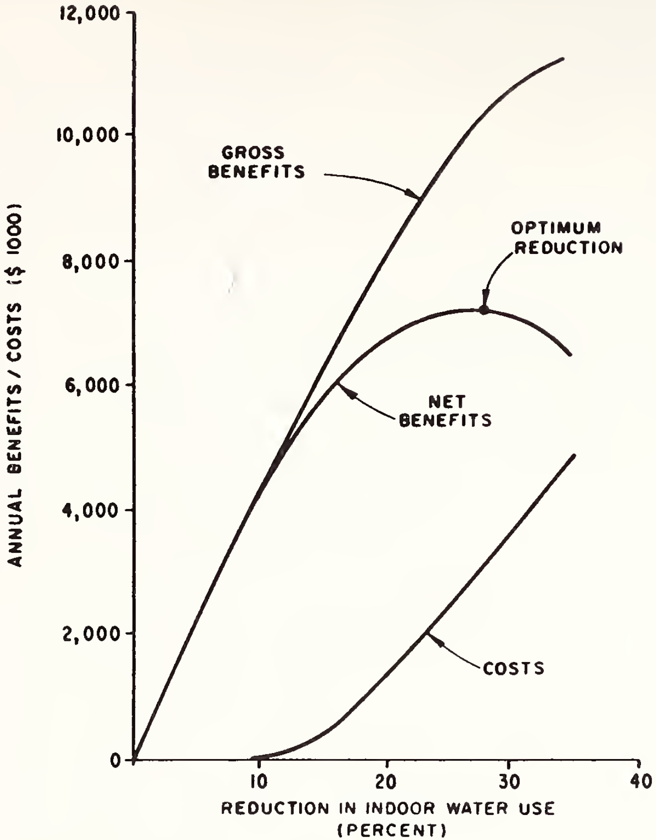



Figure 4. Percent reduction in treatment plant capital cost, Case I.



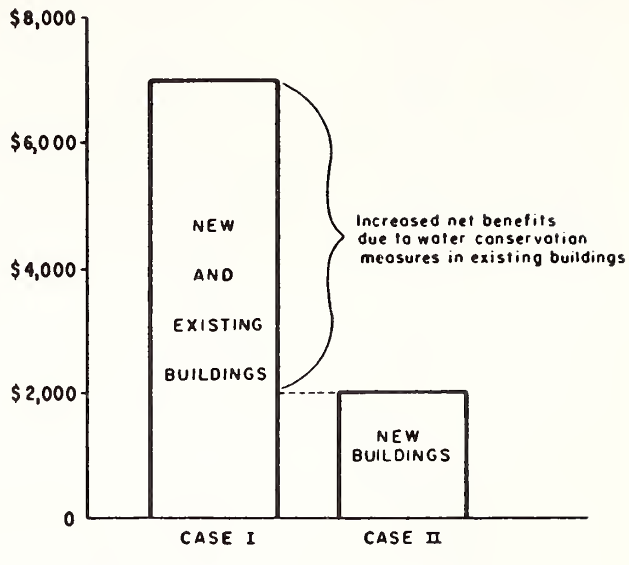

*EXAMPLE:* 0.55 $m^3/s$ (12.5 mgd) Treatment Plant Size.

Figure 5. Annual water conservation benefits, Case I.




*NOTE:* Optimum level of indoor water use reduction is nearly 30 % and requires an intense water conservation effort. This illustration pertains to 0.55 $m^3/s$ (12.5mgd) treatment plant size.

Figure 6. Annual water conservation net benefits, Case I.




*EXAMPLE:* 0.55 $m^3/s$ (12.5mgd) Treatment Plant Size.

Figure 7. Annual net benefits of water conservation at optimum level of indoor use reduction.

# EFFECTS OF WATER CONSERVATION ON MUNICIPAL WASTEWATER TREATMENT FACILITIES

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## ABSTRACT

As part of a regional environmental planning study, the Association of Bay Area Governments estimated the effects of water conservation on wastewater treatment facilities. In general, passive water conservation programs that save 10 to 20 percent of municipal water use will have a minor effect on existing secondary wastewater treatment plant performance. New facilities downsized to accommodate a 10 to 20 percent average dry-weather flow reduction would net a construction cost saving of 2 to 5 percent. Hydraulically sized unit processes could be downsized; organically loaded processes could not and may even need to be enlarged.

## INTRODUCTION

A comprehensive environmental management plan for the San Francisco Bay Area was completed in 1978 by the Association of Bay Area Governments. The plan includes water quality, water supply, air quality, and solid waste elements. The water quality element contains a list of wastewater facilities needed to provide sewerage service in the region until the year 2000. A guiding principle followed during plan preparation was that the plan elements should be fully integrated; that is, they should be based on a common set of land use, economic, and population projections and that the effect of environmental controls proposed in one plan element on another element should be taken into account.

The purpose of the water supply element was to determine how the future demand for water in the Bay Area might be met. The plan recommends a mix of wastewater reclamation, water saving, and development of new water sources. Clearly, if water savings programs are implemented the flow of municipal wastewater will decrease. In order to make the water supply and water quality elements consistent with each other it became necessary to estimate the extent of the flow reduction and how this might influence the need for, and cost of, wastewater facilities.

## WATER SAVINGS

In 1975, residential, commercial, and industrial water use in the nine-county bay region totaled 40.9 $m^3/s$ (934 mgd). If the region's population grows from its 1975 level of 4.6 to 6.1 million in the year 2000, then water use is expected to grow to 61.5 $m^3/s$ (1,404 mgd) if water-saving programs are not put into effect.

The Bay Area's environmental management plan includes a recommendation that a "moderate level" of water conservation be implemented throughout the region. A moderate conservation program is defined as one that emphasizes retrofit of water-saving devices in existing structures and building water-saving devices in new structures. Shower flow restrictors and toilet tank volume displacement bottles will be installed in existing homes. New homes will be fitted with low-flow shower heads, low-flush-volume toilets, faucet flow controls with mixers, shower cutoff valves, pressure regulators, and hot water pipe insulation. State legislation already exists requiring the installation of low-flush-volume toilets in new construction.

It is estimated that retrofit of water-saving devices in existing homes will save about 34 l/cap/d (9 gal/day/cap). It is expected that if the devices are distributed to homeowners without charge, but installation is voluntary, then they will be installed in 15 to 30 percent of homes. Thus the average saving in existing homes is 6.4 l/cap/d (1.7 gal/day/cap). It is assumed that all new structures will be fitted with water-saving devices; a saving of 62.8 l/cap/d (16.6 gal/day/cap) is expected. In addition to the savings resulting from installation of devices, it is estimated that a further overall 5 percent saving will result from informational programs designed to increase public awareness of the need for water conservation.

Implementation of the program described above will reduce the demand for water in the Bay Area by about 7.0 $m^3/s$ (160 mgd) by the year 2000.

## WASTEWATER FLOW PROJECTIONS

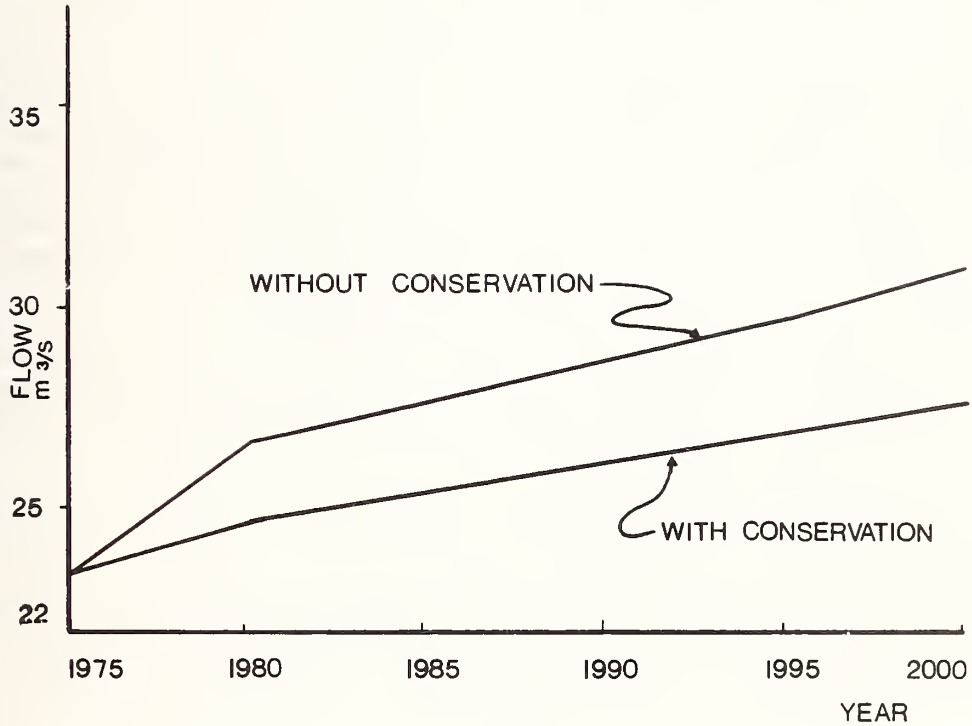
The initial wastewater flow projections were made for each of 50 sewerage units assuming that no water conservation program would be implemented. It was further assumed that in most areas historic per capita rates of wastewater flow generation would be maintained until the year 2000. In a few areas where a large amount of development is expected the rates were adjusted upwards. The rate used for most of the 50 sewerage units was in the range 303 to 397 l/cap/d (80 to 105 gal/day/cap). Industrial flows were estimated from data contained in individual dischargers' facilities plans.

A second set of projections was made assuming implementation of the "moderate" water-savings program. It is estimated that of the 7.0 $m^3/s$ (160 mgd) of water saved in the year 2000, approximately 3.2 $m^3/s$ (75 mgd) will be translated into reduced wastewater flows. Projections with and without conservation are shown in Figure 1.

## ANALYSIS OF EFFECTS OF CONSERVATION ON WASTEWATER FACILITIES

While water-savings programs are expected to result in some re-

FIGURE I




FUTURE WASTEWATER FLOWS

duction in wastewater flows, they are not expected to reduce the mass of pollutants discharged to the sewer. The latter is obviously of great significance with respect to effects on treatment facilities because these facilities are designed to handle a certain pollutant load as well as a certain flow rate. The effect of water savings on individual wastewater treatment process units is discussed at the end of this section. The discussion is preceded by some remarks on the differences in effects on new and existing plants and the relationship between conservation program-induced wastewater flow variations and variations caused in other ways.

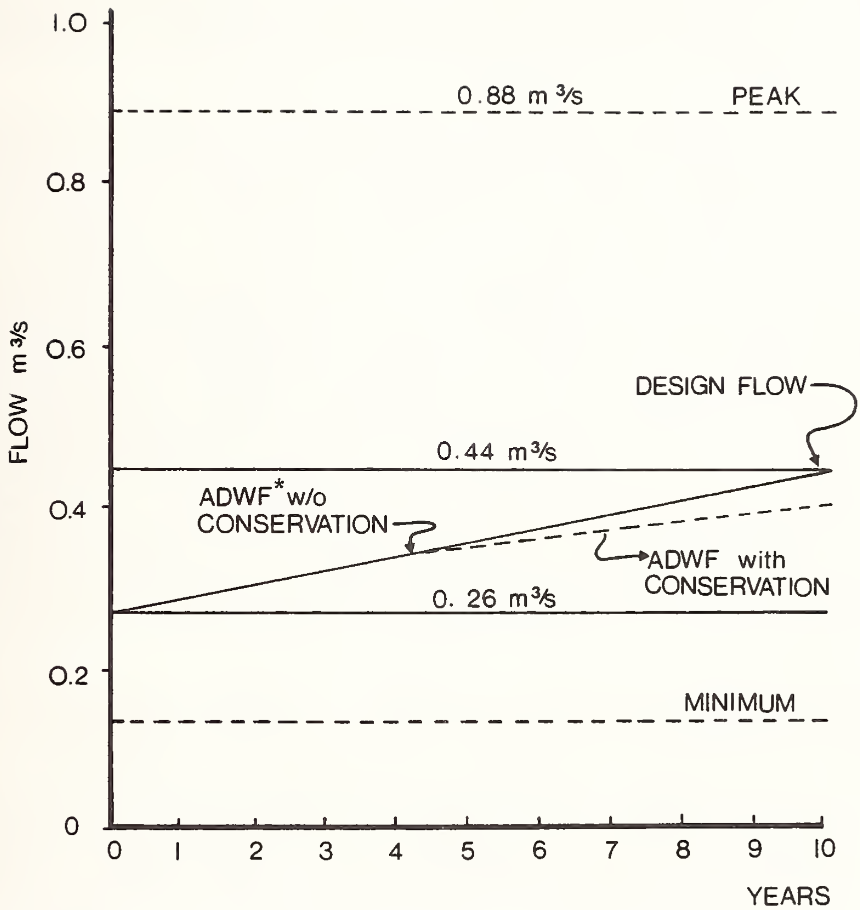
New and Existing Facilities. A distinction must be made between the effects of water saving on existing facilities and on those yet to be designed and built. In the former instance a wastewater facility was designed to treat a certain waste flow and pollutant load. The expected waste flow and pollutant load were determined based on population projections and historic records of per capita waste generation rates and wastewater strength. The effect of a water conservation program initiated sometime during the life of the plant will be to reduce expected flows while still retaining the expected pollutant load. Wastewater strength obviously will increase. Subsequent sections attempt to estimate the effect of this change on plant performance.

In the case of new facilities the existence of a water conservation program is a given in the design process. Subsequent sections attempt to determine to what degree this will alter the size and cost of needed facilities as compared to a no-water-conservation scenario.

Water Savings and Flow Variation. The volume of wastewater entering a treatment plant varies depending on the hour of the day, day of the week, and month of the year. In addition, flow tends to increase annually as more homes and businesses are connected to the sewer system tributary to the plant. Thus, in most cases, a municipal treatment plant must be designed to accommodate a fairly wide range of flows.

It is conventional engineering practice to design a plant to treat the average daily dry-weather flow in the last year of the design period. The design is then checked to make sure that the process units will continue to function reasonably well during extreme high and low flows. Most process units will operate satisfactorily within a range of loading rates. Figure 2 shows flow into a hypothetical 0.44 $m^3/s$ (10 mgd) treatment plant during a 10-year period. It is assumed that the plant comes into service at Year 0 and is designed to treat flows until Year 10. At startup the average dry-weather flow through the plant is 0.26 $m^3/s$ (6 mgd). If effluent limitations are to be met, it is clear that the plant must perform well within the flow range 0.26 to 0.44 $m^3/s$ (6 to 10 mgd), the range of average dry-weather flows that the plant will experience during its design lifetime.

FIGURE 2




FLOW VARIATION

*ADWF = Average Dry Weather Flow.

For a plant serving a population of 100,000, the Water Pollution Control Federation Manual of Practice No. 9 (1) indicates that the ratio of peak to average daily flow will be 2 and the ratio of minimum to average daily flow will be 0.5. If it is taken as a design principle that the plant must perform adequately during daily extreme values for its entire design life, then the design flow range becomes 0.13 to 0.88 $m^3/s$ (3 to 20 mgd), minimum flow in Year 0 and maximum flow in Year 10. From Figure 2 it is apparent that the plant must perform perfectly within the flow envelope defined by the solid lines and at least adequately within the flow envelope defined by the dotted lines.

If it is now assumed that water agencies in the sewerage service area initiate a water-saving program beginning in Year 2, the rate of increase of wastewater flow will decline. By the tenth year, the design year, average daily dry-weather flow will be about 0.39 $m^3/s$ (9 mgd), approximately 0.04 $m^3/s$ (1 mgd) less than would be expected if no savings program had been initiated. If the same peak and minimum flow factors apply, it is apparent that even with the saving program the flows will remain within the flow envelope within which the plant will perform adequately. Thus, from the point of view of hydraulics of an existing plant, the flow variations resulting from water savings are much smaller than those that result from normal diurnal changes in use of the sewer system and consequently no adverse impact on performance might be expected. In fact, again from the point of view of hydraulics, the reduction in flow could extend the life of the plant. Clearly, however, organic loading as well as hydraulic loading must be considered in an analysis of the effects of water savings on treatment plant design.

Analysis of Process Units. Design practices for process units including sewers, headworks, primary and secondary sedimentation, trickling filters, activated sludge, lagoons, chemical treatment, filtration disinfection, and solids handling were reviewed to determine how a reduction in flow might affect them. In most cases, the source of the design practice was "Wastewater Treatment Plant Design," published by the Water Pollution Control Federation (2). The results are presented in the Conclusions section.

## EFFECTS OF DROUGHT ON WASTEWATER FACILITIES

During 1976 and 1977 California experienced a severe drought. In the Bay Area many water distribution agencies imposed mandatory water rationing programs. Wastewater flows were reduced correspondingly. To provide a check on the predictions of the effects of water conservation on wastewater facilities, the effects of the drought on several treatment facilities in the Bay Area were determined. Table I summarizes the effects on a typical conventional activated sludge plant.

TABLE I: Effect of Drought on Plant Performance

| PARAMETER | UNIT | PRE-DROUGHT JUNE'75 | PRE-DROUGHT JULY'75 | DURING DROUGHT JUNE'77 | DURING DROUGHT JULY'77 |
|---|---|---|---|---|---|
| Flow total | $m^3/s$ | 0.24 | 0.23 | 0.20 | 0.20 |
| Per capita | l/cap/d | 291 | 276 | 212 | 220 |
| SS: | | | | | |
| Influent | mg/l | 250 | 225 | 448 | 403 |
| Per capita | kg/cap/d | 0.08 | 0.06 | 0.1 | 0.09 |
| Effluent | mg/l | 69 | 94 | 62 | 40 |
| Removal rate | % | 72 | 58 | 86 | 90 |
| BOD: | | | | | |
| Influent | mg/l | 252 | 199 | 401 | 377 |
| Per capita | kg/cap/d | 0.08 | 0.05 | 0.09 | 0.09 |
| Effluent | mg/l | 103 | 93 | 107 | 110 |
| Removal rate | % | 59 | 53 | 73 | 71 |
| Clarifier loading: | | | | | |
| Primary | $m^3/m^2/d$ | 69.3 | 65.2 | 55.0 | 58.7 |
| Secondary | $m^3/m^2/d$ | 26.5 | 25.1 | 21.2 | 22.4 |
| Biological Reactor: | | | | | |
| MLSS | kg | 6940 | 7530 | 7258 | 6940 |
| F/M ratio | -- | 0.77 | 0.53 | 0.93 | 0.97 |
| Chlorine gas | kg/d | 249 | 290 | 277 | 336 |
| Power | kWh/d | 6580 | 6530 | 6600 | 6270 |

During the drought, per capita wastewater flows dropped by about 20 percent. At the same time, per capita SS and BOD loads increased. No explanation for the latter phenomenon was apparent but it was observed at several plants. In general, plant performance improved substantially. The improvement was particularly marked at one plant (Table I), probably because the primary clarifiers were somewhat overloaded at normal flows. Few savings in energy were observed because most energy use is associated with the aeration equipment. Chlorine usage usually declined, although not at the plant for which data are given in Table I.

## CONCLUSIONS

Performance of Existing Facilities. A theoretical analysis of the effects of water conservation on existing wastewater facilities leads to the conclusion that, within the expected range of water savings

(10 to 20 percent), effects will be fairly minor. Conservation-induced flow variations are relatively small compared to variations caused by other factors. With the exception of biological reactors, the reduced per capita flow will result in some extension in the length of time before treatment units reach their design capacity, as shown in Table II. Theoretical analysis indicates that in order to maintain effluent quality with increased wastewater strength, the performance of biological reactors must improve. Practical experience with plants receiving reduced flows has shown that the overall performance of secondary plants does tend to improve. The improvement is probably attributable to increased solids removal in the clarifiers. In general, it appears that water conservation programs will not cause any major problems at existing plants and may, in fact, improve performance and extend the time to reach design capacity.

Cost of New Facilities. The capital cost of a new facility designed to treat wastewater for a 10-year period, assuming implementation of a water-savings program, will be less than for a similar facility designed assuming no water saving. As indicated in Table II, the process units that can be down-sized represent about 40 percent of the total cost of, as an example, a 1.31 $m^3/s$ (30 mgd) activated sludge facility. Thus, with scale economy, 2 to 5 percent cost savings will result from a 10 to 20 percent reduction in wastewater flow. Operation costs also will be slightly less. It should be noted, however, that these cost savings can be accrued only when infiltration and inflow are small. If wet-weather flows far exceed dry-weather flows, the need to provide hydraulic capacity for these large flows will eliminate the opportunity for cost savings.

TABLE II: Wastewater Treatment Unit Processes Affected by Water Conservation

| UNIT | EFFECT ON TIME TO REACH DESIGN CAPACITY | EFFECT ON NEEDED SIZE OF NEW FACILITY | PERCENT OF CAPITAL COST FOR 1.31 $m^3/s$ (30 mgd) ACTIVATED SLUDGE FACILITY |
|---|---|---|---|
| Sewers | Increase | Decrease | Not included |
| Headworks | Increase | Decrease | 18 |
| Primary sedimentation | Increase | Decrease | 8 |
| Biological | Very Slight Decrease | Very Slight Increase | 22 (activated sludge) |
| Secondary sedimentation | Increase | Decrease | 10 |
| Chemical treatment | Varies, Insignificant | Varies, Insignificant | Not included |
| Filtration | Increase | Possible Decrease | Not included |
| Disinfection | Increase | Decrease | 4 |
| Sludge handling | No Change | No Change | 34 |
| Administration/ Maintenance | No Change | No Change | 4 |

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# Planning for the Future

# PLANNING FOR THE FUTURE

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## ABSTRACT

There is a long-standing base of environmental consciousness among the people of the Pacific Northwest. The conservation ethic is an important part of policies and actions affecting the region's resources. In 1975 a number of prestigious policy-making bodies and organizations strongly recommended water conservation as an alternative to development of new resources. The low rainfall of 1976-77 was the incentive to the Seattle Water Department to consider the conservation alternative. The Department examined the feasibility of the subject during the three ensuing normal years and, in 1980, the City adopted a Conservation Program. Without an impending disaster, the Program could assume a course based upon human value and rationality associated with future sources of supply. A cost/benefit analysis was conducted during the initial study for the Program based on an eight percent reduction in total demand to be reached over a ten-year period. The findings supported the adoption of the Program. The need to construct another source of supply will be delayed by six to seven years if the Program goal is reached. At the core of the Program are six voluntary cooperation projects and three public use management projects. Water customers were targeted and specific water use habit changes were identified to accomplish demand reductions through the projects. Program evaluation methods are being closely monitored by the City Council, which expects timely accomplishment of the projected reductions. Currently, the Office is involved in assessing evaluation in the light of staffing, methods and computer capabilities.

## WHY DOES "RAINY CITY, U.S.A." HAVE A WATER CONSERVATION PROGRAM?

The question has been posed to the Seattle Water Department (SWD) Conservation Office Staff, "Why, in one of the nation's cities noted for its damp, rainy climate, are you undertaking a water conservation program?" There are a variety of strong reasons for our efforts and they are addressed in this paper. In the Seattle water-served area there exists a strong awareness and conservation attitude toward the environment among many native and new residents. There has long existed a base of environment consciousness in the Pacific Northwest. This conservation ethic is reflected widely in policies and actions affecting the region's resources. Water, in the form of rain - one of the region's unappreciated and ubiquitous resources - is usually in abundant supply. Even among the environmentalists it is taken for granted to a large degree until an infrequent low-rainfall year occurs.

A number of issue-sensitive citizens who served on important advisory committees during the '70's brought into regional consciousness the importance of water. Beginning in 1975, several prestigious regional policy-making bodies and organizations began to strongly recommend water conservation as an alternative to the development of new sources of water supply. The River Basin Coordinating Committee (RIBCO) and Water Resource Management Study (WRMS) recommended in 1975 that water conservation policies be adopted by responsible decision-making bodies. Municipality of Metropolitan Seattle (METRO), the regional sewage disposal and treatment management agency, made a recommendation in 1975 for the implementation of water conservation practices before development of additional sources of water. A City resolution and a citizen task force also supported these statements.

The low rainfall of 1976-77 became the strongest incentive for the SWD to undertake conservation. The SWD responded to that minor crisis and then undertook to research the subject during the three ensuing years of normal rainfall. Few agencies in the nation involved in water resources and conservation have had a similar luxury, that of unhurried preparation of a conservation plan.

The Seattle Metropolitan Water Supply Study (SEAMWWS) and the Seattle Comprehensive Regional Water Plan (COMPLAN), finalized in 1977 and 1980 respectively, both recommended conservation; the Conservation Program is part of the COMPLAN. There was no emergency and no impending disaster. Pragmatic stop-gap measures were not necessary and the direction for the Program assumed a course based on human values and rationality for the future.

A cost-benefit analysis was conducted to examine the financial consequences of the conservation program. The analysis sought to examine the effect of an eight percent reduction in annual projected demand for a ten-year period. Results supported the adoption of a conservation program.

If the Program goal is reached, the need to construct another source of supply for the Seattle area can be delayed for six to seven years. Delay of construction will result in savings because costs and rates will remain lower during the period of delay.

It was recognized that the size of the savings to be sought by the Conservation Program may be limited by the feasibility of achieving significant conservation in the absence of an observable shortage. In addition, the public may not perceive the need for the actions suggested to them as a means to lower demand.

Reliance on developing a conservation ethic is an important part of the Conservation Program. One project, which focuses on the conservation education of school children (tomorrow's citizens), has a direct relationship to the awareness and adoption of water-saving actions which will hopefully delay development of future sources of supply.

At the core of the Program are six voluntary cooperation projects which are adaptations of actual projects or directions taken by other national programs. These include the Denver Water District, the Washington Suburban Sanitary Commission, North Marin County Water District and the East Bay Municipal Utility District. Emphasis is on the benefits to the customer in energy savings and lower water and sewer costs, plus the preservation of a natural resource, rather than on the spectre of brown lawns or empty reservoirs.

In addition to the voluntary cooperation projects there are three public-use management projects: reservoir rehabilitation, leak detection and pipeline relining. These efforts are being implemented under system repairs and maintenance. The Conservation Office role is to act as a liaison between the Department and the public, utilizing the media. The water conservation benefits being realized by these system improvements will be emphasized.

The voluntary cooperation projects were designed to target customers in the residential sector, which account for 52 percent of the demand in the Seattle system. Specific water-saving devices and actions have been identified which will aid in accomplishing projected demand reductions. Identification of the most efficient means of evaluating the projects is currently being developed. This will allow the relationship between project benefits and costs to be gradually learned in the ensuing months and years of the Program.

The Department exists within City government and the evaluation methods to be used are being closely monitored by the City Council, which expects timely accomplishment of the projected demand reduction. The Office is currently involved in assessing program evaluation in the light of staffing, methods and computer capability.

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# WATER CONSERVATION IN ARIZONA: PAST, PRESENT, AND FUTURE

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## ABSTRACT

In the desert regions of Arizona and much of the Southwest, water is an extremely valuable commodity and should have the highest of priorities. Water conservation and good quality water are the key to our future and the future of our Nation. Arizona is currently involved in three water conservation programs. They are: 1) Beat the Peak and Slow the Flow, 2) Flow Reduction, and 3) A New Groundwater Law.

## BEAT THE PEAK AND SLOW THE FLOW

Beat the Peak was initiated in 1976 by the City of Tucson. It was an urgently needed summer program to reduce outdoor water usage during the periods of highest demands. Water treatment plants were at their capacity and the peak flows had to be reduced until facilities were expanded. Out of $145 million needed for capital improvements, $45 million could be postponed if a conservation program was implemented. Beat the Peak Public Awareness Campaign requested Tucson residents to only water every other day and never between 4:00 p.m. and 8:00 p.m. (This followed a recent 17 percent increase in water rates.) Public response was terrific and Beat the Peak has resulted in a 25 percent reduction in peak flows. The per capita water consumption dropped from 179 gallons per day to 139 gallons per day, which resulted in a total water savings of 3.5 billion gallons. It was calculated that the average household saved $50.00 a year. All of this was accomplished through voluntary efforts.

Pima County, like other areas in Arizona, is experiencing a rapid depletion of groundwater. Slow the Flow was a year-round water conservation program developed in 1979 to supplement Beat the Peak. This was sponsored by the Pima Association of Governments, the City of Tucson, Pima County Wastewater Management and the League of Women Voters. Slow the Flow was designed to decrease the ever-growing demand on groundwater tables and to reduce flows to the wastewater treatment plants. Slow the Flow is a cooperative effort encouraging residents to reduce their indoor water use by installing simple home water-saving devices, such as faucet aerators and toilet dams, and by practicing simple water conservation techniques. Nearly 100,000 free water saver kits have been distributed countywide. An extensive public education program was developed utilizing billboards, bus ads, public service announcements, slide shows, exhibits, etc. The key to the success of Beat the Peak and Slow the Flow has been communitywide cooperation.

## FLOW REDUCTION

The Flow Reduction Program was developed by the State Water Quality Control Council. The policy is simply this - in order to be eligible for a U.S. Environmental Protection Agency (EPA) grant to construct a wastewater facility, grantees must incorporate a wastewater flow reduction program into the facility planning process.

A Technical Committee was appointed to design workable guidelines for implementing the policy. The Committee was composed of city officials, attorneys, public works directors, government representatives, plant operators, and engineers. The guidelines require a 10 percent reduction in wastewater flows for municipalities over 10,000 in population. Municipalities with a population between 3,500 and 10,000 must develop a plan, and if it is cost-effective, implement the program. Each Flow Reduction Plan will cover a period of 20 years. To achieve the 10 percent reduction, each municipality will choose the method best suited to its needs. As an example, a community with a rapid growth pattern may simply amend the building codes to require low-flow fixtures in all new construction. This method might not be effective for a community with little or no growth. The flow reduction requirement will only affect the communities within the State that will receive an EPA construction grant. This could, however, conceivably include up to 94 percent of the State's total population. This policy is expected to generate capital savings by reducing the size of the wastewater treatment plants.

## GROUNDWATER LAW

Two-thirds of all water used in Arizona is from groundwater sources. The most progressive and comprehensive conservation effort thus far is the State's newly passed Groundwater Management Act. This legislative action was brought about by the realization that there was a very serious and rapid depletion of the State's groundwater. Depletion of groundwater in some areas of Arizona is approximately five times faster than nature can replenish it. State legislators and citizens were aware that we could not continue withdrawing groundwater at the present rate. Until passage of the Groundwater Management Act, which created the Arizona Department of Water Resources, there was limited control of Arizona's groundwater. The Act designated four major Active Management Areas. Each has an Area Director and Groundwater Advisory Council. The Active Management Areas are located in Arizona's most populated areas and where groundwater is a major source of water supply. Additional Active Management Areas may be established when the need arises. Each Active Management Area Director has the responsibility to determine the area's per capita, industrial, and agriculture usage. During management planning, the uses will be compared to the available surface and groundwater supplies, and their future impact on groundwater levels. These management plans will identify how much groundwater can be used by each farm unit, each city, town or private water company, and each independently supplied industry.

A major goal of the Groundwater Management Act is to balance groundwater withdrawal with recharge in the urbanized Active Management Areas by the year 2025. Methods which are to be used in management planning are: 1) Conservation, 2) Augmentation of water supplies, and 3) Purchase and retirement of irrigated land.

The Act mandates that persons selling subdivided lands in an Active Management Area will be required to obtain a certificate assuring a 100-year water supply. Groundwater pumpers will be required to maintain records and to file reports. The Department of Water Resources will have the authority to inspect property for compliance with the Groundwater Law. Penalties for noncompliance can be civil or criminal.

The Groundwater Management Act provides financial assistance to increase water supply. The Act is designed to be fully coordinated with the large federally constructed Central Arizona Project (CAP), which will transport mainstream Colorado River water into the urbanized areas of central and southern Arizona. The Central Arizona Project will be completed in 1988 at a cost of over $2.0 billion. If by the year 2006, conservation methods do not balance groundwater withdrawal with recharge in the Active Management Area, the Act authorizes the purchase of Grandfathered Rights of irrigated agricultural lands for permanent retirement. A Grandfathered Right is a person's right to withdraw groundwater which he was legally withdrawing and using prior to the establishment of the Active Management Area. Grandfathered Rights will be established on a person's usage between January 1975 and January 1980. Persons who have been irrigating land during this time may continue to do so; however, no additional irrigated land will be allowed. When land is sold the irrigation rights may also be sold.

All wells in Arizona must be registered. To drill a well or to relocate an existing well requires either a Notice of Intent to Drill or a permit from the Director of Water Resources. Well drillers are required to be licensed and well construction standards apply statewide. Wells pumping over 35 gallons per minute must install an approved water-measuring device. Groundwater withdrawal fees will be established.

This has been a brief summary of a very complex law. The rules and regulations are being developed at this time. The first management plan is scheduled to be completed by 1983 and implemented by 1985. This plan will cover a five-year period, from 1985 to 1990. Each following management plan will cover a 10-year period (1990 to 2000, 2000 to 2010, etc.). I hope to have conveyed the fact that this is an enforceable law which will change the water use habits of Arizona's agriculture, industry, and residents.

Arizona has made substantial progress in water conservation. These three programs are essential to the future of Arizona, for without an adequate water supply, desert living would be an impossibility. Conservation is the key to the future growth and general well-being of the State, and it will require a concerted effort on the part of all concerned.

SOURCES CONSULTED


1. Ms. Carol Dorsey, Public Information Officer, Pima Association of Governments, Pima County.

2. Mr. Don Maughan, Deputy Director, Department of Water Resources, State of Arizona.

# WATER CONSERVATION AS A LONG-RANGE SUPPLY OPTION FOR MASSACHUSETTS: DISPELLING THE MYTHS AND FACING REALITY

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## ABSTRACT

The Metropolitan District Commission (MDC), serving Metropolitan Boston, is considering conservation as a long-term water supply option. The present MDC supply system has enormous storage capacity, however, and the impression of abundant water supply creates a situation quite different from the public perception of imminent shortages which characterize the national experience with water conservation.

A conceptual framework must be developed for converting national experience to realistic expectations for a long-range program in an area suffering from a myth of abundance but facing a gradual depletion of supply.

In order to include water conservation in long-range water supply plans we must scale down our expectations for potential demand reductions and be more realistic in our assessment of the costs and benefits of various programs.

## INTRODUCTION

The Metropolitan District Commission (MDC) delivers water to 44 communities serving almost 2.5 million people, mostly in Metropolitan Boston but also in communities nearer to the supply source 80 miles west of the city.

The principal supply source is Quabbin Reservoir. With a capacity of 412 billion gallons, it is one of the largest reservoirs in the world built specifically for domestic supply. The Commission also receives supply from the Ware River Watershed and the Wachusett Reservoir, a smaller facility (65 billion gallons) about 35 miles from Boston. Safe yield estimates are presently under review but have previously been set at approximately 300 million gallons per day (mgd).

It is estimated that for the last 10 years MDC users have been consuming water at an average annual rate which exceeds the estimated safe yield of its supply by as much as 10 percent. Recently, the problems of chemical and sodium contamination of groundwater supplies in neighboring communities have compounded the potential shortage. Now the MDC communities must consider sharing their supply with those whose supplies have been impacted by contamination incidents. The MDC is considering at least 9 alternatives for closing the gap between supply and demand -- water conservation is one of those options.

The MDC's first plan for the current shortage was a traditional structural supply augmentation solution: divert part of the flood flows of the Connecticut River and/or a tributary to supplement Quabbin's supply. Wallace, Floyd, Ellenzweig, Moore, Inc. (WFEM) is presently preparing an environmental impact study for this option and several other structural solutions in addition to water conservation and watershed management.

It is apparent that the MDC's enormous storage capacity is at once a blessing for the system's users, and a problem for the MDC in promoting water conservation. The size of the facility gives the deceptive impression of timeless abundance. The continual withdrawal of average amounts in excess of the calculated safe yield from so large a storage facility results in a gradual drawdown of the reservoir during years of average precipitation rather than the prospect of imminent shortage. Even in a drought, serious shortage would be forestalled several years by the storage capacity and the more immediate danger is that of quality degradation.

Developing a conservation program for such a situation has been first a matter of dispelling the myths and then the more difficult matter of determining what kind of program is realistic in the absence of a public perception of shortage or a crisis under which most conservation programs have been successfully implemented. Specifically, WFEM is trying to determine the degree of confidence which the MDC can place on estimates of anticipated demand reduction from a conservation program given the lack of national experience with long-range conservation efforts.

The Northeast has for years believed in a myth of abundant water supply. It enjoys a high rate of precipitation compared to many areas of the nation where conservation is not such an unfamiliar concept. Massachusetts averages 43" of precipitation each year at the watersheds supplying the MDC system. Nevertheless, Massachusetts, not unlike most states, has long faced regional shortages caused mostly by growth in certain river basins outstripping the recharge capacity of its water resources. The solution has always been to turn to another basin for diversion of new supply. This was the way in which Quabbin Reservoir was developed. As closer supplies serving the Metropolitan area became inadequate, the more distant ones were made available.

Now, along with dispelling the myth of abundance, we must dispel some myths about conservation before it can be adopted as a realistic long-range demand management program.

The first myth is the definition of conservation. Based perhaps on the actual experience with conservation during times of crisis, conservation remains distastefully linked in the New England mind with the discomforts and rigors of energy shortages. People with their thermostats set at an all-time low seem to find warm showers a helpful alternative (for those not perceiving the direct energy-cost link). It does not seem likely to be successful to ask more lifestyle changes of consumers already skeptical about shortages and feeling, as a region, over-burdened by the energy crisis. It would, as the traditional definition of conservation suggests, be asking more of them or their beleaguered economic sector than is fair. The reality is that the kinds of changes in user habits generally perceived to be required by "conservation" are not appropriate for long-range supply planning. In fact, the kinds of techniques available are many and varied and are not likely to cause hardship on the part of the consumer. For this study, conservation methods have been defined as "any action by the MDC, its user communities or their consumers which contributes to a reduction in the quantity of water which must be collected and distributed by the Commission."

The variety of conservation programs which fit this definition also have accomplished a wide variety of results in communities where they have been implemented. These experiences have documented that potential water use reductions cannot be extrapolated from the theoretical water savings in individual households. A review of the theoretical literature describing the various conservation methods in comparison with national experience clearly illustrates a gap between theory and practice. Individual household, industry, or commercial reductions can always be demonstrated in a controlled experiment. The uncertainty is about actual water savings which might result from a community-wide program. Experience with program implementation nationally report a variety of water use reduction outcomes ranging from zero to over 60 percent. The differences are in part due to varied baseline conditions: for example, the amount of discretionary water use in the community. But, more importantly, the degree of success is dependent on the degree of private participation in the program. The amount of consumer cooperation is a key variable.

A long-range program should not depend on private, voluntary action for success in the absence of a public perception of crisis, but rather on those measures most within administrative control. Methods requiring the most intensive private participation or habit changes by users should be saved for drought contingencies. Conservation measures therefore have been organized for the study in four scenarios reflecting increasing reliance on private action and therefore decreasing the degree of confidence in success, or at least requiring increasing levels of public action to get compliance. These scenarios provide the conceptual framework for estimating expected water savings from a range of actions with the potential for quite dramatically different impacts upon the general public. We are developing information with which to estimate the water savings which could be made from these programs for the study period (from the present to the year 2020).

SCENARIO 1: PUBLIC ACTION

These are measures largely within the control of the MDC, local, or state government. Included are those which reduce water wasted in the distribution system or offer incentives to users to reduce consumption.

Programs

- System leakage detection and repair;
- Meter repair and replacement;
- Pressure reduction in areas where it is excessive;
- Pricing and rate structure changes to encourage conservation;
- Regulatory options requiring water-saving fixtures in new construction or renovations and enforcement of same;
- Educational programs to develop water consciousness;
- Income tax credits for investments in water-saving devices; and
- Low-flow device installation in all public sanitary facilities.

Implications for Long-Range Planning

It is estimated that the largest amount of water from any of the programs can be realized from the leakage detection and repair program. Initial estimates of potentially recoverable leakage from the distribution systems of the 44 MDC water user communities range from six to 27 percent of the total flow, with the most probable value at 15 percent ( 1). In order to narrow these estimates and help determine how much is actually recoverable, we are developing a rough model of the relationship between estimates of leakage and the actual drop in consumption in those systems having completed a formal detection and repair program. In every case this actual net value is lower than the estimates of potentially recoverable leakage.

This indicates that we must contend with the myth of total leakage recovery and, at least in the Northeast, lower expectations for recovery programs are warranted. National standards call for unavoidable leakage to be reduced to about five percent of system flow. In the Northeast this is probably not realistic since national standards are based on averages from all systems and partially a standard formula for leakage per length of pipe. Densely populated areas like the majority of MDC communities have a high density of service connections per mile of pipe and experience in Boston indicates that 80 percent of undetected leakage probably occurs in service connections. In addition, the systems are older than many in the nation and the degree of deferred maintenance has been costly. Furthermore, the heavy frosts experienced in Boston mean yearly damage to the infrastructure making it more difficult and costly to keep up with continuing leakage. The rate of leakage continuing to occur between programs must be taken into account in estimating annual benefits of leakage repair programs and long-range expectations for reduced consumption.

We must also be realistic about the costs of leakage repair. Although it has been estimated that the direct costs of locating and repairing a typical leak is about $2,000 in Boston, the indirect costs of disruptions from torn-up streets, traffic control, administrative costs, and public inconvenience are harder to estimate ( 1). Nevertheless, it can be shown that it is cost effective to repair any leak which can be detected with conventional electro-acoustical equipment, at the MDC communities' typical rate of about 50¢ per 1,000 gallons (retail to customers) ( 1 ).

It is apparent that, as a political and policy matter as well as a judgment about good management, this first scenario will be required of the MDC and its user communities as an adjunct to or, if it produces enough water, an alternative to new structural supply augmentation programs. We are recommending that estimates of water savings from this scenario therefore will be used to reduce demand projections for the planning period.

The study design proposes that the impact of three additional scenarios reflecting increasing reliance on private action should be assessed in comparison with structural supply options.

SCENARIO 2: COMBINED PUBLIC AND PRIVATE ACTION

This scenario is a device-oriented demand reduction program.

<u>Programs</u>

- Domestic leakage detection and repair;
- Residential device installation through mass distribution of water-saving showerheads, toilet tank capacity reduction devices and faucet aerators; and
- Tax credit incentives for devices to retrofit all other (multi-unit residential, and non-domestic) use categories financed by private investment, including:

- a campaign directed at apartment owners and managers to install water-saving devices in rental units;
- an industrial, commercial, and institutional sanitary use device installation program; and
- a program to encourage, through tax incentives and technical assistance, recycling or reuse of industrial and commercial cooling and process water.

Implications for Long-Range Planning

This scenario presents the real difficulty of estimating results in the absence of experience with acceptance of such a program in a non-crisis atmosphere.

Much has been learned from national experiences, however, which is useful for designing a program for a large regional system which includes a variety of community types. We cannot transfer directly the results of programs implemented elsewhere to an estimate of potential reductions in the MDC service area because of varying baseline characteristics -- climate, demography, per capita water use, housing stock, etc. But experience documented in California and other areas does lead to some useful conclusions about the factors affecting voluntary installation rates in programs encouraging the use of residential water-saving devices. The demographic makeup and existing water use habits of households can help to indicate where and by whom water-saving devices are more likely to be installed.

Residential Use

All studies evaluating programs targeting residential use seem to share three underlying assumptions: 1) the most important factor in the success of a residential water conservation program is the consumer's willingness to cooperate; 2) most experience is with short-term intensive campaigns during periods of shortage and the perception of a problem or a crisis situation will generate more consumer cooperation (2) (15) (20); and, 3) an educational program is a necessary adjunct to and improves the success of all other programs (15) (23).

In New England, a program by the Department of Energy distributing flow-reducing inserts for showerheads clearly demonstrated that devices which also achieve energy savings (i.e., hot water reductions) are likely to be accepted and installed (23).

Other findings of residential device installation programs elsewhere which may be transferable to a long-range program in the Northeast are that:

- Proper installation and follow-up maintenance in a device installation program is very important (3) (15). Therefore, use of better designed devices may achieve greater overall reductions than less satisfactory devices which have greater theoretical per unit savings but which cause problems (such as double flushing, removal of shower widgets).

- Devices are more likely to be installed by households with higher income and educational levels which have higher initial water use characteristics (12).

- Additional efforts in a long-term device installation program are likely to continue to reach new audiences in lower income/educational groups (4).

- Incentives for renters to install devices are less direct. Therefore higher success in apartments may be achieved by directly addressing the large unit owners or managers (27).

Non-Domestic Use

The potential for water savings from device installation to reduce sanitary use in industrial, commercial, and institutional uses as well as for recycling and reuse of industrial and commercial cooling and process water is being estimated through a direct telephone survey of 300 large users in the district. An initial finding is that many conservation steps have already been taken by these firms in response to energy costs and the pretreatment requirements of the Clean Water Act. Here we may be contradicting some long-held views of the price elasticity of demand for water. On the one hand is a popular view that water prices should reflect the true cost of service and that raised prices would reduce use. On the other hand is the weight of evidence from popular experience and studies indicating a very low price elasticity for residential water demand. The reality lies somewhere between these two shibboleths. Indoor residential use probably is not responsive to limited price changes alone but in combination with rate structuring, pricing is an essential element in an overall conservation program.

Previous studies have found that major non-domestic users are more responsive to price than residential users. In addition we are finding that the true cost of water is comprised of not only the direct price but also energy and sewer charges. New elasticity studies may be necessary to evaluate these real costs. A direct assessment of how much conservation activity has already been accomplished as well as the configuration of the demand characteristics of these users will result from the direct survey of major users. This information will lead to a realistic estimate of remaining potential for cutting demand in this sector.

Action to reduce energy use may be having an additional impact on indoor domestic water use. New water-using fixtures such as dishwashers and washing machines have energy-saving requirements which reduce hot water use. Estimates of replacement rates for these and other fixtures may indicate a major decrease in domestic water use regardless of further public action for water conservation.

SCENARIO 3: MAJOR PRIVATE AND PUBLIC INVESTMENT IN USE OF NON-POTABLE SOURCES

Another popular conception of water conservation is that it does not require major capital investment. But under our definition, scenario three would include the development of dual systems for delivery of non-potable water from local sources or treated municipal effluent to selected large users.

Programs

- Reuse of treated wastewater effluent by selected large non-domestic users for cooling or process use;
- Reuse of treated wastewater effluent for aquifer recharge; and/or
- Use of non-potable groundwater sources by local non-domestic users for cooling or process use.

Implications for Long-Range Planning

There are many examples from other areas of the country where low-quality water is used by industry or for aquifer recharge (16). Unlike areas where water is much scarcer and more expensive, however, the costs of dual piping involved in this option in combination with the treatment costs for delivering water to a few major users may mean that this will not prove to be a cost-effective alternative in New England.

Information from the non-domestic user survey will indicate where a major user might be able to accept some amount of non-potable water for cooling or process use. This data will be correlated with local groundwater surveys to be conducted in the next phase of the study. If a match is indicated, a feasibility study will be done to evaluate the costs and benefits of this type of supply option.

SCENARIO 4: PRIVATE USER HABIT CHANGES

Program

Scenario 4 is a drought contingency program. It includes all the traditional measures ranging from voluntary outside use restrictions to rationing.

Implications for Long-Range Planning

The estimates of reductions in use under this scenario will more nearly approximate the traditional conservation experiences in other areas of the country. The difficult part will be to integrate this scenario in a long-range conservation program. How often can such restrictions be called for? Can a supplier accept a higher risk of system failure and depend on drought contingency plans for the long-term?

Here some additional myths come into play. What is a successful program? The dramatic cutbacks experienced under drought conditions do not represent the measure of success for a long-range conservation program. The true measure is cost-effectiveness in comparison with unit costs of supply augmentation proposals.

## CONCLUSIONS

Two additional conceptions about water conservation are unrealistic for long-range planning. They are that programs must make dramatic percentage savings to be successful and that water conservation is cheap. Including the cost of shortage to the consumers, estimates of the unit cost of the water saved in the California drought ranged from $89 per acre-foot in the East Bay Municipal Utility District to $308 per acre-foot in Marin County (20). In each case conservation was half as expensive as the supply augmentation measures used but each case benefited from the massive media coverage, since the program was implemented during a drought crisis. Here is the real issue in trying to estimate the costs and benefits of trying to get consumer cooperation. It is possible that the MDC can substitute paid or public service advertising for the free media which encourage cooperation during a drought. After all, Madison Avenue has been persuading consumers for years to buy things which are far less crucial to their self-interest than water conservation. It is well known, however, that such successful advertising programs are not cheap. And it is unlikely that taxpayers will be persuaded to pay for being persuaded to do things they do not wish to do.

We have not yet arrived at a level of detail that will enable us to estimate a unit cost for a long-range water conservation program. And even if the direct costs are great they must be weighed against the indirect environmental and energy costs of augmentation alternatives. Probably the most likely estimates will be related to level of effort. It cannot be assumed that long-range conservation programs can be achieved through voluntary efforts of residents persuaded by free media coverage. Demand management under these circumstances will have substantial program costs and the level of expenditure will probably relate directly to the water savings achieved.

We have also found that converting national experience with water conservation during drought crises to realistic expectations for such programs as part of long-range water supply plans in the Northeast requires dispelling some additional myths about water conservation:

- Appropriate programs for a long-range water supply plan are different from those for a drought contingency. The key variable is consumer participation. Greater reliance must be placed on programs requiring less consumer cooperation and which are more in the control of the public sector.

- Water conservation programs for long-range supply are likely to be more expensive, both because they are more capital and labor intensive (such as leakage repair) and because they will not have the free media coverage of a crisis situation.

- The success of a long-range water conservation program should not be measured alone in terms of total percentage reductions but rather in terms of unit costs for water conserved against unit costs of alternative supply augmentation options.

Overall, it appears that for long-range water supply planning to include water conservation we must scale down our expectations of inexpensive use reductions and be more realistic in our planning. On a long-range basis, conservation programs are not free and probably will produce significant but not dramatic reductions in use.

From the standpoint of a professional effort to assess the potential results of a program with some degree of confidence, we must be more rigorous in our analysis of the consequences of water conservation efforts and not rely on the traditional mythology. However, it is probable that achievement is likely to be related to the degree of effort, and results are not predetermined by program selection but by levels of public investment in the program. As practitioners, or as consultants employed by practitioners, it is apparent that we need to detail the "how to" of the water conservation options and advise immediate implementation. Conservation programs are tending to be available sooner, freer of ancillary political and environmental costs, and are generally producing tangible benefits in lieu of supply augmentation options.

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Publicly Supplied Potable water conservation '81 A NATIONAL CONFERENCE

# Education/Information: Past Experiences and Current Plans

# WATER CONSERVATION IN RENTAL APARTMENT COMPLEXES BY MEANS OF CONTROLLED INSTALLATION OF WATERSAVING DEVICES

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## ABSTRACT

Howard County, Maryland, in common with many other local jurisdictions, is experiencing rapid growth of its population and housing stock. As a result, it is expected that demand for water and sewer service will continue to increase, and that expansion of service into new areas will be necessary. In order to satisfy these needs, major new investment will be required. A primary strategy designed to offset the impact of this trend is reduction of per capita water use and waste flow.

The program which has been developed to implement the strategy will initially focus the County's efforts (to reduce water use and waste flow) on rental apartment complexes. It will be accomplished by employing a relatively unique concept: co-funded, controlled installation of watersaving devices concurrent with leak detection, repair, and preventive maintenance.

Howard County proposes that the development of a practical conservation program, based on controlled use of resources and corrective maintenance, will result in significant reductions of water (and energy) costs relative to investment, will enhance the state-of-the-art, and will provide a valuable case study for use by other jurisdictions.

## OBJECTIVES

The purpose of the program is to reduce water use and waste flow in rental apartment complexes which represent 25 percent of Howard County's residences. The goal is to accomplish a 20 percent reduction by means of co-funded, controlled installation of watersaving devices concurrent with leak detection and repair. In order to insure continuity of the savings achieved by the program, preventive maintenance programs (funded by a portion of the savings which accrue to apartment complex managements) will be developed. In addition, the program will add to the state-of-the-art by demonstrating the efficacy of cooperative programs which enable management to reduce operating costs with minimal investments and, at the same time, enable local government to offset the need for expansion of water and sewer service capacity. It is expected that the development of such a program, with its emphasis on a practical, cost-reduction approach to the problem, will elicit positive cooperation from management, thus increasing the likelihood of success. The results of the program will provide valuable case study data for other jurisdictions.

In the future, Howard County expects to propose that the concepts developed by the program be tested by application to developments of townhouses, condominium apartments, and neighborhoods of single-family dwellings.

## METHODOLOGY

In the experience of many jurisdictions, conservation programs are conceived and implemented in response to drought emergencies. Under such conditions, little or no time is available for planning or definition of suitable program target groups. Mass distribution of watersaving devices, without means for verification of installation, exposes these programs to waste and reduced effectiveness. Without focus, and with less than sufficient emphasis on concurrent leak detection and repair, such programs are only temporarily effective because they can exercise emergency mandates to impose price penalties and other punitive measures. Other programs, developed during periods of normal supply, have emphasized the educational and attitudinal aspects of the conservation effort which, while important, cannot alone be expected to be completely effective without the stimulus of emergency conditions.

The co-funded controlled installation approach to water conservation in rental apartment complexes is considered to be unique in several respects:

1. Simple, inexpensive watersaving devices will be purchased by the County and distributed, free of charge, <u>by means of the installation procedure</u>.

2. <u>Rental Apartment managements will be required to co-fund the program</u> by paying for installation of the devices, for leak repairs, and for preventive maintenance.

3. <u>Installation will be accomplished only by contractors</u> who are paid on a per-unit basis by the rental apartment managements. Installation will be monitored by the program administrator. On-site apartment maintenance personnel will not be required to install devices, since it is assumed that they have other duties, but they will be made fully aware of the procedures for installation and the

3. operation of the devices. Devices will not be distributed directly to apartment residents, but they will be notified, prior to installation, that the management intends to reduce water use.

4. Concurrent with installation in each apartment unit, the installer will perform a leak check and provide the management of the apartment complex and the program administrator with written reports detailing repairs which are required. It will be the responsibility of the program administrator to review repair requirements with the management of the apartment complex in order to expedite completion of the repairs.

5. Base data regarding per-unit consumption of water in each apartment complex will be prepared by the program administrator with the assistance of the water-billing section of the Office of Finance. Follow-up data, developed from future water bills or meter readings, as required, will be used to measure the results of the program. Reports of this activity will be made available to the apartment complex management.

6. Upon completion of installation and repair procedures and initial verification of savings, the program administrator will meet with the apartment complex management to develop plans for ongoing preventive maintenance.

7. A technology transfer report will be prepared by the program administrator for distribution to interested jurisdictions.

RELEVANCY

The events of the summer of 1980 underscore the importance of water conservation, and the value of programs which are in place before the onset of drought conditions. Water supplies, already threatened by Weather Service predictions of below-average rainfall, are further strained by increasing residential and manufacturing demand. Howard County suggests that the proposed program goes directly to the issue of water conservation by focusing on flow reduction and waste, requiring participation but providing service, and by enthusiastically encouraging rewards for conservation.

The hypothesis to be tested is whether or not controlled installation of watersaving devices coupled with reduction of needless waste (leakage) and ongoing preventive maintenance is an effective approach to conservation in rental apartment complexes, and by inference, other multi-family unit residential areas, including townhouse and condominium developments and neighborhoods of single-family homes.

ENHANCED WATER EDUCATION VERSUS STATUS QUO ET AL.

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ABSTRACT

Water resource authorities, appointed by the governors of the twelve western states, determined six years ago that there was a significant need for better water education. These officials, members of the Western States Water Council, felt it was important for the public to be well informed on water resource issues as the nation moves ahead and faces many difficult water resource decisions. They determined that the Western States Water Council was not the appropriate vehicle for the preparation of these water education programs, and that the need for water education was not limited to the western United States. The Council instructed that a non-profit water education corporation be formed to pursue these most worthwhile educational efforts.

Water & Man, Inc. is the new non-profit corporation fostered by the Council, and has been growing from a very humble beginning six years ago, through various stages of support, solicitation, fundraising, and the creation of water education materials. The Trustees of Water & Man have determined that their first effort would be to prepare and disseminate quality water education materials to be used in the public schools of the nation in grades K-12. Initial materials have been prepared and they are currently being disseminated to participating states.

THE BEGINNING

It has been said that we should have no small dreams for they fail to stir the imagination of man. Six years ago, when I first was approached by a representative of the Governor of the State of Idaho concerning a potential water education program, I was caught up in a dream, and I was almost overwhelmed by the scope of it. The thesis of the concern was that Americans are poorly informed about their water resources and that students in the schools of this nation are taught limited concepts which are prejudiced to various special interest points of view. The dream said, let's do something about it.

The dream was first presented to the Western States Water Council, composed of gubernatorial appointees from twelve western states including: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, and Wyoming. Appointees debated the merits of the State of Idaho proposal and found it to be meritorious. They concluded, however, that the Western States Water Council was created by the western governors to deal primarily in water politics; water education was not their specific mission. They further concluded that if the water education effort was successful, the size of the staff and the magnitude of the effort would far exceed the ongoing efforts of the Western States Water Council.

The Council contributed some funds to the effort and instructed that a non-profit water education corporation be formed. Participation in the corporation was to be solicited from a broad base of public interest groups, and the materials created would be objective and balanced.

Water & Man, Inc. is the result of the initial Western States Water Council effort. Funds were contributed not only by the Western States Water Council, but by the National Water Resources Association, the American Farm Bureau, Morrison-Knudsen Company, and International Engineering. These funds were used to assist a small grant from the U.S. Bureau of Reclamation, in making an analysis of the need for water education and to create some sample water education materials. A contract was entered into with Energy and Man's Environment, a non-profit energy education corporation, and some preliminary investigation was completed. Some materials were prepared and reports issued. Trustees of Water & Man (see Appendix I) concluded that they would initially focus on the preparation ot classroom materials for grades kindergarten through twelve. With the concepts refined, the Trustees turned to a plan of implementation. This was a difficult time as there was a significant need for the creation of sample materials, but a dirth of funds to complete the creation of such materials. The question was, "Which comes first, the duck, the duckling, or the egg?" We concluded that the egg must come first.

With a great deal of donated labor from the many water resource specialists and educators who expressed an interest in this water education effort, and the limited funds provided by the participants, the egg was fertilized and an embryo was developed. The initial reports were published and it became a time for show and tell.

The U.S. Water Resources Council and the U.S. Office of Water Research and Technology were intrigued by what they saw. They entered into a contract and provided grant monies to Water & Man for a nation-wide survey of ongoing water education programs. The survey also inquired regarding the need for water education materials as seen by water resource officials in all regions of the nation. The results of the survey revealed that no comprehensive water education program was available in any of the fifty states. It was further revealed that there was nationwide interest in securing water education materials.

Many water education subject areas were identified. It was determined that water conservation should be a part of all water education subject areas. The contract with the Water Resources Council/Office of Water Research and Technology also called for the preparation of framework materials that would outline the approach that should be undertaken and the materials that would be needed for a comprehensive water education program.

## EMERGENCE FROM THE EGG

With the completion of these studies and reports, the duckling had emerged from the egg. It was the time to show and tell again. Eight states decided to enter into contracts with Water & Man for the creation of water education materials. These states include: Arizona, Nevada, Wyoming, Colorado, Utah, Oklahoma, Texas, and Idaho. Much time was spent in the preparation and revision of a conceptual framework, the creation of activity guides for three grade levels, the preparation of lesson plans, and the creation of supportive materials, such as a bibliography, glossary, and a poster. These materials were created by water resource specialists and educators as they were brought together in various workshops for creation and review purposes. The states contracted not only for the creation of the materials, but for printing them in a form that would be attractive and usable in the classroom.

## THE BIRD SHOWS ITS FEATHERS

Six publications have now been printed and are available from Water & Man. Materials are listed as Appendix II of this discussion. They can be purchased by contacting Water & Man, whose address is 220 South 200 East, Salt Lake City, Utah 84111, or by calling 801-355-4458. The States of Arizona, Wyoming, Nevada and Texas have contracted for workshops that will allow specialists in water education to introduce water education materials to the classroom teachers. Water & Man has determined that this is a most important part of the process and strongly encourages teachers to participate in workshops before purchasing and utilizing the water education materials.

Lesson plans have been created and are available for distribution as individual lessons. The lesson plan is a step-by-step procedure for teachers to use in presenting a particular concept and objective of water education. Lesson plans cover a wide variety of subject areas and are available for kindergarten through twelfth grade.

Water & Man is now busily engaged in contacting additional states, school districts, and water resource agencies and organizations in search of further opportunities to provide water education materials to the students of this nation.

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APPENDIX II

"A Conceptual Framework for Water Education"
"Water Education Activity Guide", K-4, 5-8, and 9-12
"Water Jargon"
"Water Education Bibliography/Directory"
water poster
set of twenty-four lesson plans for grades K-4, 5-8, and 9-12

# INFORMATION AND CONSUMER ADOPTION OF WATER CONSERVATION MEASURES

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## ABSTRACT

Educational campaigns concerning a specific issue are likely to fail unless they are based upon specific information about the recipients. There is some experience that some consumers respond to pleas for reducing water use during periods of shortage. However, during non-drought periods, more specific information is needed in order to design an effective water conservation program: it simply is not sufficient to assume that knowledge of water conservation measures will result in adoption.

## INTRODUCTION

The fact that a person is aware of the opportunities to conserve water is no guarantee that he or she will act upon that information, except under conditions of a serious drought. Little is known about the effectiveness of water conservation measures, and even less is known about the changes required to elicit the public to adopt water conservation measures during times when drought is not present.

The purpose of this paper is to briefly review what is known about the effects of public education programs on water conservation, conservation being the beneficial reduction in water use and/or water losses. The potential dividends to a better understanding of the public response to water conservation educational efforts are twofold: (1) to better predict the extent of public acceptance of conservation measures in order to obtain more precise estimates of effectiveness in water supply planning; and (2) to promote efficiency in water use.

### How Effective Are Conservation Measures?

It is not uncommon to read about enormous reductions in water use for a specific community attributed to conservation. For example, a study in Rhode Island noted that municipal water use can be reduced during periods of shortage by 35 percent without drastically changing life styles (1).

How useful are such estimates in assessing the role of conservation in urban water resource planning? As will be pointed out, such estimates are of little value and frequently misleading.

Based upon a review of the literature, the major conclusion about the effectiveness of water conservation measures is that comparatively little is known. Concerning information about the probable adoption of voluntary conservation measures, even less is known.

There are numerous reports that provide estimates of expected reduction in water use, but there is marked variability among such estimates. For example, estimates on reduction of water use for shallow trap-flush toilets range from 3.9 gallons per capita per day (gpcd) to 7.5 gpcd, and for dual-flush toilets the range is from 4.4 gpcd to 15.5 gpcd.

There are two major reasons for the variation in estimates of the effects of specific water saving strategies. First, many estimates are applicable only for the conditions at the sites from which they were derived. Second, the studies to estimate effectiveness may be poorly designed, leading to erroneous conclusions.

The environmental and socio-economic conditions of each community in which water use reducing strategies are evaluated have a profound effect on the extent of adoption and consequently on the degree of effectiveness. Clearly, during a prolonged drought residents are more likely to employ water reducing devices than during average or wet years; hence, estimates on effectiveness measured during drought cannot be assumed to be applicable during nondrought years. However, most of the estimates of effectiveness have been derived during periods of drought. This is particularly true today concerning the recent California drought. In addition to drought, average weather (climate) varies from place to place and is an important determinant in water use and therefore on the effectiveness of water conservation measures. Similarly, the socio-economic conditions with which each community influences the effectiveness of water conservation vary markedly. Is the community primarily residential or is there significant industrial and commercial water use? What is the price of water? What is the income of the customers? What is the lawn size of the residential customers? In order to calculate more precise estimates of water use reduction, community water use must be disaggregated and relevant information on the characteristics of each user class must be obtained to derive more precise estimates of effectiveness.

A related problem is that estimates on the effectiveness of <u>specific</u> conservation measures are site specific. Statements that a given conservation measure will result in a savings of 35 percent of total water use contain little information regarding effectiveness of specific measures or proposals. Water conservation measures are frequently directed to specific water uses or they may affect different groups of water users differently; e.g., higher prices result in different responses from different types of users. Since no two communities have exactly the same mix of water uses, and many communities differ markedly from others, stating effectiveness in aggregate terms has the effect of concealing the actual water use change by the affected group of users. The aggregate change in reduction of water use is relevant only to the community for which it was originally calculated; it cannot support estimates for another community with a different water use structure.

The second fundamental reason for the variability of estimates in the published literature stems from the quality of the studies. One must be alerted to several problems when evaluating the credibility of specific estimates of effectiveness. First, many estimates are nothing more than a priori judgments; they are not derived from carefully designed empirical studies. For example, low-flush toilets are estimated to reduce water use per flush from 5 to 6 gallons to 3.5 gallons; however, reduction in actual water use may not be as great as one might expect because of multiple flushes! Inspection of chapter two in The Role of Conservation in Water Supply Planning provides additional examples in the variation of estimates (2).

Second, empirical studies of the effectiveness of conservation measures are few and may be poorly designed and/or pertain solely to drought conditions. The most common problem is simply stated: the research design and analysis is based upon a before and after condition, not a with or without condition. It is not uncommon to read about the great reduction in water use during the two years following a community-wide education program to save water. However, seldom are the other factors that affect water use during the same period of time analyzed, such as weather conditions or price. For example, a widely cited study of an experimental installation of devices to reduce flushing volumes in water closets has been reviewed in an unpublished paper by Manning (1979) (3). Based on eleven years of data, Sharpe and Fletcher claimed an average reduction in water use of 97 gallons per household per day. Manning noted that available estimates of the effectiveness of the devices used indicate potential savings of about 30 percent of the water used for flushing, which is approximately 40 to 45 percent of total household water use, giving a maximum reduction of only about 39 gallons per day--about two-fifths of the effectiveness suggested in the earlier study. Furthermore, after accounting for the effects of certain systematic errors in the data, changes in weather conditions, and near doubling of real price, Manning estimated the effectiveness of the devices at no more than 30 gallons per household per day!

Finally, there is little or no information about the factors affecting consumer adoption of voluntary water conservation measures. Estimates on the effects of educational campaigns are usually based upon communities under crisis conditions, namely drought. Clearly, additional research is required to determine the factors that affect consumer adoption of water conservation measures during noncrisis situations. Such information is essential in estimating the effects of proposed measures and in the formulation of a cost-effective educational campaign.

Educational Campaigns to Promote Water Conservation

Sound planning and management of water supply facilities, fully incorporating water conservation, requires the ability to predict the effectiveness and the costs of various water conservation programs. In particular, it must be possible to identify the factors which affect the adoption or non-adoption of various water conservation measures by the consumers. Insight must be gained into the benefits and costs of water conservation measures, as perceived by the individual consumer, in order to understand the incentives that various conservation programs might offer. Sharpe notes that many constraints exist concerning the adoption of conservation measures and there is available little data. As cited in the U.S. Office of Water Resources and Technology, Water Resources Conservation Research Program Priorities, " very little is known about what changes will be necessary to convince the various components of our society of the need for water conservation."

In a recent review of mass media campaigns, the conclusion was reached that is directly relevant: educational campaigns concerning a specific issue are likely to fail unless they are based upon specific information about the recipients. We have some evidence that some consumers respond to pleas for reducing water during periods of stress (drought), but more specific information is needed in order to design an effective water conservation program during the time when shortages do not appear imminent. It simply is not sufficient to assume that awareness of water conservation measures will result in adoption or implementation.

A few studies claim success in the reduction of water use because of an educational campaign. However, the findings must be approached with caution for the reasons cited in the previous section. Brigham (4) emphasizes that "education is the key to success in water saving." The program instigated by the Washington Suburban and Sanitary Commission (WSSC) is purported to be highly effective, as Brigham reports reductions in wastewater flow ranging from 6.1 to 17.9 percent over a two-year period. Larkin also reports reductions of 38 percent in the East Bay Municipal Utility District (EBMUD) during the intensive conservation campaign but which occurred ruring the recent drought (5).

In both of these educational efforts (WSSC and EBMUD) a variety of techniques were employed: television and radio announcements, leaflets, information centers. It is important to note, however, that in neither of these examples was the educational campaign the sole effort made to reduce water use. The WSSC has implemented plumbing code restrictions aimed at reducing water usage and the EBMUD had launched a multi-pronged attack on demand reduction by changing to a new rate structure. Thus, the effect that an educational campaign exerts in and of itself is still unknown.

It is only with the past decade that specific studies have begun to investigate a wider variety of variables drawn from the fields of economics, demography, sociology and psychology (6-13).

Linaweaver and his associates conducted a study in the city of Baltimore (14). The principal factors found to affect annual residential use were the number of homes in a given residential area, the economic level of the consumer, the climate, and whether the consumers were on a metered or a fixed rate schedule. By utilizing disaggregate data from Santa Barbara County, Morgan (15) demonstrates "an economics of scale with respect to household size holding other variables constant." In transforming his equations to a per capita form, Morgan (16) claims, "It is easily seen that as household size increases, water use per person declines approaching the asymptotic value of 17.8 hundred cubic feet per year." He summarizes the exercise by stating that the number of persons per dwelling is important and that, "area projections based on Howe and Linaweaver's residential domestic demand model could lead to biased per capita use figures unless the people per dwelling unit is similar to their sample mean."

While Dunn and Larson also found the factor of family size to be a significant factor in household water demand, they found that it was the occupation of the household head that had the highest correlation with water use (17). The authors go on to note that individual domestic water use patterns differ "but slightly from the use patterns of the socio-economic group of which they are a part."

A study in Boulder, Colorado by Hanke found that as the price of water increased, water demand fell (18). A change from a flat rate to metering substantially reduced the average residential water use by approximately 36 percent and this reduced consumption rate did not tend back towards its original level. Personal interviews of Boulder residents indicated that 51 percent of those samples adopted conservation practices with the advent of metering and had further intensified those practices; only 1.7 percent reported a drop in conservation practices after the first year (19).

Watkins employed a factor analysis in conjunction with a Guttman attitude scale to assess both the relationships between water consumption in residential areas with socio-economic variables and with water conservation attitudes (20). Using Homestead and West Palm Beach, Florida, as the study area, Watkins reports that the income of the family head and the number of appliances in the home were the most important variables related to water use. He claims that the number of persons per household is not important, a finding that contrasts sharply with previously cited studies. Measuring three attitudinal factors: (1) the perception of water as an economic commodity, (2) the willingness to conserve, and (3) the awareness of water conservation as a social issue, Watkins found them to be significantly related to the education and income level of the family head.

A study of residents in Albuquerque, New Mexico by Lupsha, Schlegel and Anderson demonstrated a positive relationship between water use and income, home value, and level of education. These relationships interacted with conservation attitudes (21). Thus, the authors state: "One sees that per capita use at every income level is significantly lower if one has what we have classified as water conservation attitude. We also note that this has a particularly strong effect on use at the higher income and demand levels." They suggest that, "Attitudes can indeed have an effect on use...," but state that,

> "Overall, it would appear that the impact of attitudes on demand is a relatively weak and minor aspect of any water use equation. While attitudes do have an impact, it is small and tends to reflect self interest, which probably has stronger surrogates in economic and appliance variables and the micro-environmental factors which are probably better tested by the landscape and sprinkling practice variables."

In their survey of eastern U.S. water managers and customers, Abbott, Cook and Sleight have found that voluntary conservation measures are as effective as compulsory ones and that 75 percent of their respondents preferred metered to flat rates (22). They concluded that most people are willing to conserve water in an emergency but due to their ignorance of water use and supply, lack the capability to save water. The authors suggest that a continuing educational campaign be initiated and maintained.

Bruvold, studying conservation programs in drought-stricken California, identifies two factors as determinants of their effectiveness -- one, a program must be seen as fair and equitable, and two, a program must be seen as a response to a serious situation (23). Thus, the public reacts more positively to reduced allotments made on a per capita basis (as opposed to previous use), and to programs that are mandatory (as opposed to voluntary).

In summary, economic factors such as income, number of persons per household, price of water and value of home are closely related to residential water usage. Other factors such as the perceived seriousness of a water shortage, attitude toward water conservation and knowledge of water uses are also linked to water conservation behavior. However, because most efforts to reduce residential water use have utilized a combination of water conservation measures such as restriction, voluntary measures and pricing changes, it is difficult to extract the actual role that any one of these two factors plays in this process.

The literature review thus far has concentrated solely on the topic of residential water use. Research in a related area -- individual responses to other environmental problems -- can contribute further insights into conservation behavior. The predominant thrust of research in this domain has been in the area of human response to natural hazards. Several studies have demonstrated that variance on dimensions of personality are correlated with differing hazard behaviors (24-31). Whether or not low probability, high-risk events, as dealt with in such natural hazards research, are analogous to shortage problems of water borders on the speculative. However, the findings cited provide a fertile framework for the conceptualization of research on water conservation behavior.

Research dealing with conservation and the energy crisis has yielded some interesting results. Haas, Bagley and Roger's study (32) claims that, "Although increases in the perceived likelihood of an energy shortage had no effect, increments in the perceived noxiousness or severity of an energy crisis strengthened intentions to reduce energy consumption." This agrees rather closely with the results of Bruvold already discussed. Foster and Sewell, in studying early adopters of solar energy technology, have found that those subjects committed most deeply to solar energy were more technically oriented, greater risk takers and less socially independent than those least involved in the same sample (33).

Finally, a recent study (publication forthcoming) by the Institute for Water Resources of the U.S. Army Corps of Engineers on the social acceptability of water conservation in Atlanta, Georgia, and Tucson, Arizona, provides additional direction in the understanding of the role of information and adoption of conservation measures. There appears to be a marked lack of correspondence between how much a person knows about a measure and how highly he rates that measure overall. For example, building codes and sewage reuse, despite a consumer's high overall assessment, are rated 5th and 8th, respectively, in how much is known about them. Conversely, reduction of lawn watering, a measure with which the public is most familiar, ranks only 6th in overall favorable evaluation. Familiarity with a conservation measure is no guarantee of its perceived value. This finding casts doubt on the assumption that an effective educational campaign can convince the public of the value of a technically feasible conservation measure. The single most potent predictor of a conservation measure's overall evaluation is its perceived effectiveness; that is, how much water it is thought to save. Thus, when the two highest and two lowest ranking measures in overall evaluation (building codes and sewage reuse vs. pricing and growth control) are examined, three out of four of these measures occupy the same positions in perceived effectiveness. And the fourth measure, pricing, differs by only one position in perceived effectiveness.

At least two explanations exist for this strong association. First, it may be that the general public, in forming an overall evaluation of a conservation measure, considers, first and foremost, how effective it would be. In this view, a perfectly objective cost-benefit analysis results in a totally pragmatic determination of the value of a particular measure. Or, conversely, it may be that the general public's rating of the effectiveness of a measure is a function of its overall evaluation of the measure, an evaluation which, in turn, is determined by other factors. Implied in this position is the assumption that clear perceptions and rational processes are vulnerable to unknown influences from uncritically held belief systems.

Which one of these explanations is the more persuasive would have ramifications for efforts aimed at educating the public regarding water conservation measures. For example, if perceived effectiveness determines overall evaluation of a measure, then educational campaigns would stress potential savings of gallons per day and dollars per year. But if, on the other hand, perceived effectiveness is the <u>result</u> of the overall evaluation, careful attention must be paid in educational campaigns to the "collateral" qualities of a proposed measure such as its convenience, equitability, etc. Which of these alternatives is true is indicated by the fact that the correspondence between perceived effectiveness and overall evaluation is not very strong for middle-ranking conservation measures. Thus, for example, educational campaigns rank only 7th in perceived effectiveness but 3rd in overall preference. It seems, then, that the determinants of overall ranking are complex and require further research.

Moreover, the survey in Tucson showed that there is little or no relationship between how much an individual knows about a specific water conservation measure and how highly that measure is rated overall. Moreover, a low overall ranking of a specific water conservation measure does not result from ignorance of the measure. There is, however a weak relationship between an individual's perception of the effectiveness and economy of a specific conservation measure and its overall evaluation. Finally, there is some weak evidence to suggest that if people are given the opportunity to learn more about a particular measure, they tend to evaluate it more favorably -- if true, an educational campaign would hold promise.

In summary, the available evidence is weak on the relationship between awareness or knowledge and the consequent adoption of conservation measures. While the obverse is <u>not</u> true, that is, that <u>no</u> information will result in behavior change, the effects of information can be simply summarized:

> Information may lead to behavior change...
> under highly specified conditions...
> if properly executed...
> with specified targets.

The question then is, what influences an individual to adopt a potential conservation measure? The answer is that little is known, past research is suggestive and offers, at best, some general directions or guidelines. With respect to the role of the mass media in providing information to elicit behavior change, our knowledge is at an embryonic stage; a similar conclusion (34) was reached concerning the same question in managing natural hazards: "...Little is known about mass media activities in hazard mitigation and preparedness."

The question still stands: Why do some persons listen and act while others appear to deny and do nothing? What factors or guidelines are available that do convey to the target population that warrants their adoption of a measure? In summary, past research has provided some general insights and direction:

1) The information must be clear;
2) The information must convey what are the most beneficial measures;
3) The information must be perceived as coming from a credible source;
4) The information must be reinforced socially and at the local level;
5) The medium used to disseminate the information is important; and,
6) The type of appeal must be considered and assessed.

In summary, what is needed is the identification and formulation of the most cost-effective strategies of encouraging the adoption of water conservation measures. A few examples should suffice: Who is most likely to adopt? What should be the content of the message? That is, what kind of information on water use and water conservation will result in the greatest rate of adoption? Which water conservation measures are most likely to be adopted, and conversely, which measures meet with resistance? What is the best agency or authority to disseminate the information?

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# Resources: Manuals and Handbooks

RESIDENTIAL WATER CONSERVATION HANDBOOK
Pabon, Sims, Smith, and Associates, Inc.

A PROCEDURES MANUAL FOR EVALUATING WATER CONSERVATION PLANNING
James E. Crews and Kyle E. Schilling

AWWA WATER CONSERVATION HANDBOOK
George L. Craft

BEFORE THE WELL RUNS DRY: A HANDBOOK FOR DESIGNING A LOCAL WATER CONSERVATION PLAN
New England River Basins Commission

RESIDENTIAL WATER CONSERVATION HANDBOOK

Pabon, Sims, Smith, and Associates, Inc.
Under Contract to:
U.S. Department of Housing and Urban Development
Washington, D.C.

ABSTRACT

This practical guide to residential water conservation entails the review and evaluation of water-saving plumbing devices, appliances, and techniques for their technical and economic feasibility, as well as their public acceptance and regional applicability. The resulting consumer handbook aimed at the homeowner was produced to help consumers conserve water. The handbook was market tested for content, theme, readability, language and style. A national information dissemination plan was researched to ensure widespread distribution of the handbook to targeted audiences.

BACKGROUND

Water conservation is a long-term need--not a short-term measure designed to combat crisis situations. Consumers can be convinced of the genuine need to protect this valuable resource through public education and participation in conservation. Only then can truly effective conservation programs be implemented that will actually alter long-term consumer attitudes and behavior.

A recently conducted National Science Foundation study which examined consumer willingness to adopt residential conservation measures confirms this statement. The two successive years of short supply in central California (1976-1977) represented a natural experiment whereby the equity and effectiveness of various conservation programs could be evaluated and compared. It was found that in three water supply districts, people actually saved more water than they were requested to by effecting average reductions of 58 percent. Additionally, the people with the lowest per capita daily use of water were those who perceived the drought as a harbinger of a longer-term need to live with less water in the future. These consumers continued conservation behavior even after the emergency situation ended. People who believe only in a short-term crisis did not reduce water consumption as effectively, either during the crisis or in the long run. This example proves that people can and will implement conservation programs if the need is clearly communicated and if they perceive an economic incentive to save.

In order to encourage water conservation, consumers must also be shown the methods available to save water. One of the most effective tools is the distribution of conservation handbooks to residential customers which explain techniques and devices that can be used to cut down on both the use of water and the generation of wastewater. Most of the booklets, however, do not provide comparative performance information for various water-saving methods, devices, and appliances, nor do they indicate the estimated cost savings of the various measures. The purpose of this U.S. Department of Housing and Urban Development (HUD) sponsored project was to fill in this important gap in consumer information and to ensure the broadest dissemination of this material to residential water users. Practical information would help consumers make informed conservation decisions and prove a valuable addition to the available water-savings literature.

## PROJECT SCOPE

The application of a variety of market research techniques and dissemination strategies enabled the development of this residential water conservation handbook. Aimed at homeowners, this handbook contains cost and performance information about various water-saving devices, appliances, and lifestyle modifications.

### Handbook Outline

| | |
|---|---|
| TITLE: | SAVING WATER MAKES CENTS |
| THEME: | The handbook stresses the potential economic benefits of water conservation. |
| TARGET AUDIENCE: | Extensive research concluded that single-family homeowners and condominium owners were the most appropriate target audience. |
| OBJECTIVE: | To encourage the practice of water conservation by providing easily implemented techniques; device and appliance performance information; and cost comparisons. |
| METHODOLOGY: | Market-research applications were used to tailor the handbook theme, audience, and graphic design. |
| FORMAT: | The handbook is divided into eight major sections; it is 28 pages in length; text and illustrations are attractively integrated; contains charts and tables usable by |

readers; and ranks tips, devices, and habit changes in order of cost-saving priorities.

STYLE: The language is simple and easy to read; the illustrations are sex, age, and race representative; patronizing tone and language are avoided; and illustrative characters appear on a recurring basis throughout the handbook.

## HANDBOOK ORGANIZATION

The handbook has been organized into the following eight sections:

### Section 1: Why Conserve

This section serves as an introduction to the handbook. It is designed to capture reader interest, present handbook organization and content, as well as present several inducements for saving water. While economic incentives are stressed, mention is also made of environmental considerations.

### Section 2: Down the Pipe, Down the Drain

Average residential water-consumption tables and charts are included in this section enabling the reader to compare his/her personal consumption with typical residential patterns. Savings derived from practicing water conservation are also described. Instructions for measuring water use and reading conventional water meters are provided.

### Section 3: The Inside Story on Saving Water

Indoor water conservation practices, devices and appliances are provided for the reader in Section 3. Methods for saving water on indoor activities such as dishwashing, showering, and garbage grinding are identified. Specific devices and practice recommendations ranging from dual flush toilets to simple toilet inserts are also described. Faucet leak detection and repair procedures are identified for the reader.

### Section 4: There's an Outside Chance You're Wasting Water

Outdoor water savings tips from gardening to recreational activities are presented in this section of the handbook. Specific gardening tips include floral selection, winterizing hose bibs, sprinkler systems, and moisture meters. This section additionally presents an overview of water pressure and its effect on appliances and water consumption.

Section 5: The Cost of Water

This section is a general overview of the varying types of water rate structures. Declining and inclining block rates, uniform commodity rates, peak demand rates, and lifeline rates are described. The advantages and disadvantages of each rate type are discussed.

Section 6: Spreading the Word on Water

The benefits of community-wide involvement in water conservation efforts are described in this section. It additionally suggests a number of steps the reader can undertake to organize a community-wide water conservation program.

Section 7: And What's More

Sources for obtaining additional information about water conservation are identified for the reader. A reading list is provided for handbook readers wishing to delve more deeply into the water conservation issue.

Section 8: Waterlog, A Trouble Shooting Guide

This detachable, tear-out table enables readers to chart their water-saving maintenance and repair activities.

# A PROCEDURES MANUAL FOR EVALUATING WATER CONSERVATION PLANNING

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## INTRODUCTION

In the past few years, the role of water conservation in the management and planning of water resources has become increasingly important. A number of factors account for this emphasis: (1) new reservoir sites have become increasingly scarce; (2) concern for environmental quality has grown; (3) groundwater resources are increasingly inadequate to meet the demands of urban areas; (4) political, economic, and institutional problems of interbasin transfers have proliferated, making it nearly impossible to plan for transfer of water from one basin to another; (5) the costs of water resource development have risen enormously in the last decade as a result of the increase in the price of energy, the increase in the cost of money, and the rise in water quality standards as manifested in the passage of Federal legislation such as the Federal Water Pollution Control Act Amendments (1972), the Safe Drinking Water Act of 1974, and the Clean Water Act of 1977; and (6) the demand for urban water has continued to increase. In combination, these factors have created a situation which directs attention to the possibilities of water conservation.

The Corps of Engineers recognized these trends and began policy studies and research early in 1978 to define and integrate water conservation into its Civil Works program. This paper presents one of the major outputs of this research effort and discusses how the Corps views water conservation.

## WATER CONSERVATION?

Water is an essential resource. It is important in everything we do--food and fiber, production, energy, pollution control, transportation, environmental quality--and the list goes on. Along with this, the growing scarcity of water is well documented. Cost-efficient and environmentally sound water conservation measures offer an excellent opportunity to meet growing future demands for water-dependent goods and services. Used in conjunction with traditional water supply development and more efficient use of existing supplies, our limited water resources can be stretched to meet ever-growing demands.

To most people, water conservation is a noble and laudable goal, but in the formulation and implementation of water conservation policies a formidable obstacle is encountered: "What exactly is water conservation?"

Water conservation is not a new term; however, its use has been so varied that a universal definition has not evolved. Water conservation is different from other forms of conservation. Energy conservation is usually thought of in terms of non-use so that the resource will be available at a future time. Fish and wildlife conservation provides for use of the resource, but in a manner that preserves and protects the regenerating capability of the resource. Non-use of water does not automatically insure its availability at a later time, and the regenerating process (hydrologic cycle) is pretty much beyond our ability to manage at this time.

Since the historic 1908 Governors Conference in Washington, D.C., the term conservation has been subject to many interpretations. Gifford Pinchot, considered by many to be the father of the conservation movement in this country, stated that "conservation is the use of natural resources for the greatest good of the greatest number for the longest time."

Critical analysis of this definition, however appealing the prose, concludes that it fails as an operational definition. It does not serve as a guide to the formulation of national policy.

Historically, many other definitions have emphasized the wise and judicious use of available supplies, but few distinguished between water conservation and comprehensive, efficient water supply and demand management.

In summary, many past definitions leave something to be desired; while laudably comprehensive, they lack precision. Consequently, the Corps of Engineers developed a water conservation definition and evaluation process that emphasizes a balanced approach to analyze both supply and demand management on a similar basis. This will permit a consistent trade-off between increments of new supply, water conservation measures, and measures that result in more efficient use of existing resources.

## WATER CONSERVATION DEFINED

To be helpful, the Corps' definition possesses two attributes: (1) it is precise; and (2) it is practical, and it considers conservation as management of the demand function. Therefore, the Corps' definition is as follows: "Water conservation is any beneficial reduction in water use or in water losses."

Based on this definition, water management practices constitute conservation only when they meet two tests: (1) their purpose is to conserve a given supply of water through reduction in water use (or water loss); and (2) their total national economic and environmental benefits outweigh their total national economic and environmental costs.

Water use is the withdrawal of water from a supply or other action which denies the availability of that water to another user. Uses range from human consumption to support of fish and the natural environment associated with streams. A reduction in water use is beneficial if the aggregate of all beneficial economic and environmental effects resulting from implementation of the water management practice exceeds the aggregate of all adverse economic and environmental effects occasioned by such implementation. Recognizing that just as in the case of augmenting supply, conservation measures may deplete other scarce resources (such as energy), the above definition of beneficial reductions assures that all scarce resources are conserved.

Water supply and water conservation, as defined above, have much in common. Neither can be implemented without making demands on other scarce resources, and the merits of both must be evaluated using the same basic criteria. In addition, the fact that not all new supplies should be considered desirable is also applicable to water conservation measures. The evaluation of the adequacy of existing water supplies and the measures needed to address future water needs require an assessment of: (1) demand reduction practices; (2) more efficient utilization of existing supplies; and (3) need for new supplies.

## EVALUATION PROCEDURE

The Corps of Engineers has developed a procedures manual (The Evaluation of Water Conservation for Municipal and Industrial Water Supply: Procedures Manual), detailing an evaluation process that permits a consistent and balanced trade-off between water conservation and increments of new supply.

Figure 1 presents an overview of the general evaluation procedure indicating that simultaneous evaluations can be made of both the supply and conservation options.

Water supply plans are formulated according to existing procedures without consideration of additional water conservation measures. Water conservation measures are identified by the measure-specific analysis. These individual measures are then evaluated against alternative water supply plans. Based on this evaluation, water conservation proposals are developed which can be integrated into water supply plans, yielding alternative water supply/conservation plans.

# GENERAL PROCEDURE : AN OVERVIEW

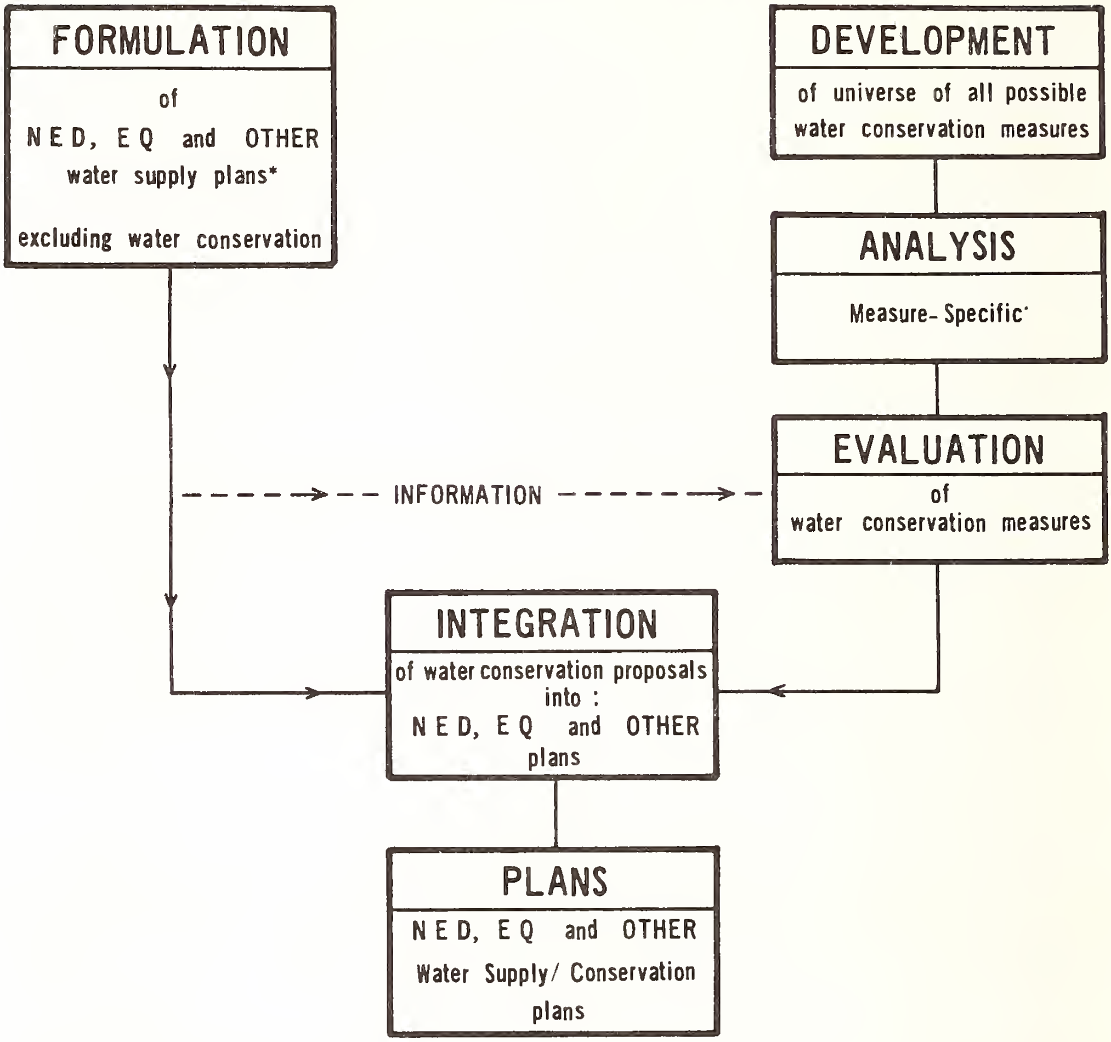


FIGURE 1

* Water supply plans may also be the water supply portion of a multi-purpose plan.

## DEVELOPMENT

The evaluation of water conservation starts with the development of a universe of possible water conservation measures (regulation, management, and education, as shown in Table 1). These measures are then tested for applicability, technical feasibility, and social acceptability. The potential measures are those that are applicable to the study area and setting, are technically feasible, and have potential for being socially acceptable.

## MEASURE-SPECIFIC ANALYSIS

A measure-specific analysis, as shown in Figure 2, establishes the characteristics of the measures that are independent of the water supply plans. These include the implementation conditions (coverage and duration), the effectiveness of the measures, the costs foregone for water supply, energy savings, the costs foregone for treatment of raw water and wastewater, implementation costs, and environmental effects.

## EVALUATION OF WATER CONSERVATION MEASURES

Other positive and negative effects of substituting a water conservation measure for an equivalent amount of water supply are dependent upon the specific water supply plan considered. To test all potential measures and combinations thereof for inclusion in several supply plans requires an inordinate number of calculations. The procedure outlined in Figure 3 was developed which reduces the number of calculations, yet retains acceptable limits of accuracy. The procedure is to include each potential measure in the water supply plan, one at a time, to determine the net change in outputs of the plan that are attributable to that measure. The measures are then ranked in merit order based on their net increase in the desired output. For example, the measure that produces the largest increase in net economic benefits is ranked first for that process of integrating water conservation into the plan. Other measures would be ranked according to their impact on net benefits. The same ranking procedure would apply to the environmental quality with net positive impacts on the environment being the ranking factor.

## INTEGRATION OF WATER CONSERVATION INTO WATER SUPPLY PLANS

The ranking of measures in merit order permits a once-through process for integration of the water conservation measures into the water supply plans to produce plans that maximize the desired outputs. This procedure is shown in Figure 4.

The maximization of outputs is accomplished by substituting the measure ranked first in merit order for an equivalent amount of water supply. The increase in net beneficial effects of the plan is then calculated. The second measure in merit order is then substituted

Table 1. Illustrative List of Water Conservation Measures

**REGULATIONS**

Federal and State Laws and Policies

A. Presidential Policy
B. PL 92-500
C. Clean Water Act Amendment 1977
D. Safe Drinking Water Act

Local Codes and Ordinances

A. Plumbing Codes for New Structures
B. Retrofitting
C. Sprinkling Ordinances
D. Changes in Landscape Design
E. Water Recycling

Restrictions

A. Rationing
   1. Fixed Allocation
   2. Variable Percentage Plan
   3. Per Capita Use
   4. Prior Use Basis

B. Determination of Water Use Priorities
   1. Restrictions on Public and Private Recreational Uses
   2. Restrictions on Commercial and Institutional Uses
   3. Car Wash Restrictions

**MANAGEMENT**

A. Leak Detection

B. Rate Making Policies
   1. Metering
   2. Pricing Policies
      a. Marginal Cost Pricing
      b. Increasing Block Rate
      c. Peakload Pricing
      d. Seasonal Pricing
      e. Summer Surcharge
      f. Excess Use Charge

C. Tax Incentives and Subsidies

**EDUCATION**

A. Direct Mail

B. News Media

C. Personal Contact
   -Speaker Program

D. Special Events
   -School Programs

# MEASURE – SPECIFIC ANALYSIS

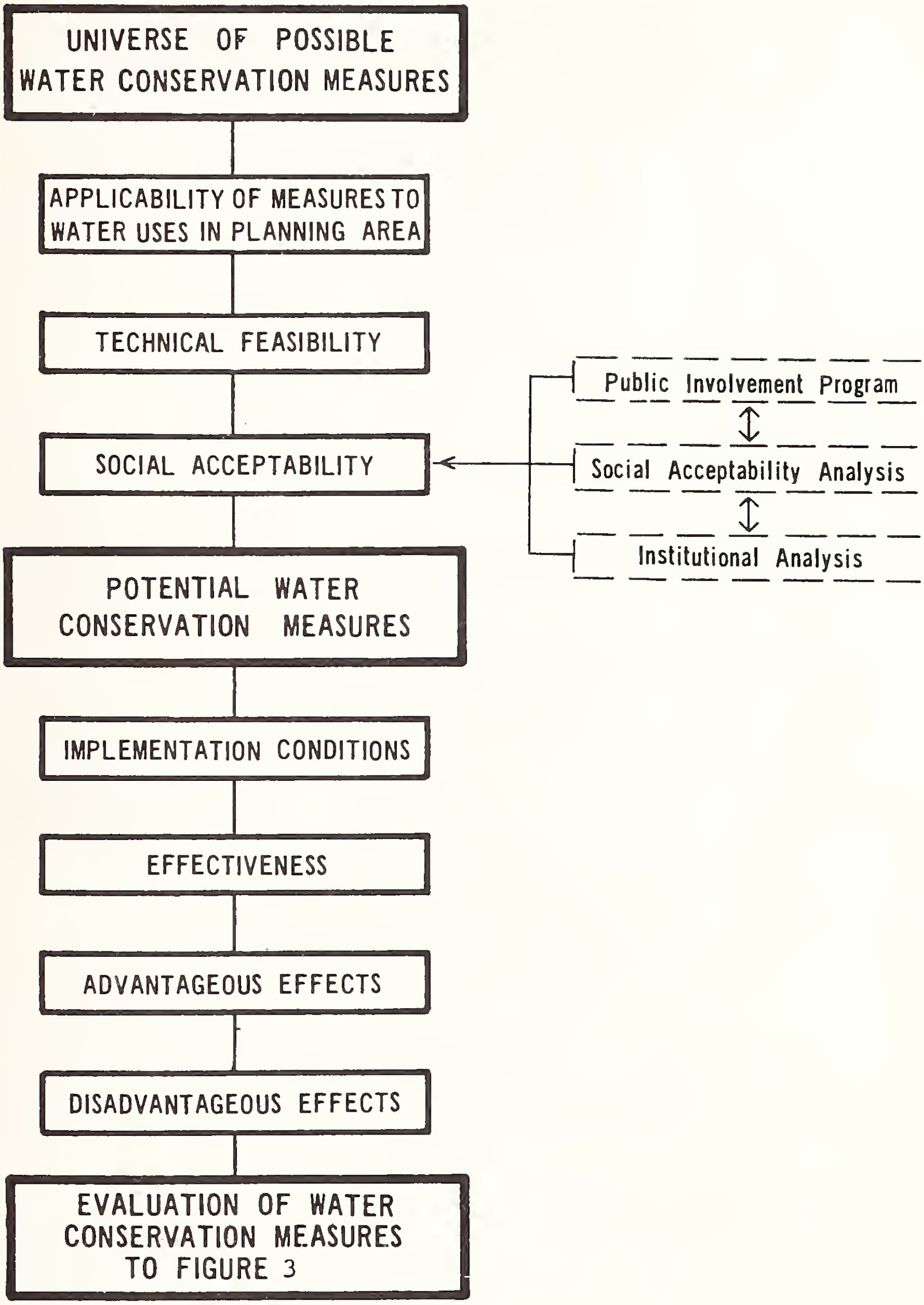


FIGURE 2

# EVALUATION OF WATER CONSERVATION MEASURES

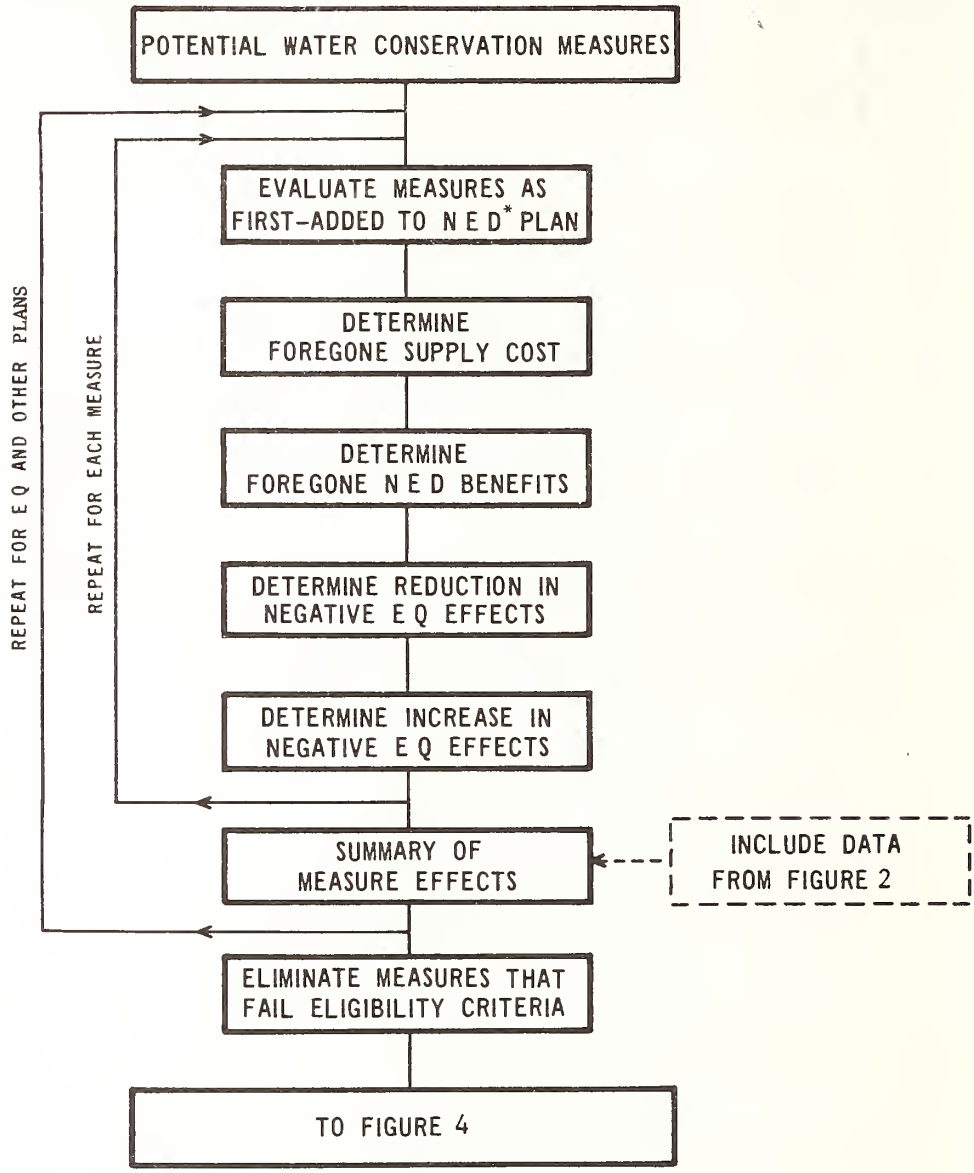


FIGURE 3

* N E D, E Q or Other as appropriate.

# INTEGRATION OF WATER CONSERVATION INTO WATER SUPPLY PLANS

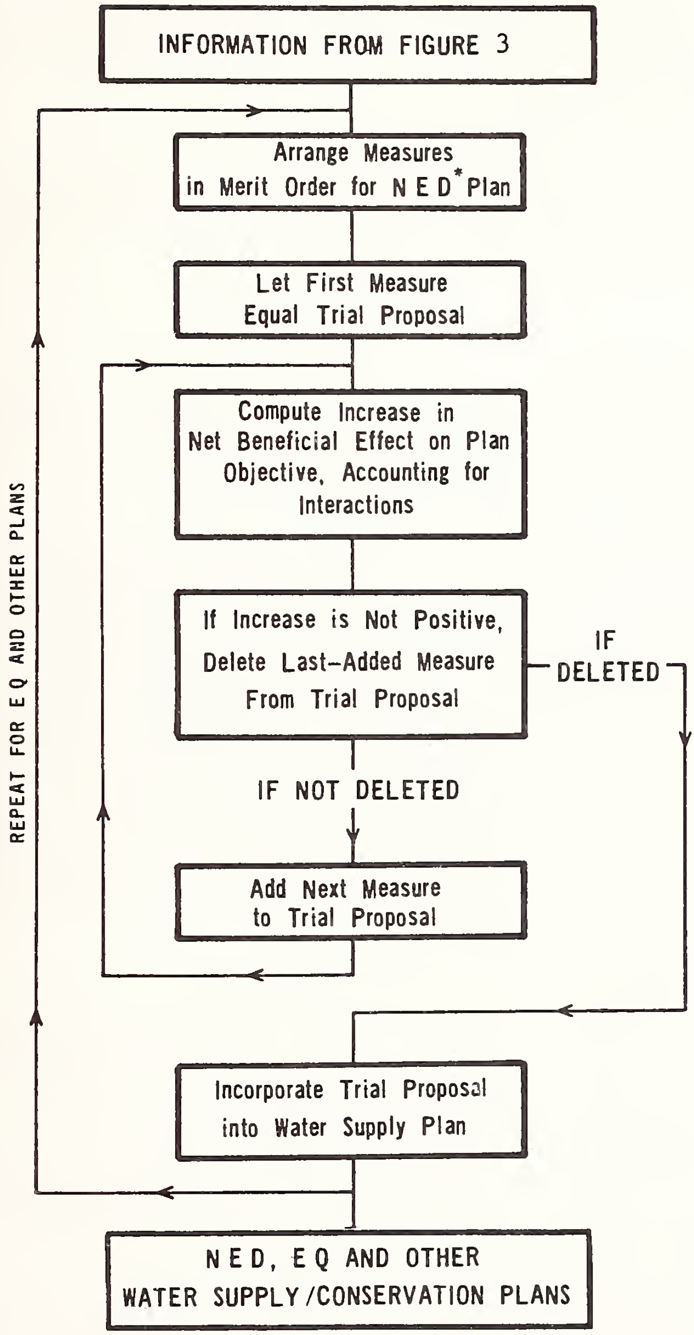


FIGURE 4

* N E D, E Q or Other as appropriate.

after careful consideration of the interactions between the first and second measures. When interactions exist, the incremental effect of the second measure will probably be less than its effect as a single measure. This procedure continues until the addition of another measure reduces the net beneficial effects on the plan objective. For the NED plan, measures are added until the next measure would reduce the net NED benefits of the plan. The resulting plan represents the NED plan for water supply/conservation.

Finally, the water supply/conservation plans should be tested for compliance with the desired system reliability. Dependability can be designed into plans that include water conservation in the same way that it is included in plans for water supply.

## APPLICATION

The Corps of Engineers has developed a methodology to evaluate water conservation in its planning process. Obviously, this type of research must now be tested, evaluated, and communicated to the users in the field districts and changed if necessary.

To accomplish this objective, continuing research will be conducted to refine and clarify portions of the manual, such as the more longer term effects of specific conservation measures and data availability. Specific case studies are being conducted or planned where close coordination and specific guidance can be given by IWR personnel to fully test the procedures manual. Workshops are being planned to impart the principles of the manual to the Corps field personnel who will actually be conducting the studies, and additional policy studies and guidance (such as advancing the state of the art in dealing with groundwater conjunctive use and improving forecasting methodologies) are planned to further develop the Corps' role in water conservation planning.

## SUMMARY

Water conservation has taken on an increasingly important role in Federal water policy these past few years. The Corps of Engineers has met the challenge to fully integrate water conservation into its Civil Works program. The Corps defined water conservation in such a way that the definition is both precise and practical. Along with this definition, a procedure was developed that permits an evaluation of water conservation where consistent trade-offs between increments of new supply and measures that result in more efficient use of existing supplies can be made. This procedure encompasses four basic steps: (1) the development of a universe of possible water conservation measures; (2) a measure-specific analysis which is independent of the water supply plan(s); (3) an evaluation of conservation measures incorporating the characteristics of the water supply plan(s); and (4) the integration of the water conservation measures into the water supply plan(s) to form the final water supply/conservation plan(s).

Continuing Corps research will further refine and enhance the Corps' involvement in water conservation planning.

# AWWA WATER CONSERVATION HANDBOOK

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## INTRODUCTION

I am really here under premature circumstances in that the AWWA Water Conservation Handbook that was scheduled to be completed by now is not. Therefore, instead of telling you what our handbook is, I will tell you what we hope it will be, as well as some of the problems encountered during its development.

The American Water Works Association (AWWA) is a nonprofit, scientific, educational society for the drinking water industry. Our membership numbers 32,000 and consists of water plant operators, utility managers, engineers, consultants, manufacturers, and water utilities. These members comprise sections representing the United States, Canada, Mexico, and Puerto Rico. With this widespread and diverse membership, you can see that many regions with varying types of climates are represented, and there begins our problem of uniform policies.

Water Conservation: What is it? Can you define it? Water conservation means something different to each of us, depending on where we live. At the end of 1980, for example, New York was starting to see the bottom of their reservoirs and began trying to "think conservation." The Institute for Water Resources, U.S. Corps of Engineers, defines water conservation as "any beneficial reduction in water use or water losses."

AWWA has not really tried to define water conservation as such, but does refer to conservation in the official AWWA Policy Statement on Water Resources by stating: "Water is a renewable natural resource. It must be managed to best meet all of the many needs of man. Every effective means to prevent and minimize water loss and promote wise use should be employed by all entities, public and private, engaged in water resource activities." Now that's a mouthful! But it does promote the "wise use of water" from the broad viewpoint of the water utilities--a nice, comfortable middle ground for a conservation policy.

The need for AWWA to publish its own water conservation handbook was brought to the forefront with the western drought years of 1975-76. An Ad Hoc Committee was formed by the AWWA Technical & Professional Council consisting of nine AWWA members from the water industry. The committee members were from all regions of the United States and were the most capable men available to oversee the formulation of the Handbook.

In July 1978, AWWA hired a professional engineer to write the Handbook for the committee to approve. After 10 months of working on this book, the writer produced 200 pages of water utility experiences with drought, but no conservation material. We then contracted another author plus an editor to edit the copy prior to submittal to the committee. This second effort began in the spring of 1979 and concluded in August of 1980. This author furnished us with a good, philosophical, middle-of-the-road approach, but failed to include the how-to-do-it portion for the Handbook. The committee is now working with a third author who has provided an additional draft of how-to-do-it water conservation practices to be implemented by water utilities that are running out of water due to drought, political restraints, or emergency disasters.

At this point in time, AWWA does not advocate water conservation; officially, however, it does advocate the wise use of water--all the water you need, not one drop to waste. The Handbook that was originally begun in 1977 is now nearing completion; it will be targeted to water utilities and will emphasize that water conservation is not a substitute for good management and planning.

The Handbook will also tell the water utilities that water conservation is not a substitute for eliminating system leakage. Leak detection and repair of existing systems will not only conserve the existing water supply, but will help improve the efficiency of water production and increase income by eliminating nonrevenue-producing water that is now disappearing somewhere. It is estimated that 5-15 percent of a utility's water is lost in a leaking system. This water will be saved by diligent leak detection and repair of leaks. In older systems, this lost water may be higher than 15 percent.

How does a utility account for its water, and how does a utility charge for water use? Metering, of course. This is one tool that is a must to a successful water conservation plan. AWWA has officially advocated 100 percent metering of water customers for several years. Many individual utilities have adopted that policy because it is necessary to have complete metering. Metering presents a mechanical, nonarbitrary method of recording water use, but also a way to account for the water distributed in the system. Without water accountability, how can a utility know the conservation effort is furnishing results or even know if it is running out of water?

After instituting good management procedures with long-range planning and meter maintenance programs, and eliminating all leakage that is possible to locate, the water supply is still slowly being used up. This situation is needed for severe problems if water usage is not curtailed quickly. The Handbook will suggest to the water utilities emergency measures that can be taken to prolong the water supply until an emergency, such as drought or disaster, is over. Examples are: Quotas can be imposed as implemented in the San Francisco area in 1976; retrofit restrictions in the home can be installed as in Elmhurst, Illinois, and in several other cities in 1976; and water rates can be increased for increased use of water as the Washington Suburban Sanitary Commission has utilized for the past few years.

Public education, a "must" as discussed in John Nelson's paper entitled "Motivating the Public to Save Water in the Absence of Crisis," should begin immediately because attitudes and perceptions of the water customers are very important considerations in achieving maximum effectiveness in implementing a water conservation program. A program that is understood by the customer as a viable option to running out of water will be successful.

The AWWA Water Conservation Handbook will provide guidance as well as examples of how a water utility can conserve water. It will also contain all pertinent bibliographic references for those desiring more information on the subject.

BEFORE THE WELL RUNS DRY: A HANDBOOK FOR DESIGNING A LOCAL WATER CONSERVATION PLAN

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ABSTRACT

In February 1979, the New England River Basins Commission (NERBC) received funds from the U.S. Geological Survey (USGS), Resources and Land Investigations Program, to research and develop a planning procedure for water conservation. The project included an extensive literature search, development of local case studies, interviews with water supply engineers and policy makers, and an evaluation of the effectiveness of alternative water conservation measures. From the information it gathered and analyzed, NERBC developed a seven-step procedure for designing a local conservation plan. The sources for the procedure and the procedure itself are presented in a two-volume technical report, Before the Well Runs Dry.

In 1980, NERBC received additional funds from USGS's Water Resources Division to prepare a handbook for the practical application of the information contained in the technical report. The handbook is designed to provide a concise, clear-cut procedure for local water supply planners to follow in designing a conservation plan. The procedure outlined in the handbook has been reviewed by water supply engineers, administrators, superintendents, and planners throughout New England. It is flexible, can be used by any type of water utility, and can meet a variety of goals. This paper summarizes the information presented in the handbook.

INTRODUCTION

Water conservation is an effective and efficient means of solving many water supply problems: it can ease a community over a short-term shortage; it can eliminate the need for new source development; it can improve a water system's efficiency; it can reduce operating costs; and it can help a community cope with water supply emergencies including the loss of supply due to contamination.

Many communities in California have used conservation measures successfully to cope with serious water shortages: in one of their worst droughts in history, up to 60 percent water use reduction was achieved through conservation. Most residents and businesses were able to pull through the drought with little hardship. In Madison, Wisconsin, and Elmhurst, Illinois, conservation programs were introduced to reduce the need for new source developments. By not having to drill new wells, Madison saved $750,000; Elmhurst saved $400,000. The Boston Water and Sewer Commission in Massachusetts is currently undertaking a conservation program to improve its system's efficiency. Already, it has reduced average use from 150 million gallons per day (mgd) to 134 mgd. In Arlington, Massachusetts, water costs were reduced by $36,000 per year through conservation. Numerous communities, including Woodbury, Connecticut, and Provincetown, Massachusetts, have used conservation to cope with losses of supply due to contamination.

Conservation has also been successful in helping to solve other water-related problems including excessive waste water flows and excessive energy consumption. The Washington Suburban Sanitary Commission, Maryland, implemented a comprehensive conservation plan to reduce waste water flows to its overloaded sewage treatment plant. The State of California initiated a conservation plan to determine how much energy could be saved by reducing the need to heat water. It was estimated that the city of San Diego, California, could save 57,300 barrels of oil (or $860,000) per year if most of the residents conserved water.

To ensure that a conservation program will achieve its full potential and will help a water system in the way it helped the systems described above, the program must be carefully planned. Too often water conservation programs are designed without considering the full range of options, and the potential impacts of each option on the utility, the users, and the community.

The seven-step procedure for designing a local conservation plan presented in the handbook has been developed to help you design a plan that will achieve its full potential in your community. The procedure was developed primarily to deal with water supply problems, although it can be used for other problems as well, including excessive energy consumption and excessive waste water flows. If the procedure is to be used for problems other than water supply, however, certain modifications will be needed. For example, if you are interested in reducing waste water flows or energy used for heating water, you will want to focus on the conservation programs that are aimed towards reducing users' consumption. If you are interested in reducing excessive energy consumption within your utility, you will want to focus on the programs that will reduce loss and waste within the water production and delivery systems. However, before a specific area of concentration can be chosen, it is helpful to have a general knowledge of the many factors that enter into the development of a water conservation plan including the social, political, and economic impacts. These factors are interspersed throughout the seven-step procedure.

The seven steps include the following:

Step 1: Identify problem/establish conservation goal;
Step 2: Assess potential of supply management;
Step 3: Analyze cost-effectiveness and impacts of management programs;
Step 4: Identify actions to minimize adverse impacts;
Step 5: Choose management program(s)/design the specifics of each management program(s);
Step 6: Evaluate and select hardware/software;
Step 7: Summarize conservation plan.

As stated previously, this procedure can be used in part or in its entirety. However, to get an idea of all the conservation programs available, and the advantages associated with them, you should begin by reviewing the complete procedure.

Even though water supply planning is conducted at all levels of government, the water supplier has the prime responsibility for developing adequate sources, ensuring safe and potable water, and delivering water in the most cost-effective and equitable manner possible. You (if you are the water purveyor) also have the prime responsibility for water conservation planning.

As a local supplier, you are expected to answer to the various federal and state regulatory agencies, local government bodies, corporate boards, and water users who oversee and/or depend upon your operation. Your conservation planning, therefore, will have to reflect your local legal-institutional setting. The seven-step procedure presented in this handbook is designed to accommodate individual communities with distinctive needs.

To use the procedure, you will need to gather information about the utility and the community you serve. The type of information needed includes system data, use data, and revenue and budget data.

## OVERVIEW OF THE SEVEN-STEP APPROACH

The planning approach is designed to help you to:

- Consider the full range of options;
- Evaluate the advantages and disadvantages of various options, and;
- Assess the potential impacts of each option on your utility, the users, and the community.

The <u>first step</u> is to analyze the problem and establish a conservation goal. This is also the time to begin thinking about a public participation program.

The <u>next step</u> requires an analysis of whether your goals can best be met on the supply side -- making improvements in the water supply system -- or on the demand or consumption side of the system, or a combination of both.

The third step calls upon you to analyze the cost-effectiveness and impacts of various management options.

In Step 4, you consider ways to avoid or minimize any adverse impacts evident in the supply and demand management programs you are reviewing.

In Step 5, you choose and design the specific supply and/or demand management programs you will use.

For demand management programs, this includes designing new water rates, water-use restrictions, or educational materials.

In Step 6, you choose the actual hardware or software that physically reduces water use.

In the final step, you combine the results of your various analyses and decisions in the form of an implementable water conservation plan.

Step (1), Establish a Conservation Goal, is the key to the planning procedure because all decisions are based on whether the various alternatives under consideration can meet the goal.

The goal is defined by 3 factors or needs:

1. Peak and/or average use has to be reduced;
2. High or low percentage reduction in use is needed, and;
3. Short- or long-term span.

Peak use refers to the summer average daily use usually caused by outside uses.

Average use refers to the annual average use.

Express percentage reductions by number, with a range of 1-10% as low and 10-20% as high.

A short-term time span is approximately one year or less, while long-term is a year or more.

Step (2), Assess Potential of Supply Management. At this point, discussion of Steps 2-6 for supply management will be presented first, and then Steps 2-6 for demand management.

This step is conceptually straightforward. Yet, it requires considerable analysis and planning.

The goal of supply management is to improve efficiency within the production and delivery system. It is often the best long-term option because conservation goals are met without depending on water uses. While this is standard operating procedure for a well-run utility, sometimes a water supply problem can be solved through better management alone.

Supply management is best used for long-term, low percentage reduction goals. It may be useful for short-term goals if your system has not been adequately maintained over the years. It may also be useful for peak-use reduction if the problem is caused by inadequate storage capacity or inadequate pipe capacity.

The advantages of supply management are the following:

- program under your direct control;
- lost revenues could be recovered; and
- slack maintained in system.

The disadvantages include the following:

- programs could be expensive;
- programs could be labor intensive; and
- long lead time may be necessary.

Your analysis may require much time or little time, depending upon past studies and experience. In general, supply management is preferable to demand management because it yields long-term improvements in the system. Consider it first. Costs are high, though the "crisis mentality" created during a period of water shortages may help to build a potential constituency in favor of long-term changes, even if they prove costly.

<u>Step (3), Analyze the Cost-Effectiveness and the Impacts of Various Supply Management Programs</u>

For supply management, there are five programs: metering; leak detection and repair; pressure reduction; watershed management; and evaporation suppression.

Metering

While metering itself does not reduce water consumption, it provides an accurate accounting of all water uses throughout the system, thus being useful for leak detection and repair programs, pricing programs, and other conservation programs.

Leak Detection and Repair (LD&R)

LD&R can substantially reduce water waste within the system. LD&R also includes unaccounted for water analysis. Categories of unaccounted-for water include: abandoned services, inaccurately metered water, illegal hook-ups, defective hydrants, etc.

There are two basic methods for conducting surveys. If your system is losing water primarily through leaks, a system scan would be most effective; if your system is losing water through illegal hook-ups, meter under-registration (i.e., unaccounted-for water), a water audit would be most effective.

Leak detection and repair programs are almost always cost-effective. This strategy is best for long-term, low percentage reduction goals unless the system is not well maintained. If so, leak detection and repair could achieve a higher percentage reduction goal.

Pressure Reduction

Consider pressure reduction if there is a a significant number of areas where pressure is high (80 lb/sq in. or greater).

Pressure-reducing valves installed in street mains or individual services can reduce waste simply by reducing the amount of water passing through the system. Such an approach is used for long-term, low percentage reduction, average-use goals.

Watershed Management

Watershed management is used primarily to protect or increase water flows to the supply and to protect ground water sources. Techniques include: (1) forestry management (thinning forests in the watershed); (2) zoning by-laws to prohibit inappropriate land uses within the recharge area; (3) purchasing surrounding watershed land to maintain it under your control; and (4) sub-division regulations which allow development to proceed in a manner which does not harm the watershed. This strategy is best used for long-term, low percentage reduction, average-use goals.

Evaporation Suppression (reservoir covers)

Only useful when evaporation is responsible for significant water loss (greater than 10%). Rarely cost-effective in New England.

The impact analysis for supply management entails a review and analysis of the financial and economic, technical and environmental, and legal and institutional impacts of each of the supply management programs.

Step (4), Identify Actions to Modify Adverse Impacts

In Step 3 you identified the impacts of various supply management approaches. In Step 4 you identify actions which can minimize the adverse impacts associated with each program, and then choose the best program.

The handbook lists potential actions you could take to minimize adverse impacts.

Step (5), Choose Supply Management Programs

Now that you have analyzed the cost-effectiveness, impacts, and modifications to the impacts of supply management programs, you'll be able to select programs most effective for your community. Review each supply management program again to be sure that it has the potential to achieve the conservation goal you have established.

Step (6), Choose Specific Hardware and Software

For supply management the specific hardware/software will depend on your individual system and preference. For example, for leak detection and repair, you will have to choose a system survey method. Steps 2-6 for demand management are described below.

Step (2), Assess Potential of Demand Management

If supply management is not adequate to achieve your conservation goal set in Step 1, then consider demand management. Demand or consumption management requires water users to modify their behavior and reduce consumption in a home or business setting. It has potential to achieve any conservation goal.

The advantages include the following:

- versatility;
- low expense (potential);
- may not be labor intensive; and
- implemented quickly.

The disadvantages include the following:

- revenues may drop;
- results dependent on user's cooperation;
- requires political support; and
- possible opposition from users.

Step (3), Analyze the Cost-Effectiveness and the Impacts of Various Demand Management Programs

In the demand (consumption) management programs, you have a choice of three tools to encourage users to reduce their use: pricing; regulation; and education.

In many cases, you may mix all three tools.

Pricing - If a pricing program is carefully designed, it can generate excess revenues while it encourages use reductions. Therefore, it should be considered as part of many conservation programs. Pricing is best used for long-term, low percentage reduction goals.

The costs of a pricing program are mostly one-time costs. These costs will be for a rate survey, or cost of service study, costs to institute a new billing system, and if your utility is regulated, costs for an attorney or someone to present your new rate before the public utilities commission.

The major disadvantage to pricing is user, local government, and public utility commission opposition.

Regulation - This program can be used to achieve any conservation goal. It is most effective for short-term goals and long-term, low percentage reduction goals. Regulation can be quickly implemented and can achieve immediate results.

Costs to implement regulation are limited to costs of enforcement. If you do not have the authority and/or manpower for enforcement, you may have to secure the assistance of the police department or the local government.

The major disadvantages to using regulation are that revenues will decrease as consumption drops and some users may oppose limitations on how they can use their water.

Education - Education programs can help any conservation program because it is so well received and can reduce user opposition to other programs. It is effective for any goal, except long-term, high percentage reduction goals.

The major disadvantages to education are that revenues may decrease as consumption decreases, and results are less reliable than other programs because of its voluntary nature.

The types of impacts for demand management programs include the following:

- what a change in revenues, up or down, will mean to the utility or company;
- how a change in water rates might affect high-volume users, including potential impact on employment;
- determining the effect of reduced water use, such as reduced wastewater treatment costs, postponing new source development, potential damage to landscaping, and increasing the potential for adding new connections;
- public reaction to the conservation program, including the equity of the program;

- costs to implement the program; and
- the limit established by law, regulation, or ordinance.

A series of tables in the handbook list most of the impacts of demand management programs for different utility types (investor owned or publicly owned). They are to be used as a guide to help you determine what is most important for your more thorough consideration.

Step (4), Identify Actions to Modify Adverse Impacts

In Step 3 you identified the impacts of various demand management approaches. In Step 4 you identify actions which can minimize the adverse impacts associated with each program, and then choose the best program.

A series of tables in the handbook list potential actions you could take to minimize these adverse impacts.

Step (5), Choose and Design Specific Management Programs

After you've completed the analyses in Steps 3 and 4, choose the programs that are the most cost-effective and have most beneficial impacts. Step 5 is the place to begin detailing the specific elements of a conservation program. On the demand side, this includes the following:

Pricing: establishing a new water rate;
Regulation: choosing water use restrictions; and
Education: choosing education tools/devices/campaign materials.

Pricing: design a new water rate. A new water rate includes both price level and structure. Price level is price per unit of water. Price structures vary price level according to quantity used or time of use. Price level is most important because only when the price level is high enough -- regardless of structure -- will users consider how they are using water and conserve.

There are six basic steps for designing a new water rate.

A. Determine the goal for percent reduction -- 5%, 10%, etc.
B. Estimate the decrease in water use by consumers in response to price increases. This change is termed "price elasticity of demand." There are several guidelines to keep in mind when trying to gauge consumer response to price increases.
New price level: the lower the price, the less the response.
Average user income: the higher the income, the less the response.
Average number of people per household: the larger the number, the less the response.

Average rainfall and temperature: the more temperate the climate, the less the response.

C. Determine the percent change of price necessary to achieve the goal.
D. Calculate the new total revenue, as a result of the new price.
E. Compare the new total revenues to your annual costs (remember, variable costs will drop as water use drops).
F. Select a price structure.

Twenty common price structures are listed in the handbook. They are grouped by their applicability to meeting peak or average conservation goals.

When using pricing there are several guidelines to keep in mind.

- Responses to a price hike generally diminish as users get used to paying more.
- Pricing is most effective in reducing peak use among residential users and average use among large-volume users.
- In New England, the price of water has been traditionally low and responsiveness to price hikes is generally low, especially among residential users.

Regulation

Choose a regulation program from the following methods: restricting a specific water use; restricting the time/season during which a specific use is allowed; requiring permits for some water uses; restricting the quantity of water which can be used; and requiring appliances and equipment which use a smaller amount of water.

Various regulations have a different potential for meeting conservation goals. A chart in the handbook summarizes this potential.

Keep in mind that some regulations may be prohibited in your community. In other cases, regulations may require enforcement you are not able to provide, i.e., limiting a specific use. Finally, some regulations, such as rationing or plumbing code changes, may not be effective because of user or political opposition.

Practical experience has yielded several recommendations.

- Reserve stringent regulations such as rationing and use bans, to high percentage reduction, short-term goals, and to times of extreme emergency, such as extended drought.
- Use less stringent regulations, such as plumbing code changes and limits on specific uses for long-term, low percentage goals.

- Most regulations that limit outdoor uses are easy to implement and can achieve water use reductions immediately.
- All regulations require some level of enforcement -- make sure enforcement staff is available.

Education

Education can stand on its own, or augment price and regulation programs. The number of education tools are many -- it's important to match the right educational tools and techniques to your community setting. Each available tool is bound by two factors: type of community and budget resources.

A chart in the handbook presents just a partial list of educational methods used to encourage water-use reduction. Some are better suited to small communities than large; some are more expensive than others.

When developing education programs, work with communications professsionals. The assistance of a local newspaper editor or public relations practitioner can help you design a better, more focused program.

Past experience has provided some education-related recommendations.

- Keep the conservation message short and simple. Provide detailed data on how to reduce consumption after getting people's attention.
- Mix the media. Use visuals to strengthen claims or message.
- Reach as many consumers as possible with as many techniques as possible, budget allowing.
- Repeat the conservation message as often as possible. Users need constant reminders of the need to conserve.

Step (6), Choose Specific Hardware and Software

In this step, you select hardware/software that will reduce water use in your community.

There are 3 categories of hardware/software for demand management programs:

- water-saving fixtures;
- reuse/recycle systems; and
- user habit changes.

Again, you need to review each technique to determine which is most applicable to your community.

Water-Saving Fixtures

Reduce water use by modifying the design of a conventional plumbing system.

When suggesting water-saving fixtures, costs should be approximately equal to conventional fixtures; fixtures should not require excessive maintenance; fixtures should reduce water use significantly; and fixtures should gain easy acceptance by consumers.

There are many types of water-saving fixtures. Of more than 60 different types, the 20 most cost-effective fixtures are detailed in a chart in the handbook.

Reuse/Recycle Systems

Reduce water use by using the same water more than once. Best for long-term, high percentage goal.

Reuse: Using the same water for more than one function with little or no treatment prior to discharge.

Recycle: Using the same water repeatedly, usually with some treatment.

They are generally very effective and very expensive.

A chart in the handbook details the eight situations in which reuse/recycle systems are used most.

User Habit Changes

User habit changes are designed to reduce water use by changing the user's behavior pattern. Best for long-term, low percentage goals and short-term, high percentage goals.

There are two basic behavior pattern changes: use less water to perform the same function; and perform the function less often.

Developing a long-term or short-term education program is the key to affecting user habit changes.

Users need information before they change their routine behavior. Users need constant reminders and reinforcement if user habit changes are to continue.

A chart in the handbook matches some habit changes with conservation goals.

Step (7), Summarize Conservation Plan

To summarize your conservation plan, draw together the results of the prior steps.

GOAL
SUPPLY MANAGEMENT: HARDWARE AND SOFTWARE
DEMAND MANAGEMENT: HARDWARE AND SOFTWARE

Publicly Supplied Potable
water conservation
'81 A NATIONAL CONFERENCE

# Benefits and Impacts/Economics

# COST-EFFECTIVE RESIDENTIAL WATER CONSERVATION DECISIONS

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## ABSTRACT

An economic decision rule is presented for utilities to use in recommending water-saving devices that are cost effective for homeowners. The rule takes into account the major costs (acquisition, installation, operation, maintenance, repair, and replacement) and benefits (dollar savings on water, sewer, and energy bills) associated with the installation of water-saving devices. One of these benefits, the dollar value of water savings, depends critically on water prices. An analysis of the water rate schedules of a national sample of 90 utilities indicates that, because of the widespread use of large fixed and minimum charges, homeowners' actual benefits from saving a unit of water are significantly lower than the average price paid for water. Thus, estimated water bill reductions will frequently be overstated if calculated on the basis of average price. The decision rule allows one to select the economically optimal device from a set of mutually exclusive alternatives, or the economically optimal combination of compatible devices for all the plumbing services in the house. The paper concludes by describing an interactive computer program that performs all the calculations needed to implement the decision rule.

## INTRODUCTION

A consistent method is needed for choosing among the wide variety of residential water-saving features and devices currently available. The first section of this paper describes and illustrates a selection method that maximizes the net economic benefit for homeowners. The method considers the costs likely to be incurred over the useful lives of devices: acquisition, installation, operation, maintenance, repair, and replacement. The three major benefit categories are also considered: savings from reduced water consumption, wastewater treatment, and energy used for water heating. The dollar value of the water savings depends critically on local water prices. Thus, the second section presents a detailed analysis of water rate schedules. The paper concludes by discussing a computer program for performing the calculations needed to implement the selection method.

## SELECTION METHOD

This section presents a method for selecting water-saving devices in two situations: (1) when the devices being evaluated all serve the same plumbing function so that only one can be utilized with regard to a given fixture (mutually exclusive devices); and (2) when each device serves a different function so that all of them could be used simultaneously by one household (compatible devices).

To illustrate the concept of mutually exclusive water-saving devices, consider three alternative shower modifications: (1) replacement with a new low-flow showerhead (3 gpm); (2) replacement with a new medium-flow showerhead (4 gpm); or (3) adding a flow restrictor upstream of the existing showerhead. These alternatives are mutually exclusive in that only one of them could be applied to any particular shower. The homeowner needs to know whether any of the three alternative modifications represents an economic improvement over the existing shower and, if so, which one represents the greatest economic improvement. Both these decisions can be made by calculating the Net Present Value (NPV) for each alternative water-saving device:

$$NPV = [W + En] - [Ac + I + M + R], \qquad [1]$$

where NPV = Present value of the net benefits expected to result from installing a particular alternative device;

W = Present value of water and sewer savings, calculated by evaluating the annual amount of water expected to be saved at the price(s) for each unit of water saved (including per unit sewer charges and taxes) and discounting to the present;

En = Present value of energy savings from reduced hot water usage, calculated by evaluating the annual amount of energy expected to be saved at the price(s) for each energy unit saved (including taxes) and discounting to the present;

Ac = Acquisition cost of the device being added to an existing fixture or the differential acquisition cost of a newly installed water-saving fixture compared with a standard model;

I = Installation cost of the add-on device or the differential installation cost of a newly installed water-saving fixture compared with a standard model;

M = Present value of operation, maintenance, and repair costs expected to result from the add-on device or from the special feature of a newly installed fixture; and

R = Present value of the cost of replacing the add-on device or the special feature if replacement is expected during the homeowner's planning horizon.

The discounting of future values (savings or costs) to the present in equation 1 is accomplished by applying the standard discount formulas in table 1. For example, consider a low-flow showerhead that is expected to need replacement at the end of year 15. If the replacement cost at the end of year 15 is \$10 in today's prices, and the real (excluding inflation) rate of interest is 8 percent, then one would discount the future replacement cost as follows:

$$PV = F \cdot (1 + i)^{-n}$$

$$= \$10.00 \cdot (1.08)^{-15}$$

$$= \$10.00 \cdot (0.3152) = \$3.15.$$

Similarly, if the value of the annual water and sewer savings from the low-flow showerhead is expected to be \$20, the planning horizon of the homeowner is 20 years, and the real interest rate is 8 percent, then the discounting would be carried out as follows:

Table 1. Formulas for Discounting Future Values to the Present

| Value Being Discounted | Formula for Present Value (PV) |
|---|---|
| Single Future Value (F) | $PV = F \cdot (1 + i)^{-n}$ |
| Uniform Recurring Value (A) | $PV = A \cdot \left[\frac{1 - (1 + i)^{-n}}{i}\right]$ |
| Escalating Recurring Value (E)[a] | $PV = E \cdot \left[\frac{1 + e}{i - e}\right] \cdot \left[1 - \left(\frac{1 + e}{1 + i}\right)^{n}\right]$ |

where:

F = a future value occurring once at the end of period n;
A = an annual value repeated regularly at the end of each of n periods;
E = an escalating value increasing at a constant growth rate, e, and repeated regularly at the end of each of n periods;
i = the real (excluding inflation) rate of interest per period;
n = the number of compounding periods; and
e = the real (excluding inflation) rate of growth per period of an escalating value (e.g., the price of energy).

[a]Assumes $i \neq e$. For the special case of $i = e$, $PV = E \cdot n$.

$$PV = A \cdot \left[\frac{1 - (1 + i)^{-n}}{i}\right]$$

$$= \$20.00 \cdot \left[\frac{1 - (1.08)^{-20}}{.08}\right]$$

$$= \$20.00 \cdot (9.818) = \$196.36.$$

The last formula in table 1 is employed when a recurring value, rather than remaining fixed over the planning horizon, is expected to increase at a constant rate greater than that of general inflation. This might be likely in the case of the annual dollar value of the energy savings from reduced hot water usage. Although the same number of energy units might be saved from year to year, the dollar value of those savings could grow because of escalation in the price of energy. For example, suppose the dollar value of the annual energy savings of the showerhead is \$30 at the current price of energy. If the price of energy is expected to increase at a real (i.e., above general inflation) annual rate of 5 percent, then the present value of the energy savings over the 20 year planning horizon would be calculated, discounting at 8 percent interest, as follows:

$$PV = E \cdot \left[\frac{1 + e}{i - e}\right] \cdot \left[1 - \left(\frac{1 + e}{1 + i}\right)^{n}\right]$$

$$= \$30.00 \cdot \left[\frac{1.05}{.08 - .05}\right] \cdot \left[1 - \left(\frac{1.05}{1.08}\right)^{20}\right]$$

$$= \$30.00 \cdot (15.076) = \$452.28.$$

Before applying these discounting procedures, the analyst should eliminate from further consideration those alternatives whose acquisition and installation costs exceed the homeowner's financial budget. The economic decision rule for choosing among the mutually exclusive alternatives is to select the affordable alternative with the highest positive NPV. If none of the affordable alternatives yields a positive NPV, then none should be selected and the existing fixture should not be modified.

This decision rule for selecting one (or none) among several mutually exclusive devices is illustrated in the following example. Suppose NPVs for the three alternative shower modifications were as follows: low-flow showerhead (NPV = \$600); medium-flow showerhead (NPV = \$450) and flow restrictor (NPV = \$350). In this case, the decision rule of maximizing NPV would lead one to select the low-flow showerhead as the best alternative among the three being considered. One should note that all three modifications would represent a positive economic improvement over the existing shower, but the purpose of this decision rule is to choose the <u>best</u> affordable alternative given that only <u>one</u> can be selected (i.e., they are mutually exclusive).

Many available water-saving devices are not mutually exclusive, but rather compatible in that it is technically feasible to install any combination of them in a given house. Typically, compatible devices are those which are installed or incorporated as features in different plumbing fixtures. For example, the following devices could be considered compatible with one another: low-flow showerhead, shallow trap toilet, and kitchen sink faucet flow restrictor. When evaluating compatible devices, one, all, or any combination of them can be selected. In order to achieve the greatest net economic improvement, all those compatible devices should be selected for which NPV, as calculated by equation 1, is positive, and all the others should be rejected. This combination is optimal in that it cannot be modified (by the elimination or addition of devices) to increase the homeowner's economic welfare. It is assumed that the homeowner is able to finance the acquisition and installation costs of all the cost-effective compatible devices. If investment funds are limited, a different criterion, based on the Savings-to-Investment Ratio, must be used, as discussed in (1).

## AN EXAMINATION OF WATER RATE SCHEDULES

A crucial factor in making cost-effective water conservation decisions is the dollar value of water savings, as measured by water bill reductions. The approach commonly taken for estimating bill reductions is to use the average price* paid by the homeowner to value each unit (typically 1000 gallons or 100 cubic feet) of water expected to be saved. Because current water rate schedules are complex, however, the actual bill reduction will often be quite different from that estimated by using the average price of water. This section first describes the major types of water rate schedules. Then it analyzes a national sample of schedules to compare the correct price for valuing a unit of conserved water with the average price of water.

Water differs from most commodities in that charges for its use are based on a rate schedule rather than on a single price. A single price is the charge per unit (unit rate) applicable to all units consumed. Charges in a rate schedule, on the other hand, vary with one or both of the following parameters: (1) amount of water consumed, and (2) length of the billing period.

There are five major types of rate schedules: fixed charge per period, uniform rate per unit, varying rate per unit, peak load pricing, and mixed. Under a fixed charge schedule, any particular customer is charged the same dollar amount per period regardless of the quantity of water consumed. Some form of fixed charge must be used for customers without water meters. In a uniform rate schedule, the unit rate is the same for all units of water consumed. This is

*The average price (in $/1000 gallons) paid by a homeowner for water consumed during any period is given by: (1000 X total water bill)/ gallons consumed.

equivalent to a single price. Uniform rates are usually combined with other charges in a mixed schedule, as discussed below.

A varying rate schedule can either be a declining or an increasing block schedule. Under a declining block schedule, a certain rate per unit is charged for all units consumed up to a specified quantity. Such a bounded consumption range is known as a "block". For water consumed in the next block, a lower unit rate is charged. In this manner unit rates decrease for succeeding consumption blocks. The increasing block schedule is the reverse of the declining block type in that unit rates increase with each succeeding block.

A peak load pricing schedule uses either a seasonal rate or a surcharge. Under a seasonal rate schedule, higher unit rates are imposed in the summer, when demand increases due to lawn sprinkling. The unit rates can either be uniform or varying. Under a surcharge schedule, uniform or varying rates are charged for a base amount of water. Higher rates are charged for water in excess of the base. These higher rates can be applied either during the summer sprinkling season or throughout the year.

Most rate schedules in effect today are mixed in the sense of combining unit rates with a flat charge. The flat charge can either be a minimum charge or a fixed charge. A minimum charge includes a certain allotment of water, beyond which unit rates apply. In this paper, a minimum charge allotment is treated as a block. A fixed charge in a mixed schedule does not include a water allotment, so that the unit rates are imposed beginning with the first gallon of water consumed. Flat charges are commonly used to recover those costs that are independent of the amount of water consumed, such as billing and administration costs.

If one assumes that households are more inclined to save water at higher water prices, then the theoretical conservation incentive of each rate schedule type can be indicated. Fixed charges provide no incentive to conserve because the quantity of water used is not related to the price of water. The uniform rate schedule fosters water conservation in a manner that does not vary with increased consumption. The declining block schedule provides a conservation incentive that diminishes as consumption increases. On the other hand, the increasing block schedule and peak load pricing schedules have the most potential for inducing water conservation by creating an incentive that increases with greater water use. This type of incentive is likely to be most effective in reducing the lawn sprinkling component of water use. For mixed schedules, the incentive to conserve depends on the type of unit rate in the schedule, except when consumption lies within a minimum charge block. In this case, a mixed schedule provides no incentive to conserve since the homeowner must still pay the full minimum charge.

Table 2. Relative Frequency of Water Rate Schedule Types for a Sample of 90 Schedules[a]

| Type of Rate Schedule | Relative Frequency (%) |
|---|---|
| Uniform Rate | 2.2 |
| Fixed Charge/Uniform Rate | 6.7 |
| Fixed Charge/Declining Block | 4.4 |
| Fixed Charge/Increasing Block | 3.3 |
| Fixed Charge/Seasonal Rate | 1.1 |
| Minimum Charge/Uniform Rate | 25.6 |
| Minimum Charge/Declining Block | 55.6 |
| Minimum Charge/Increasing Block | 1.1 |
| Total | 100.0 |

[a]Schedule types were determined based on charges for the first 50,000 gallons of consumption per month. This limit represents "maximum" residential water consumption per month--the average monthly consumption for a household of six in Alaska, the State with the highest per capita consumption level.

A national sample of 90 water rate schedules will now be analyzed in terms of the mean values for key schedule variables. The sample was drawn from a survey by the American Water Works Association (AWWA) of its entire utility membership. Over 700 rate schedules from 1978 and early 1979 were submitted. The sample of 90 schedules resulted from an attempt to select at random two schedules for each State. The AWWA survey yielded fewer than two complete schedules for some States.

Table 2 presents the relative frequency of schedule types for the sample of 90 water rate schedules. Note that over half the utilities use the minimum charge/declining block type of schedule and another 25 percent the minimum charge/uniform rate type. Furthermore, less than 6 percent of the schedules can provide a conservation incentive that increases with more water use (fixed/increasing, fixed/seasonal, and minimum/increasing). This suggests that the redesign of rate schedules could lead to increased water conservation.

To assure comparability of schedules within the sample, a number of guidelines were followed.* For example, since water rate schedules do not always account for sewer service and fire protection, these charges were always excluded.

Two measures were used to determine that portion of each rate schedule relevant to this analysis: typical per capita residential

*For the complete set of guidelines, see (1).

water consumption, and the range of household sizes that accounts for most single-family dwelling units. First, a national average value, 54.6 gallons per capita per day (gpcd), was used for typical per capita residential water consumption (2). Second, rate schedules were analyzed using households of from two to six people, accounting for 92 percent of all people in families living together in a household (3).

A computer program generated the mean values of four key rate schedule variables for the sample. These values are presented in table 3 by household size. The total charges on a monthly water bill range between \$5.02 for a household of two and \$9.98 for a household of six (column 3). Assuming these average values in column 3 approximate a typical schedule, one can establish the order of magnitude of savings that might be achieved. For example, a 25 percent decrease in consumption for a household of four from 6,552 to 4,914 gallons/month (column 2) would save \$1.25 (\$7.42-\$6.17, column 3) on the monthly water bill.

The correct price for valuing conserved water is marginal price. The marginal price of water is the reduction in the total water bill resulting from saving a unit of water. Similarly, it is the increase in the total water bill resulting from the last unit of water consumed. The unit rate associated with each non-minimum charge block in a rate schedule is the marginal price for each unit consumed within that block. A minimum charge block implies a marginal price of zero for each unit consumed within that block.

The results in column 4 indicate that the mean marginal price for the block of water in which consumption for a household of four lies is \$0.78/1000 gallons. In contrast, the mean average price of water (column 5) is \$1.13/1000 gallons for a household of four. This striking difference between marginal price and average price is also seen in column 6, which presents marginal price as a percent of average price for each household size. For a household of four, marginal price represents only 69 percent of average price.

The primary reason for such a sizeable difference between marginal price and average price is the widespread use of large flat charges. As observed in table 2, over 97 percent of the rate schedules in the sample have these fixed or minimum charges. Moreover, these charges which are unrelated to consumption are a large percentage of the total water bill. For a household of four, for example, flat charges comprise on average 55 percent of the total water bill. These charges increase average price and either leave marginal price unaffected or reduce it to zero. The latter occurs whenever consumption falls within a minimum charge block. This is the case for a household of two in over one-third of the rate schedules in the sample.

The marked difference between marginal price and average price may lead homeowners to overinvest in water conservation. When calculating NPV for a water-saving device, the present value of water

Table 3. Mean Values of Key Rate Schedule Variables for a Sample of 90 Schedules, by Household Size

| Household Size (1) | Assumed Water Consumption[a] (gal/month) (2)=54.6x30x(1) | Total Monthly Water Bill ($) (3) | Marginal Price of Water ($/1000 gal) (4) | Average Price of Water ($/1000 gal) (5)=(3)/(2)x1000 | Marginal Price as Percent of Average Price (%) (6)=(4)/(5)x100 |
|---|---|---|---|---|---|
| 2 | 3276 | 5.02 | 0.62 | 1.53 | 40.4 |
| 3 | 4914 | 6.17 | 0.74 | 1.26 | 58.8 |
| 4 | 6552 | 7.42 | 0.78 | 1.13 | 69.0 |
| 5 | 8190 | 8.70 | 0.78 | 1.06 | 73.7 |
| 6 | 9828 | 9.98 | 0.78 | 1.02 | 76.5 |

[a] Based on 30 days/month and on 54.6 gpcd.

and sewer savings (W in equation 1) will frequently be overstated if based on average price. The fixed or minimum charge, which tends to raise average price, must be paid whether or not water is conserved. The accurate indicator of a homeowner's benefit from saving a unit of water is marginal price. Therefore, in the computer program discussed in the next section, marginal price is used for calculating NPV.

## COMPUTER PROGRAM

A computer program, SAVINGS, has been developed to calculate NPV for eleven water-saving devices applied to water closets, showers, kitchen faucets, dishwashers, and clothes washers. One must input only four data items to use SAVINGS: (1) local water and sewer rate schedule(s); (2) State of residence; (3) device to be analyzed; and (4) fuel used for heating water. The program contains default values for all other variables, including acquisition, installation, and maintenance costs, and usage characteristics of the device. However, the user may override these default values.

SAVINGS can be used with all types of water rate schedules with the exception of the surcharge schedule type. A few rate schedules must be modified for use by SAVINGS. The analysis assumes monthly billing periods, so rate schedules using different billing periods must be converted to an equivalent monthly basis. Likewise, the analysis assumes constant rates year round, so seasonal rates must be averaged over the year.

SAVINGS calculates monthly water and energy savings (if applicable), the corresponding monthly and life-cycle cost savings, and NPV. These results are illustrated in table 4 for a shallow trap toilet, using the current water and sewer rate schedules for Denver, Colorado. The Denver water rate schedule is based on bi-monthly consumption, so it was converted to a monthly basis. The sewer rate schedule for

Table 4. Evaluation of Shallow Trap Toilet in Denver, Colorado, by Household Size

| | Household Size | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 |
| Monthly Water Savings (gal) | 750.00 | 1125.00 | 1500.00 | 1875.00 | 2250.00 |
| Monthly Water & Sewer Cost Savings ($) | 1.22 | 1.83 | 2.44 | 3.06 | 3.67 |
| Life-Cycle Water & Sewer Cost Savings ($) | 170.96 | 256.44 | 341.92 | 427.40 | 512.87 |
| Net Present Value ($) | 149.30 | 234.78 | 320.26 | 405.74 | 491.22 |

Denver, $0.95 per 1000 gallons of water used, was added to the water rate schedule. The resulting schedule includes a fixed charge of $2.35, $1.63 per 1000 gallons for the first 15,000 gallons of water used, and $1.53 per 1000 gallons for the next 35,000 gallons used. Table 4 shows that NPV for a shallow trap toilet in Denver would range from $149.30 to $491.22 for household sizes of two and six, respectively. Although these results assume the house has only one water closet, SAVINGS can accommodate alternative cases.

In its present form, SAVINGS has several limitations. One limitation is that the analysis is restricted to the two cases of add-on devices and new applications. Add-on devices modify existing fixtures. The total costs associated with the add-ons are included in the calculation of NPV. New applications are fixtures installed as part of new construction, renovation, remodeling, or repair activities. Only the differential costs of new applications (i.e., the costs attributable solely to the water-saving features of the fixture) are included in the NPV calculation. SAVINGS does not treat the case of a retrofit application, in which a water-saving fixture replaces a properly functioning fixture.

Another limitation is that SAVINGS cannot be used to select the best combination of compatible devices. It treats each type of device independently, so that all calculations of savings are done at the margin. In other words, it treats the device being analyzed as the only type of water-saving device in the house. Rate schedules often have different unit rates for different blocks of consumption. The water savings of one device could change the homeowner's consumption block, and thereby change the amount of dollar savings attributable to the next device to be installed. When devices are treated in combination, the likelihood of changing blocks is increased. Because of this, the monetary savings from devices installed in combination do not necessarily equal the sum of the savings from the devices treated individually.

SAVINGS is also limited in that the device is assumed to be installed everywhere it is applicable. In reality, a device could be installed in only some of the places where it is applicable. With further research and program development, SAVINGS could be modified to overcome all the above limitations.

## SUMMARY

The method presented in this paper for selecting water-saving devices can encourage conservation in two ways. First, the evaluation results can be distributed by utilities to homeowners to provide them with the information they need to select cost-effective water conservation devices. Secondly, a utility can compare the results for a variety of rate schedules to determine what impact alternative schedules have on the cost effectiveness of water-saving devices. The utility could then redesign its schedule to foster voluntary installation of conservation devices.

When calculating NPV, it is important that the marginal price of water, rather than its average price, be used to value conserved water. Indeed, the foregoing analysis of a national sample of water rate schedules indicates that homeowners' actual benefits from saving a unit of water (as measured by its marginal price) are considerably lower than the average price paid for water. Thus, NPV will frequently be overstated if based on average price.

A similar study could be conducted for sewer and energy rates. Because wastewater treatment and water heating can be reduced when water is saved, a study of sewer and energy rate schedules would contribute to more rational water conservation decisions.

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# A WATER SUPPLY SIMULATION MODEL: ANALYZING FOR THE IMPLICATIONS OF CONSERVATION

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## ABSTRACT

Water conservation, as it relates to the operations of water supply systems, is not simply a problem of reducing user demand. Financing structures for water utilities are traditionally such that a reduction in demand may necessitate an increase in rates charged to the consumer, to avoid shortfalls in utility income for debt service and fixed operating expenses. In addition, a number of "beneficiaries" of the water supply system, such as those who enjoy fire protection, or those whose land is more attractive for development due to the availability of water, but who are not major consumptive users of water, tend not to bear the potential increased unit costs associated with user demand reduction.

The problem can be considered as one of spatial economics - water system customers of certain classes, located in portions of the service area, subsidize other beneficiaries of the system in other classes and areas. The impact of demand reduction, coupled with the existing financial and revenue structure, can be expected to exacerbate the existing subsidizations of water system beneficiaries. The Drinking Water Research Division of USEPA has developed a systematic approach, organized as a set of computer programs, to assist analysts in examining problems of spatial economics and physical behavior of water distribution systems. The approach, known as the Water Supply Simulation Model (WSSM), consists of a data base describing the physical, economic, and spatial characteristics of the distribution system and program modules to: create and maintain the data base; display it graphically; perform hydraulic network, time of travel, and other physical analyses; and to perform economic allocations to develop spatial cost of service. The system is general-purpose in nature, and can easily be modified to suit the needs of a specific situation. Through combination of concepts of spatial analysis, spatial economics, data base management, and analytical mathematical modeling, the WSSM provides a powerful tool for

examining the consequence of alternative policies related to water supply utilities. The structure of the WSSM, and sample applications, are described.

## INTRODUCTION

Issues related to conservation have become of increasing importance to the water supply industry over the last several years. A drought in California, a water emergency in New Jersey, and potential water shortages in other parts of the United States have heightened interest in conservation as a means of water demand reduction.

Conservation has many facets, ranging from hardware considerations such as design and installation of mechanical flow regulating devices, to broader economic issues related to conservation-oriented rate structures. Most of the early focus on conservation was on the selection of the best fixtures, fittings, and devices to be installed in households and businesses.[1] More recently attempts have been made to understand the implications of water conservation for utility financing and pricing activities.

In an attempt to explore the latter issue the Drinking Water Research Division has developed a Water Supply Simulation Model that will assist in the physical and economic analysis of water supply distribution systems. The WSSM incorporates techniques from spatial data management, data base management, mathematical modeling, and computer graphics.[2] The spatial framework within which the WSSM operates can provide a number of interesting insights into issues of equity and subsidy between users of different classes and locations within a utility service area. It provides a mechanism for the formulation and testing of "cost-of-service" pricing structures, in which the rate charged to a given user is commensurate with the cost of serving that user. The basic concepts and overall structure of the WSSM, together with implications for water conservation planning, are described below.

## MODEL DEVELOPMENT

Water supply systems are generally composed of (1) acquisition facilities, (2) treatment facilities, where needed, and (3) delivery systems.[3] Delivery can be further subdivided into transmission and distribution. Acquisition involves either tapping a source of water that is adequate in quantity to satisfy present and reasonable future demands on a continuous basis, or converting an intermittent source into a continuous supply by storing surplus water for use during periods of low flows. If the water is not of satisfactory quality at the point of acquisition, treatment plants purify it; that is, polluted water is disinfected, esthetically unattractive or unpalatable water is treated to make it attractive and palatable, water containing iron or manganese is subjected to deferrization or demanganization, corrosive water is stabilized chemically, and excessively hard water is softened. The delivery system, which constitutes the water transportation system and includes transmission and distribution components, conveys water to the consumers. Constructing and operating an urban water works system involves large investments in both operating and capital funds.

Water supply systems are often public utilities as well. These systems can be thought of as spatial service or commodity networks as will be discussed in the following section.

## Spatial Framework

Public utilities can be divided into those providing transportation services and those which provide services through physical connection between the plant of the supplier and the premises of consumers. In the first group, one might include metropolitan transit authorities and solid waste management; and in the second, electricity, cable television, gas, sanitary sewers, and telephone services.[4]

All of these utilities can be characterized as networks overlaid upon a spatial distribution of supply and demand. Most models of public utilities incorporate physical modeling of the network itself, or economic modeling of the system as a whole. Socially, politically, and economically, however, the proper functioning of a utility system is determined by the manner in which it satisfies local demand, as well as the "global" economies of the situation.

If we consider population and industry to be "spatial" parameters, described by type, intensity, and location, it is clear that there is a "feedback" relationship between these parameters and the utility networks which service them. That is, the spatial parameters describe and create the "demand" for utility services, but at the same time the extension of a particular network into an area where there is no demand can encourage establishment of population or industry. Such a pattern is common in the case of new sewer construction, which opens new land to development, creating the demand for additional utility services.

As noted above, the joint analysis of spatial and network data is seldom undertaken, but such an approach provides a powerful tool for data management, data analysis, research, and policy information. This paper describes the development of an analytical model representing the cost of distributing water supply services in a single urban area. The model explicitly includes the relationship of transmission costs to the problem of serving spatially distributed demand.

Water supply systems furnish a service that is often without competition. The local water utility is ordinarily a pure monopoly except to the extent that industrial customers of water may furnish their own supplies.

As mentioned earlier, it is possible to separate the water supply system into two components: (1) the treatment plant, and (2) the delivery (transmission and distribution) systems.[5] Each of these components has a different cost function. The unit costs associated with treatment facilities are usually assumed to decrease as the quality of service provided increases. However, the delivery system is more directly affected by the characteristics of the area being served. The cost trade-offs between the two components will determine the least-cost service area. As pointed out by Dajani and Gemmell, "Economies of scale may be offset by diseconomies of dispersion, agglomeration, or spatial arrangement and pattern."[6]

By accumulating the costs to provide water to a particular area (which will vary depending upon a variety of factors), the "true cost" (as opposed to the rate charged) can be calculated. It is assumed that, when pricing of a resource more closely approximates the time marginal cost of that resource, it more closely approximates the true marginal cost of that resource, and more efficient use (i.e., conservation) will result.

It is in this context that the Water Supply Simulation Model can be used to analyze the implications of conservation, by developing spatial distributions of cost of service, and testing alternative revenue structures.

STRUCTURE OF WSSM

The WSSM is organized into a data base and program and display modules. The data base consists of permanent data files describing a water supply network. Two inter-related files are used: the Node File and the Link File. The water supply network is characterized as a set of connected elements, each element being either a node or a link. Thus, demands and water sources (storage tanks, treatment plants, etc.) are characterized as nodal elements, while pipes are characterized as link elements. For nodal elements, information on location, elevation, and quantity of demand or supply is developed and stored in the data base. For link elements, size, length, age, coordinates of the end points, type, and other pertinent variables (including the connectivity to the nodes) are developed and stored. In addition, the Node and Link files can handle user-specified information that may be of interest for a given simulation analysis, such as number of pipe breaks or surrounding land use.

Program modules operate upon information in the data base, extracting needed information, performing analyses, and inserting calculated values into the data base, if desired. A hydraulic analysis module determines pressures and flows throughout the system (under steady-state conditions), given the above-noted information as to demand, system layout and connectivity, pipe size, etc. A general-purpose module solves a variety of problems that can be formulated as simultaneous linear equations derived from the network, including time of travel, concentration of constituents at nodes, and linear cost allocation to demands. Additional program modules allow for direct manipulation (insertion and modification) of data in the Link and Node files, and original creation and error-checking of these data files.

Display modules provide graphical or tabular display of information maintained within the data base. Graphical display consists of a computer generated map of the network, with a variety of options, including numerical annotation of nodes or links (e.g., displaying pressures, velocities, or other information maintained in the data base), selection of links to be displayed based on specific criteria (e.g., show all pipes in which velocity is less than some minimum value), and display of specific portions of the entire area. Plots can be generated at any scale desired. A general-purpose report program allows for tabular display of link or node-oriented data under user control, and other display programs allow for the display of information about individual nodes or links, as specified by the user.

The WSSM is programmed entirely in FORTRAN, and every attempt has been made to allow for programs that are transferable among different computers. The WSSM incorporates the WATSIM hydraulic network analysis program, a public-domain hydraulic simulation technique originally developed for the Office of Water Research and Technology.[7] While the overall WSSM can be implemented on medium-to-large size computers supporting FORTRAN and direct access storage techniques, the requirements of hydraulic network analysis dictate that large network simulations be restricted to large computers. Reports describing the WSSM, including documentation and program listings, are currently in the process of development.

As noted above, the concept of "true-cost" pricing should lead to more conservation-oriented consumption practices. The WSSM can aid in the development of such pricing through allocation of cost to demand points, based on a number of alternative policies. Since pressures and flows are known at all demand points, it is also possible to test alternative revenue structures, based on factors other than consumptive use and class of user. A revenue structure that combines pressure and flow factors could be used to develop pricing that takes into account the extra costs associated with providing water to high service areas. By comparing costs (as determined from the WSSM) with revenues, the pattern of spatial and class of user subsidies can also be examined.[8]

The ability to test innovative pricing structures also allows for wider considerations relative to cost and benefit incidence for a water utility. In general, water utilities need to generate sufficient income to finance debt service and fixed operating costs, independent of the amount of water supplied. As conservation practices are put into place with rate structures based on consumption, the unit costs charged must rise to bring in the same amount of fixed dollars. Thus, the consumptive users are bearing the entire cost increase. There are beneficiaries of the water system, however, who are not major consumptive users - for example, those that benefit from the existence of fire protection, in the form of developable property and lowered insurance rates, but do not consume large quantities of water, as in a warehousing operation. While it can be argued that "non-consumptive" users do not contribute significantly to the "need" for conservation, it is also true that the capital cost of a water distribution is frequently determined by the size requirements for satisfying fire demand, not average use. Thus, some methodology, such as a rate structure that takes into account the maintenance of pressure or defined fire flow capability in an area, can be devised and simulated with the WSSM, and thus capture cost recovery from a wider class of benefited users.

The physical simulation capabilities, and data management orientation of the WSSM, also allow for its use in examining problems of unaccounted water and pipe breakage. Information can be stored on known sites of pipe breakage, and correlated with spatially oriented data such as soils, pressure changes in the system, etc., to predict areas of high pipe breakage, and to optimize the repair/replace decision. At the same time, the hydraulic simulation capability can be used to assist in the identification of zones in which large amounts of unaccounted water appear. The effect of demand reduction at nodes due to specific conservation practices can also be simulated, and reductions in utility energy costs estimated.

## SUMMARY

The WSSM is a multi-purpose, flexible tool that should be useful for analyzing conservation impacts in water utility. By combining techniques of spatial analysis, economic and physical simulation, and data base management, a wide variety of analysis options are made available. The WSSM is "open" in character; that is, the user can easily modify or add capabilities to suit the needs of a particular water utility situation.

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# COST-EFFECTIVENESS OF POTABLE WATER CONSERVATION - MULTIFACETED APPROACH

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## ABSTRACT

This study evaluates the cost-effectiveness of household water conservation measures in terms of overall economic efficiency as well as from the individual points of view of homeowners, representatives of municipal wastewater treatment utilities, and representatives of public water supply utilities. The analysis considers potential capital and operation and maintenance cost savings resulting from reduced volumes of drinking water subject to conventional, as well as conventional and granular activated carbon, treatment processes; reduced volumes of domestic wastewater subject to secondary treatment; and reduced domestic hot water use. Evaluation is carried out using a net present equivalent which considers the time value of money as well as the effects of inflation and real price escalation. Results indicate that a household water conservation program consisting of a toilet-tank dam insert and a simple shower flow restrictor is cost-effective from all points of view considered.

## INTRODUCTION AND BACKGROUND

The amount of freshwater used inside the home and provided by public water supplies accounts for about 6.3 percent of the total amount of fresh water withdrawn for use in the United States. Compared to withdrawals for other purposes, such as irrigation, which accounts for 46.9 percent of total water use, and industrial/commercial uses, which account for an additional 45.7 percent of the total, household water makes up only a minor portion of the overall water use picture (1). Therefore, conservation of household water can have but a very small effect on the quantities of water available throughout the United States.

Public supplies of household water typically represent not just a volume of water, but water which has been highly purified in water treatment plants. Inside the home, some of the water is heated to provide hot water, using energy resources. Nearly all the water delivered to individual residences eventually becomes sewage and must be disposed of on site in septic tanks, or collected in municipal sewerage systems and purified in a wastewater treatment plant before being discharged, often into the same stream from which it was originally taken. A reduction in household water use would therefore be accompanied by reductions in the total amount of water treated to achieve potable quality, in the quantity of sewage to be treated.

Household water conservation has the potential to reduce the cost of supplying drinking water in three respects. First, by reducing the total amount of water that must be treated and distributed, household water conservation could reduce the flow-dependent costs of treating and pumping. Second, in growing communities, household water conservation could obviate the need for additional treatment capacity or reduce the size of the necessary increases in capacity. Third, recent Federal regulations issued under the Safe Drinking Water Act will require some communities to reduce concentrations of trihalomethanes (THMs) in the drinking water. For those communities in which THMs will be controlled by treatment with granular activated carbon (GAC), a reduction in the amount of water demanded could permit installation of smaller, less expensive GAC systems, as well as reduce the flow-related operation and maintenance (O&M) costs for the GAC systems.

A reduction in household water use also offers potential savings to the homeowner. In areas where domestic water use is metered, using less water might decrease the monthly household water bill, although a savings in reduced water bills would be offset if decreased revenue necessitated an increase in water rates. In cities where homeowners are billed a flat monthly charge for water, regardless of the amount used, household water bills would probably be unaffected by a reduction in use. But reductions in household water bills are not the only source of savings for homeowners who conserve water. Typical homeowners spend roughly 10 times as much for energy to heat the necessary portion of the household water supply as for the entire household water supply. The energy used to heat residential hot water accounts for approximately 14.9 percent of the total energy used in the home (2), and about 3.5 percent of the total end use energy in the United States (3). A reduction in hot water use would reduce household energy consumption, and result in a reduction in household energy costs.

In most cities, the majority of household drinking water used within the home is disposed of as sewage via direct discharge into municipal sewerage systems and wastewater treatment plants. The Federal Water Pollution Control Act Amendments of 1972 and The Clean Water Act of 1977 require that publicly-owned municipal wastewater treatment plants provide best practicable wastewater treatment technology over the life of the facility. In general, this has been defined to be a requirement of secondary treatment except where receiving water quality considerations dictate more stringent levels. The two acts authorize approximately $45 billion in Federal funds to States and municipalities to pay 75 percent of the cost of constructing collector and interceptor sewers and conventional wastewater treatment plants (4). A reduction in household water use, and thereby household wastewater flow, would save part of the cost of constructing a wastewater treatment plant by enabling a smaller-sized plant to serve the same population. Any O&M costs which are dependent of the quantity of wastewater flow would also be reduced through household water conservation.

A reduction in household water use can be achieved by means of a wide variety of measures. One possibility is lifestyle changes on the part of homeowners in order to use water more sparingly. Examples include turning off the shower while lathering up, discontinuing use of the toilet as an ashtray or garbage pail, and not running the water while shaving or brushing one's teeth. Some of these steps would involve little effort by the homeowner and may be able to be encouraged through only small efforts at educating the public. Other lifestyle changes may require larger changes in water use patterns and may be perceived as constrictions in personal freedom, and therefore may be met with resistance from some segments of the public. While we recognize the large potential of lifestyle changes to reduce household water use, because of the uncertainty of predicting the degree of public acceptance and the questionable feasibility of implementing some of the more drastic steps, these water conservation measures are not directly considered in this study.

Instead, the analysis concentrates on household water conservation achieved through the use of devices designed to reduce the use of water in the home with little change in the level of effort or behavior of the homeowner after installation. Numerous such devices are currently available, ranging from a shower flow restrictor costing less than a dollar to a composting waste disposal system costing thousands of dollars.

The degree of reduction in water use from a particular water-saving device would not be the same for all homeowners. Differing conditions and water use habits among homeowners cause variations in the effectiveness of water-saving devices from one household to another. For instance, a household with very high water pressure, which causes the water flow from the shower to be quite large, would probably be able to save more water by using a shower flow restricting device than would a household with lower water pressure and thus smaller water flow from the shower. Water use habits can also play a role in determining the actual quantity of water saved by a water-saving device in a particular household. At least partly because of differences among households, there is substantial variability in estimates of the water savings from similar devices.

In this study, we have performed a preliminary estimate of the financial savings from these reductions and compared them to the estimated financial cost of household water conservation. Combining these individual components, a comprehensive evaluation of the cost-effectiveness of household water conservation as it relates to the potable water supply sector, the homeowner, and the wastewater treatment sector can be carried out.

DESCRIPTION OF THE ANALYTICAL METHOD

## Overview

The approach taken in this analysis is based on examination of the net present equivalent of the series of costs and cost savings resulting from alternative, device-focused household water conservation programs. Calculation of the net present equivalent includes an assumption of continuous compounding, as well as consideration of inflation and real-price escalation, in addition to the time value of money.

The following sections describe conceptually the mechanisms through which cost savings can accrue in each of the three sectors considered: in-home hot water heating, municipal wastewater treatment, and public drinking water treatment.

## Household Energy Cost Savings

The principal cost savings that accrue to homeowners who participate in a household water conservation program are due to the energy savings resulting when heated water is saved. In the limiting case, this is the only savings that will accrue to homeowners: when water use and sewage flow are not metered or when rate restructuring is necessary to maintain revenues in a metered area.

On an individual basis, the energy cost savings that will accrue to a household during any increment of time can be calculated in current dollars from the reduction in energy required for water heating, the present energy price, and forecasted values for the average rates of inflation and real energy price escalation over the period of analysis. The aggregated savings for the community during any increment of time are the individual household savings multiplied by the number of households that are participating in the program. The net present value, in constant dollars, of the aggregated savings during some increment of time can be calculated using the conventional continuous discounting method. And the net present equivalent, in constant dollars, of the series of aggregated cost savings can be calculated by integrating the net present value over the useful life of the conservation device.

## Wastewater Treatment Cost Savings

Household water conservation can result in cost savings in several different aspects of municipal wastewater treatment. Because nearly all the drinking water used within the home ultimately becomes wastewater, household water conservation is really tantamount to wastewater flow reduction.

As soon as a conservation program is implemented, the reduction in wastewater flow results in a corresponding reduction in the flow-dependent portion of the O&M costs for the existing wastewater treatment plant. In a growing community, the O&M cost savings for each successive increment of time increase at a geometric rate determined primarily by the population growth rate. The net present equivalent of the series of O&M cost savings can be determined by accounting for the time value of money, inflation, and real price escalation, and integrating over the appropriate period of time. The more and the earlier the wastewater flow is reduced, the greater the net present equivalent of the O&M cost savings.

If the population growth rate is such that the capacity of the existing wastewater treatment plant will be exceeded, household water conservation can produce additional cost savings. Implementation of a household water conservation program really represents a reduction in the per capita wastewater flow rate. Assuming that the reduced per capita rate is applicable to the existing population at the time of program implementation as well as to all population increases thereafter, the household water conservation program will extend the life of the existing treatment plant. Present capacity will be reached later because of the lowered per capita wastewater flow rate.

If plant expansion or construction of new facilities is required when existing capacity is reached, water conservation will affect capital cost in two ways. First, since capacity will be reached later because of the smaller flow, expansion can be postponed. The net present value of this capital outlay decreases as it is moved into the future, as determined by the discount rate. Delaying the cost of construction results in a reduction in the net present value, provided that inflation and real price escalation do not increase the construction cost at a rate rapid enough to offset the reduction due to discounting.

Second, if it is necessary to provide adequate wastewater treatment capacity for some specific time horizon, then the capacity of the expanded treatment facilities can be smaller as the result of implementing household water conservation measures. This lowered capacity requirement is also likely to reduce the construction costs that would be required in the absence of flow reduction measures. The principal factor that determines whether the net present value of the smaller-capacity facility built later will be less than the larger-capacity facility built earlier is the relationship between the inflation and real price escalation rates that affect construction costs and the discount rate that reflects the time value of money. And as long as the water conservation program is implemented before existing capacity is reached, the decrease in required additional capacity and any resulting cost savings depend only on the amount by which the flow is reduced and not on the time the reduction occurs.

In general, flow reduction measures, including household water conservation programs, are mandated under the Federal Construction Grants Program that will finance 75 percent of the construction cost of publicly-owned conventional municipal wastewater treatment works. Many States have similar programs that further reduce that portion of the construction cost borne by the municipality. In the absence of State funds, any reductions in the construction cost of municipal wastewater treatment facilities accrue 75 percent to the Federal Government and 25 percent to the municipality. Through this mechanism, the Federal Government is a party-at-interest in household water conservation programs.

The wastewater from a community that has implemented household water conservation measures will be slightly more concentrated. Water conservation measures will reduce the volume of wastewater, but not the mass of organic matter and other pollutants present. The design characteristics of the expanded facilities may need to be altered slightly to reflect the higher strength of the influent. This change may offset, to some degree, the savings realized if volumetric flow reduction were the only consideration. But some small environmental benefit may be realized. The U.S. Environmental Protection Agency (EPA) has defined requirements that must be met by most municipal secondary wastewater treatment facilities in terms of effluent concentrations (5). A water conservation program will reduce the volumetric flow rate but the effluent concentration may not increase beyond the standard set by EPA. One environmental effect of a water conservation program is a reduction in the mass of pollutants entering the receiving waters by necessarily requiring a slight increase in the efficiency of the treatment plant.

Potable Water Treatment Cost Savings

Household water conservation measures can effect cost savings in both conventional drinking water treatment (directed toward improving the microbiological quality of the water) and more recent treatment techniques to reduce contamination of the water by trace organic compounds (specifically, trihalomethanes). In the area of conventional drinking water treatment, cost savings due to household water conservation behave in much the same way as in wastewater treatment. Reducing the volume of drinking water required results in a reduction in the O&M costs of drinking water treatment that are flow-dependent. And in a growing community in which the demand for drinking water will ultimately exceed treatment capacity, household water conservation will delay the construction of additional capacity as well as reduce the amount of existing capacity needed to meet demands through some specified time horizon. The relationship between the inflation and real price escalation rates for construction costs and the discount rate chosen to represent the time value of money will determine whether the net present value of the smaller treatment plant built later will be less than that of the larger plant built earlier.

Recently promulgated regulations have established a maximum contaminant level (MCL) on the amount of trihalomethanes in potable water. The MCL of 100 μg/l for total trihalomethanes (TTHMs) initially applies to water supplies that serve at least 10,000 persons (6). Of the 2,685 public drinking water supplies in the United States that serve over 10,000 persons, it has been estimated that the MCL will require

515 to take steps to reduce THMs (6). Several measures are available to reduce THM concentrations in drinking water. These include altering the point of chlorination, switching to a disinfectant other than chlorine, and implementing GAC treatment. While specific estimates vary considerably and substantial controversy is involved, GAC treatment is expensive both in terms of capital cost and O&M costs. Estimates are that about 20 percent of the drinking water supplies that currently have TTHM concentrations far above the MCL will act to meet the MCL by instituting GAC treatment (6).

For those plants that will add GAC treatment to comply with the MCL, household water conservation will reduce the amount of water subjected to the additional process. Any GAC O&M costs that are flow-dependent would be reduced. If sufficient GAC treatment capacity is to be provided to handle the increasing water demands of a growing population through some time horizon, the necessary treatment capacity will be less due to the household conservation measures. However, since the year of construction of GAC systems depends only on the timetable set by Federal regulations, a reduction in water use will not delay construction. Therefore, no tradeoff between the discount rate and inflation and real price escalation rates for construction costs is applicable here, as it was in the analysis of wastewater treatment and conventional drinking water treatment cost savings. Household water conservation necessarily results in installation of a smaller GAC system with a lower capital cost and a lower net present value.

## Cost and Timing of Program Implementation

Because this analysis focuses on household water conservation devices that become essentially transparent to the user after installation, instead of achieving water conservation through changes in behavior and daily routine, the cost of the conservation program is an important consideration. The net present savings due to household water conservation is the difference between the net present equivalent of the resulting cost savings and the net present equivalent cost of implementing the program.

On economic grounds, we assume as an objective, the maximization of the net present savings. Both the cost and timing of program implementation must be considered in conjunction with the discount rate. It may be better to implement the program soon in order to take advantage of O&M cost savings in wastewater and conventional drinking water treatment, as well as any household energy savings due to conserving heated water, all of which begin as soon as water conservation does.

On the other hand, construction cost savings for expanded wastewater treatment and conventional drinking water treatment facilities are fixed in time and amount, as long as the program is implemented before existing capacities are exceeded. Both the construction cost and O&M cost savings in GAC treatment are similarly fixed, as long as the conservation program is operational prior to the regulatory deadline for meeting the TTHM MCL. Earlier implementation of the conservation program will not affect cost savings in these categories.

It is best to implement devices that are relatively inexpensive, as soon as possible, to take advantage of the savings that begin immediately. Depending upon who pays costs and to whom the savings accrue, as expensive devices are used, it may be best to delay implementation to take advantage of the reduction in net present equivalent due to discounting. This phenomenon requires considering the possibility of staged implementation of a water conservation program consisting of installation of several different devices (for example, shower flow restrictors and toilet tank inserts) in each household. Unless there is likely to be a substantial reduction in administrative costs or increase in participation rate due to simultaneous implementation, it may be better to install the inexpensive devices immediately and delay installation of the more expensive devices as long as possible (that is, until just before existing capacities of the treatment facilities are reached).

## APPLICATION OF THE METHOD: RESULTS AND CONCLUSIONS

In order to illustrate the method, we evaluated the cost-effectiveness of applying two alternative household water conservation programs to a hypothetical community of population 600,000. The characteristics of the hypothetical community used in the analysis are shown in Table 1. The mathematical details of the analytical method are available elsewhere (7,8,9,10).

The first alternative conservation program consisted of providing a shower flow restrictor for homeowner installation at a cost of $1.00 each. The second program included both the shower flow restrictor and a toilet tank insert (plastic dam). The toilet tank insert was provided for homeowner installation at a cost of $7.00 each. Installation costs were not included. We assumed that each device achieved a 10 percent reduction in household water use. Accounting for the assumed participation rate of 80 percent and for the assumption that residential water use was approximately 40 percent of the total, Program Alternative I (the shower flow restrictor) reduced total water use by 3.2 percent and Program Alternative II (the shower flow restrictor and the toilet tank insert) reduced the total by 6.4 percent. For simplicity, we also assumedthat when each program was implemented, sufficient devices would be purchased to provide the needs of the growing population for the planning horizon of 30 years. Under these conditions and for devices that reduce household water use by 10 percent and cost less than approximately $10.00, optimal implementation time is immediately, in the hypothetical community.

Table 2 shows the results of our analytical method as applied to the hypothetical community. This table shows that Program Alternatives I and II result in total overall net present savings of $59.83 and $73.13 million, respectively. Table 2 also shows that by far the largest portion of the total savings from household water conservation is the energy cost savings realized by homeowners as a result of reduced hot water use. These savings to homeowners account for approximately 60 to 70 percent of the total savings. The Federal Government and the wastewater utility each realize savings that are in the range of 10 to 15 percent of the total. The savings to the drinking water utility make up approximately five to 10 percent of the total net present savings. But all four sectors have net present equivalent savings that far exceed (by at least a factor of two) the net present cost, for both program alternatives. This means that it would be cost-effective for any one of the four sectors to bear the entire cost of the conservation program, even if the cost-effectiveness criterion were a comparison of costs and cost savings for each sector separately.

The results indicate the importance of the household energy cost savings from reduction in household hot water use to the implementation of a successful community-wide household conservation program. In the hypothetical community, this was the only source of savings to homeowners. We assumed no reduction in total water bill or sewer charges. Even if the wastewater and drinking water utilities offer no economic incentives for homeowners to make use of the water-saving devices, the homeowners will still realize large savings in the form of reduced energy costs if devices which conserve hot water are used in the water conservation program. In addition, conservation of hot water allows homeowners to participate in furthering the national goal of conserving energy resources.

These energy cost savings to homeowners imply two important policy considerations for a community which plans to implement a large-scale household water conservation program. First, since energy cost savings provide a substantial incentive to homeowners to make use of water-savings devices, the utility implementing the water conservation program should make use of this fact to encourage public participation in the conservation program. This could be done through implementation of a public education program designed to make homeowners aware of the potential energy cost savings from the use of a particular water-saving device. Second, because a shower flow restrictor is less expensive, smaller, easier to distribute, and may even be easier to install than a toilet tank dam, it might be the preferred choice for a community-wide conservation program which makes use of only one type of water-saving device.

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Table 1. Characteristics of Hypothetical Community for Analysis

| | |
|---|---|
| Population in year zero | 600,000 persons |
| Population growth rate | 2 percent/year |
| Water use/wastewater generation rate | 145 gallons/cap·day |
| Residential component of water use/ wastewater flow | 40 percent |
| Average numbers of persons/fixture | 2.5 persons/toilet<br>2.5 persons/shower |
| Existing drinking water/wastewater treatment capacity | 110 MGD (million gallons/day) |
| Current dollar discount rates: | |
| Homeowners | 18 percent/year |
| Drinking water/wastewater utility | 10 percent/year |
| Combined inflation and real price escalation rates: | |
| Household energy cost | 10 percent/year |
| Construction cost | 7 percent/year |
| O&M cost | 6 percent/year |
| Household water heating fuels: | |
| Natural gas | 60 percent |
| Electricity | 30 percent |
| Fuel Oil | 10 percent |
| Marginal prices* of energy: | |
| Natural gas | $0.29/100 cubic feet |
| Electricity | $0.042/kWh |
| Fuel Oil | $0.49/gallon |
| GAC treatment required | year 5 |
| Planning horizon | 30 years |
| Program participation | 80 percent |
| Reductions in water use/wastewater flow: | |
| Shower flow restrictor | 10 percent |
| Toilet tank insert | 10 percent |
| Costs* of conservation program: | |
| Shower flow restrictor | $1.00/device |
| Toilet tank insert | $7.00/device |

*June 1978 prices expressed in June 1978 dollars.

Table 2. Net Present Equivalent of Costs and Cost Savings Resulting from Alternative Household Water Conservation Programs

| | Program Alternative I | Program Alternative II |
|---|---|---|
| Total Overall Net Present Savings (million dollars) | 59.83 | 73.13 |
| Net Present Equivalent for the Wastewater Utility (million dollars) | 5.65<br>(9.4)* | 11.28<br>(14.7) |
| Net Present Equivalent for the Drinking Water Utility (million dollars) | 3.57<br>(5.9) | 7.13<br>(9.3) |
| Net Present Equivalent for the Residential Community (million dollars) | 43.8<br>(72.7) | 43.8<br>(57.2) |
| Net Present Equivalent for the Federal Government (million dollars) | 7.25<br>(12.0) | 14.42<br>(18.8) |
| Net Present Cost of Program Alternative (million dollars) | 0.44 | 3.50 |

*Numbers in parentheses indicate percent of the total net present equivalent of savings.

MUNICIPAL WATER CONSERVATION -- A WATER PROJECT THAT PAYS FOR ITSELF

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## ABSTRACT

Municipal water conservation's direct economic impact is one of its most intriguing aspects. When analyzed and presented carefully, it is also one of water conservation's strongest selling points. This paper describes a structure utilized for analyzing municipal water conservation benefits and costs. The key to the structure is inclusion of all significant direct benefits and costs. Three examples of results from utilizing the analytical structure are then described.

## INTRODUCTION

Over the past few years, we at INTASA have been participating in a group of projects addressing municipal water conservation. These include:

- The U.S. Environmental Protection Agency's (EPA's) "Water Supply - Wastewater Treatment Coordination Study" (1). This report to Congress was developed in response to Section 1442(c) of the Safe Drinking Water Act and Section 516(e) of the Clean Water Act. One topic selected for detailed discussion was municipal water conservation--due to its obvious implications for quantities of flow in both water supply and wastewater.

- The U.S. EPA's handbook on "Flow Reduction: Methods, Analysis Procedures, Examples" (2). This handbook is designed to assist community planners and engineers in the context of EPA's Construction Grants Program.

- A research project for the U.S. Office of Water Research and Technology (OWRT) on "Local/Regional Variations in Benefits and Costs of Municipal Water Conservation."

- A U.S. Army Corps of Engineers case study applying its "Manual of Procedures" (3) for water conservation analysis to Tucson, Arizona.

In each of these projects the economics of municipal water conservation has been a central focus. The purpose of this paper is to highlight the common thread in these projects--municipal water conservation economic analysis.

## SCOPE AND STRUCTURE OF THE ECONOMIC ANALYSIS

Three imperatives characterize the economic analysis approach utilized:

- Focus on direct economic impacts.
- Maintain a community-wide perspective.
- Include all significant benefits and costs.

The focus on direct economic impacts is achieved by identifying direct water-related expenditures and asking which ones change with water conservation. It is not implied by this focus that secondary or indirect impacts don't matter. The crucial thing is to properly characterize the direct impacts first.

Maintaining a community-wide perspective is important to avoid confusion. Otherwise it is easy to get a mixture of perspectives which results in a partial or duplicative coverage. Thus, rather than focusing on a single family, one thinks in terms of all residential water users in the community while doing the economic analysis. The obvious need for a community-wide perspective is to then include commercial, industrial, and public users as well.

The third imperative--including all significant benefits and costs--is then facilitated by the bounds established by the first two. The task becomes that of identifying a complete (but nonduplicative) group of expenditures that change significantly. The following categories of benefits and costs have been found to be workable.

The direct economic benefits of municipal water conservation accrue primarily as cost savings in three categories:

- Lower overall expenditures by the water supply utility.
- Lower overall expenditures by the wastewater utility.
- Other decreases in water-related expenditures by water users--especially for energy to provide hot water.

In the cases of the water supply and wastewater utilities, one looks at the changes (with versus without conservation) in the annual utility budget over time. This includes changes in capital expenditures (e.g., delayed or smaller capacity expansions) and changes in operation and maintenance expenditures (e.g., less pumping cost). The difference, discounted to the present year, is the present value of this type of cost savings (i.e., the benefit). In the third category, the primary saving to the user which is not reflected in his water and wastewater bills is hot water energy savings. If he uses less hot water he uses (and pays for) less energy to heat it. The present value of such savings over the study period is another direct water conservation benefit.

The most important point is to include all three types of water conservation benefits in order to achieve a true community-wide perspective. Many early economic analyses have left out one or two of these benefits. For example, water people have often overlooked the hot water energy savings and thereby significantly underestimated the benefits.

The direct economic costs of municipal water conservation are primarily the costs of a "conservation program" which usually has three components:

- Conservation devices (including installation labor when appropriate) such as flow controllers to retrofit showers or pressure reducers as an added item in new construction.

- Public information so people understand and cooperate with the program.

- Program implementation activities such as staff activities to study and change water rate structures or building codes.

This overall structure for economic analysis of municipal water conservation and each type of benefit and cost are presented in detail in EPA's recently published handbook--"Flow Reduction: Methods, Analytical Procedures, Examples" (2).

EXAMPLES OF POTENTIAL RESULTS

The following subsections present some examples of the potential economic results of municipal water conservation. At this point they are analytical--they do not represent any specific community. They have been chosen to indicate aggregate economic impacts which municipal water conservation potentially could have.

Typical U.S. Community

The first example is oriented toward a composite of characteristics which could represent a typical U.S. community. These assumed characteristics include:

- Population is 50,000.

- Growth rate is two percent per year.

- The community is close to needing expanded capacity in its water supply and wastewater facilities.

- A water conservation program is designed and adopted which, over time, achieves a 20 percent reduction in per capita water use.

The 20 percent reduction in per capita use is taken as an example of potential--something that might realistically be achieved if the relatively simple and inexpensive water conservation steps were widely implemented both in new construction and through retrofit of existing buildings. The results of an economic analysis (utilizing many more very detailed assumptions) are shown in Table 1. Note that the benefits greatly exceed the costs. Benefit to cost ratios in the range of five to ten should be common in such analyses.

Table 1. Typical U.S. Community Results (present value; $ million)

| Benefits | | Costs | |
|---|---|---|---|
| Water Supply | 9.8 | Devices (& Labor) | 1.4 |
| Wastewater | 12.1 | Public Information | 1.0 |
| Hot Water | 8.2 | Implementation | 0.4 |
| | 30.1 | | 2.8 |

Net Benefits: 27.3

## Changes With Different Population Growth

In the research project being sponsored by OWRT, the foregoing analysis is being extended by looking at the sensitivities of costs and benefits to changes in several local/regional parameters. The community's population growth rate is one example of a parameter that is especially interesting. Figure 1 shows water-related costs (with and without water conservation) for the previously discussed "typical U.S. community"(the 2 percent growth rate) and for similar communities with three alternative growth rates. Figure 2 then shows the difference between the two curves in Figure 1--the net benefits of water conservation for each growth rate. Note the following with respect to Figure 2:

- The increasing net benefits with increasing growth rate.

- The range of the present value of net benefits between $20 and $35 million--no small amount for a community of 50,000.

- The community-wide net benefits translate into approximately:
  - $550 per capita for the 2 percent per year growth rate,
  - $680 per capita for the 5 percent per year growth rate.

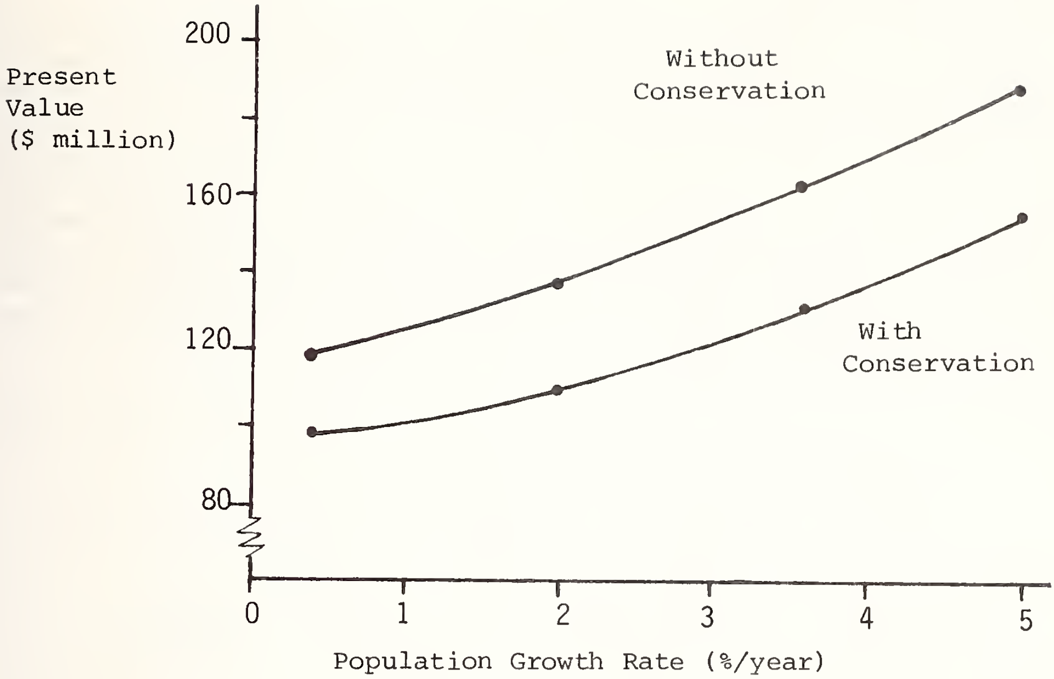


Figure 1. Community-Wide Water-Related Costs.

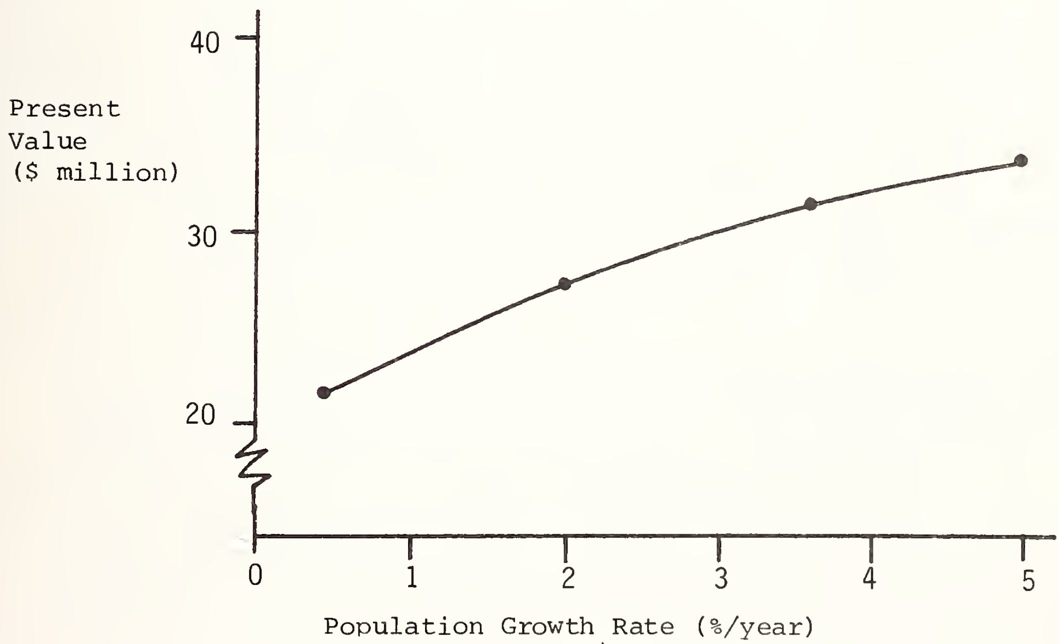


Figure 2. Community-Wide Net Benefits of Municipal Water Conservation.

National Implications

Of particular interest from a national viewpoint is the impact which municipal water conservation could have on energy imports. Assuming nationwide implementation of the 20 percent reduction in per capita water use, the energy savings would have an oil equivalent of approximately 260,000 barrels per day--about 90 percent of this being hot water energy savings and about 10 percent being energy savings in water supply and wastewater operations. As shown in Table 2, this is equivalent to approximately 3 or 4 percent of the Nation's oil imports. Similarly, the energy savings can be translated into an impact on the Nation's balance of trade. As shown in Table 3, the value of the energy savings is in the range of 4 to 9 percent of the trade deficit.

Table 2. National Impact on Oil Imports (barrel of oil equivalents)

| Year | Oil Imports ($10^6$ bbl/Day) | Energy Savings ($10^6$ bbl/Day) | Percent |
|---|---|---|---|
| 1977 | 8.8 | 0.26 | 2.9 |
| 1980 | 7.0 | 0.26 | 3.7 |

Table 3. National Impact on Balance of Trade

| Year | Oil Price ($/bbl) | Savings ($$10^9$/yr) | Trade Deficit ($$10^9$/yr) | Percent |
|---|---|---|---|---|
| 1977 | 13 | 1.2 | 26.5 | 4.5 |
| 1980 | 31 | 2.9 | 32.3 | 9.0 |

## CONCLUDING OBSERVATIONS

The most obvious question regarding municipal water conservation economics is one which was quickly asked at this conference--"If municipal water conservation is so economically sensible, why don't we (the Nation) do more of it?" This writer believes we will do more municipal water conservation but that its present status and slow progress is related to three major needs at the community level.

- Improved awareness of community-wide economics. Too often only part of the benefits are recognized. The water supply utility manager tends to look only at the cost savings for his utility and to ignore wastewater and hot water energy savings. Similarly, the wastewater and energy people consider only their areas of activity. The benefits of municipal water conservation are significant in all three areas and analyses must draw them together to create the needed community-wide picture.

- Cooperative, community-wide, long-term outlook. Part of the answer is for the three utilities (water supply, wastewater, and energy) to work jointly in developing perspectives on the future needs of the community and beneficial ways of influencing those needs. In that way specific problems (such as potential water supply revenue reductions) can be identified and agreeable responses worked out.

- Programs oriented toward a high percent coverage and long-term effectiveness. Presently, many water conservation programs achieve a relatively low percentage penetration (e.g., 20 to 30 percent of existing households) and utilize conservation devices with limited life spans. To really reap the benefits of municipal water conservation, program designs must be developed which are cost-effective and socially acceptable and, at the same time, achieve high percentages of penetration with essentially permanent devices or improvements.

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ACKNOWLEDGMENTS

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'81 A NATIONAL CONFERENCE

# Devices and Technology

DEVICES AND TECHNOLOGIES FOR WATER CONSERVATION - STATE OF THE ART: STANDARDS FOR INDUSTRY

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MODERATOR'S REMARKS

The United States and Canada share the largest freshwater system in the world, the Great Lakes. Both east and west of the Great Lakes, river systems form or cross the international border. It is natural that the two countries share similar problems in dealing with a shared natural resource. There are also many differences due to Canada's substantial freshwater lakes and streams, in addition to the Great Lakes, and also due to a much lower density of population and to the special problems of the Far North. Both countries face the economic factors of increasing energy costs, the treatment of waste water, and the capital cost of expanding water supply and disposal systems. A recent study done by the Canadian Department of the Environment, which identifies a few problem areas, and also another recent study under the auspices of the Canadian Standards Association, will be reviewed to see if reduction in maximum flow rates for plumbing fittings would help solve certain municipal supply problems.

It is an honor and a distinct pleasure for me to be here in Denver. We share the largest freshwater system in the world, the Great Lakes. In addition to this mutual resource, there are river systems flowing into the Atlantic, the Pacific, and the Arctic Oceans. We share geography, rainfall, weather, and the benefits and problems of a heavy industrialized society.

Like so many of our resources, we have had to reassess our attitudes and consumption patterns to practice conservation to assure water will continue to be readily available in those parts of the country where it is in short supply. The availability and cost of energy to distribute, heat, and treat water have escalated in the last decade and are now important factors in our thinking. The capital costs of expanding water distribution and waste treatment facilities can be reduced by good programs of water management.

In my country, the provincial governments have the direct responsibility for water conservation within their boundaries. At present, Alberta is the only province that has been concerned with water supply on a provincial basis. This is because of inadequate reservoir capacity in growing communities.

The Federal Department, Environment Canada, supports research including many river basin planning studies and university research projects. In addition, they have special projects dealing with water supply, use, and conservation in the Yukon and Northwest Territories where, because of low precipitation and extreme climatic conditions, it is difficult to transport water and dispose of wastes for many months of the year.

In a report published last year, Environment Canada discussed water conservation alternatives of the North. It describes a broad range of devices, lists advantages and disadvantages, and details initial and operating costs. However, no government testing program was carried out. Performance data are based on published literature, manufacturers' information, and the personal experiences of the authors. Nevertheless, it does provide a valuable guide for Canada's northern communities.

Generally speaking, Canada has an abundant water supply, but regional variations do exist. The southern interior of Western Canada is generally regarded as a water-short region, basically short of agricultural water for irrigation.

In the regional municipality of Waterloo, an industrialized area 60 miles west of Toronto, they have depended on ground water sources rather than piping water in from the Great Lakes, as has been done in other communities in the area. They have also experienced periodic shortages. The region has done a comprehensive study of conservation and has developed standards for water-efficient plumbing devices. The regional government offers grants to encourage builders to fit new structures with toilets, showerheads, and faucets that comply with their criteria. The people responsible for this conservation program are here and will be telling their story later this afternoon.

The Waterloo program is similar to a number of local programs in this country. It is in the initial stage of implementation, so it is too early to report any statistical results. The Canadian Standards Association set up a task force to determine if flow rates in faucets would (materially) reduce water consumption.

Data from the city of Montreal had an important bearing on the conclusions reached by the committee. Both daily and annual water consumption figures in Montreal continued to rise in spite of negative population growth from 1970 to 1978. Uses other than residential represent over 50 percent of consumption. It was estimated that less than 1 percent of the potable water was used for cooking or drinking.

The committee concluded that an effective water conservation program must include the following elements:

1. Water meters, with bills related to consumption.

2. Conservation programs must be developed for industry.

3. Domestic use of water is, on one hand, time related: for example, showers; on the other hand, it is receptacle- or cycle-related: for example, wash basins, toilets, washing machines, and dishwashers. Therefore, a reduction in flow rates could result in water savings in time-related functions but not necessarily in receptacle-related use.

4. User satisfaction and long-term, trouble-free service life must be maintained in water conservation products if consumer support is to be sustained.

As a member of the Plumbing Manufacturer's Institute (PMI), I have followed the recognition of the need for water conservation and have followed the development of conservation standards. The PMI program was undertaken during a severe drought in the Southwest. Shortly after the first standard was published, there was a flood in California. I am going to be very interested to see what happens following this conference.

# PERFORMANCE REQUIREMENTS AND TEST PROCEDURES FOR WATER CLOSETS

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## ABSTRACT

Stevens Institute of Technology has completed the development of requirements and procedures for evaluating the sanitary performance of water closets. This effort was undertaken in conjunction with the U.S. Department of Commerce - National Bureau of Standards and the U.S. Department of Housing and Urban Development. The overall objective of their program is to provide technology to achieve a significant reduction in residential water use.

The objective of our study was to develop test methods for use by industry, code groups, enforcement agencies and others to determine the functional performance of water closets and thereby provide safe and efficient designs and installations. This activity has paralleled the development of the proposed revision to the American National Standard A112.19.2 - Vitreous China Plumbing Fixtures. The opportunity to incorporate our findings into the product standard has added to the significance of this program.

A review of the present techniques found many of the major producers using test media spanning a wide range of size, form and density. Little information was found within the industry as to the characteristics of waste products; however, an electronic search of biology and medical journals produced several interesting studies which led to the selection of the test media. In addition to physical simulation, the media must lead to repeatable and discriminatory tests.

The primary characteristics of the water closets for which test methods and procedures were developed include: surface cleansing, waste removal, including solids and liquids, and volumetric efficiency. As a service to industry and the general public the Laboratory makes available a test kit which includes the media, instructions and data sheets.

## INTRODUCTION

An awareness and public education program can effect savings in potable water. This, however, is just the beginning. Significant opportunities exist - first with little or no change in technology and second with new technologies. The key to the success of these alternative techniques is the development and acceptance of plumbing products based on functional performance requirements.

Plumbing fixtures and appliances may be divided into two classes: fixed volume devices where the user has little or no control over the water consumption (examples are water closets, washing machines and dishwashers) and variable rate fixtures such as lavatories and sinks. Fixed volume fixtures account for as much as 64 percent of the water used in homes equipped with dishwashers and automatic laundry equipment. For this reason, their functional performance and water efficiency is paramount in our conservation effort.

In this paper, one fixed volume plumbing product, the water closet, is addressed and a review of what has and is being done to measure the sanitary performance of this device is given. This research effort is part of a major undertaking of the U.S. Department of Housing and Urban Development and the U.S. Department of Commerce - National Bureau of Standards to provide the technology to achieve a significant reduction in residential water use.

## OBJECTIVE AND SCOPE

Our specific objective was to develop test methods for use by industry, code groups, enforcement agencies and others to determine the functional performance of water closets and thereby provide safe and efficient designs and installations. This activity has paralleled the development of the proposed revision to the American National Standard A112.19.2 - Vitreous China Plumbing Fixtures. The opportunity to incorporate our findings into the product standard has added to the significance of this program. The scope of our work included the following:

- Documentation of Existing Performance Requirements
- Establishment of Field Operating Parameters
- Development of Test Methods and Procedures
- Recommendations for Consensus Standards

A full documentation of the research effort is underway.

## TEST MEDIA

The widely recognized existing product standard, ANSI A112.19.2-1973, Vitreous China Plumbing Fixtures, provides information relative to materials of construction, types and sizes of commercially available designs, features of construction, dimensions, grading, inspection methods and one flushing test using paper as the media. A review of the evaluation techniques used by the industry found many of the major producers using test media spanning a wide range of size, form and density. The demand for water saving units necessitated the establishment of requirements based solely on the requirements for collecting and transferring body wastes to the drainage system. While little information was found within the industry as to the characteristics of waste products, an electronic search of biology and medical journals produced several interesting studies, which suggested the normal maximum weight of waste as 243 grams. This led to the selection of the proposed test media. In addition to physical simulation, the media must provide the basis for repeatable and discriminatory tests.

## TEST METHODS AND PROCEDURES

Uniformity in the reporting of the performance of units mandates that a standardized water supply system be used. This technique ensures that the water closet under test will have an adequate supply under conditions simulating installation in a single family residence. The experimental arrangement for tank type closets is shown in Figure 1. A similar setup is used with flushometer units.

A high pressure water supply system is connected to a flow meter, pressure regulator, control valve and a fixed orifice or second valve simulating a standard ballcock. The static pressure is set at 20 psi. A flow rate of 3 gpm at 8 psi flowing pressure is established by adjusting the control valve and simulated ballcock. These conditions (position of control valve) are not disturbed when the supply system is connected to the water closet under study and the performance tests conducted at higher pressures. The rationale for using static pressure as the reference is derived from nationally recognized model codes.

In our Laboratory, the spent water is collected in a receiving vessel mounted on top of a load cell. The output from the load cell is displayed through an electronic voltmeter calibrated such that the display units read directly in gallons. This experimental setup is shown in Figure 2.

The primary characteristics of the water closets for which test methods and procedures were developed include: surface cleansing, waste removal, both solids and liquids, and volumetric efficiency.

The five performance requirements and test procedures are shown in Figure 3. The ball test measures the basic function of bowl design and is considered fundamental to the evaluation of water closets.

Tests of this type are used throughout Europe as a standard measure of performance. The granule test, developed to simulate a slurry, has been found a good indicator of the quality of the siphonic action. The cylinder test, conceived as a measure of the bowl capacity, has been useful in evaluating trapway design. Aside from the waste removal tests are the surface wash test, which at present measures cleansing in a qualitative way, and the water change test, which provides a quantitative method for the dilution of liquids.

As a service to industry and the general public, the Laboratory makes available a test kit which includes the media, instructions and data sheets. The kit contents are shown in Figure 4.

## TEST RESULTS AND CONCLUSIONS

Fifteen water saving water closets, three each of five distinct designs, were evaluated in our program along with three of each of two designs for conventional equipment. The following general comments refer to test results obtained at 20 psi static pressure. The conventional equipment passed all tests with the exception that one bowl in each design failed the cylinder test. The water saving equipment, with the exception of one design, did very well. Eleven out of twelve units tested passed the ball test, all passed the granule test, six out of twelve passed the cylinder test, nine out of twelve passed the surface wash test and nine out of twelve passed the water change test. While there is an obvious reduction in performance in the water saving units, we are confident that the manufacturers will consistently produce good products. We have continued to improve the cylinder test and have recently acquired one-piece cylinders which we believe provide a better simulation of waste material. We expect this to improve the reported performance of all units.

The establishment and acceptance of a reasonable set of performance requirements has stimulated the manufacturers to increase the production of water saving units and may lead to offsetting the confusion that exists by the passage of numerous water conservation laws and regulations. It appears, today, that the volume of water required to dispose of wastes is governed by the transfer of body wastes into the system. As more efficient water closets are developed and marketed the governing parameter may become the transport mechanism as the basic function of water in waste systems is to act as the carrier.

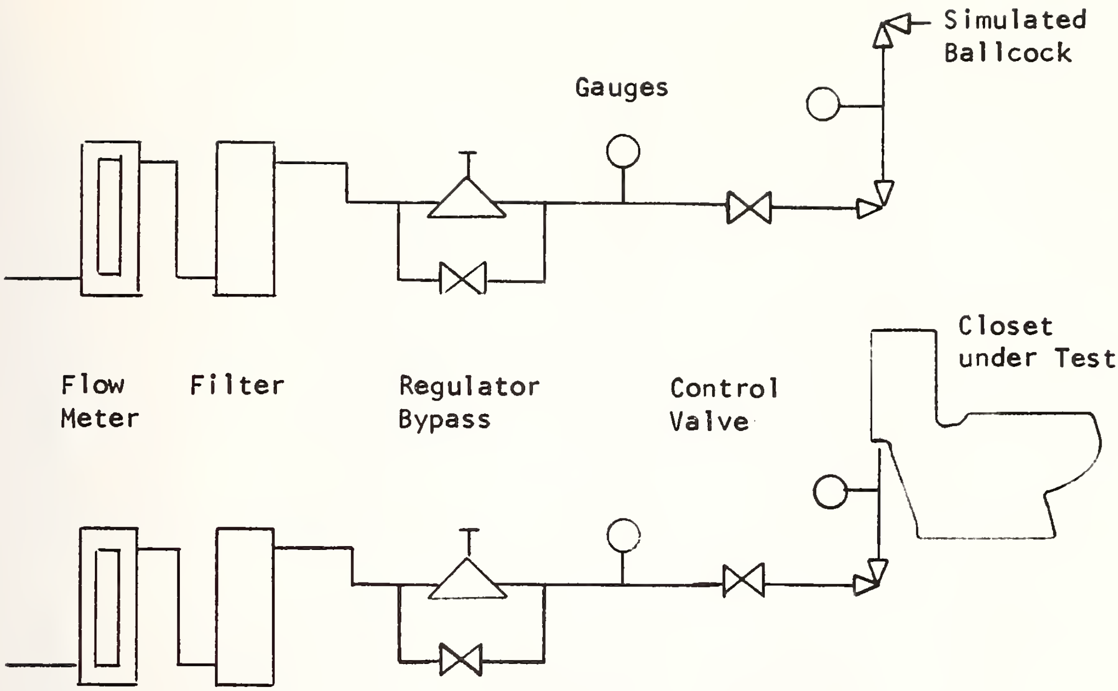


Figure 1. Water Supply System for Closet Tests

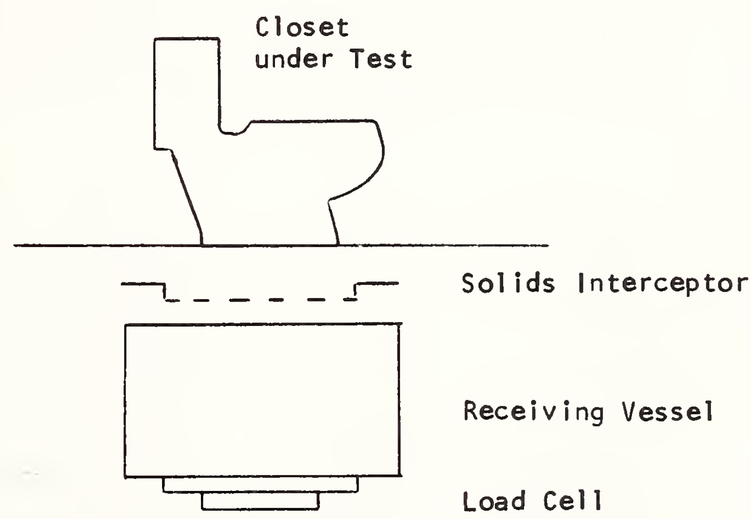


Figure 2. Test Stand for Closet Tests

SANITARY PERFORMANCE TEST METHODS AND REQUIREMENTS

Refer to ANSI Standard A112.19.2 for Additional Important Details

| Test Media | Procedure | Performance Requirement |
|---|---|---|
| 1. Ball Test - 100 polypropylene balls having a diameter of 3/4-inch and an average bulk density of 0.85-0.90 grams/$cm^3$. | Drop the 100 balls in the well. Trip the flush release device. After completion of this initial flush, count the balls remaining visible in the well and those passing completely through the trapway. Repeat the procedure until five sets of data are obtained. | An average of 75 balls shall pass through the trapway on each initial flush based on the five initial flushes. |
| 2. Granule Test - 100 ml of disc-shaped polyethylene granules 2-3 mm diameter, 1.6 mm thick and an average bulk density of 0.90-0.95 gram/$cm^3$. | Add the 100 ml of polyethylene granules to the water in the bowl. Trip the flush release device. After completion of this initial flush, count the granules remaining visible in the well. Repeat the procedure until five sets of data are obtained. | Not more than 125 granules (5 percent) shall be visible in the well after each initial flush. |
| 3. Cylinder Test - four latex cylinders, 1-inch diameter with round ends 1/2-inch radius, an overall length of 4-3/8-inches, and a bulk average density of 0.95 to 1.05 grams/$cm^3$. | Gently place the cylinders in the bowl side by side running horizontally in the long direction of the water surface. Trip the flush release device. Count the number of cylinders remaining in the well and those passing through the trapway. Repeat the procedure until five sets of data are obtained. | A total of at least fifteen cylinders shall be flushed out in the five initial flushes, and not less than two cylinders shall be flushed out in the initial flush of each test run. |

Figure 3. Summary of Test Methods and Procedures

| | | |
|---|---|---|
| 4. Surface Washing Test - felt tip pen with dark color water soluble ink. | The flushing surface shall be scrubbed clean with commercial scouring powder. The surface shall be rinsed and dried with oil free air. Draw a line around the circumference of the flushing circle one-inch below the rim jets. Trip the flush release device. Measure the lengths of the unwashed line segments and record their approximate position. Repeat the procedure until three sets of data are obtained. | The total length of line segments remaining on the flushing surface after each initial flush shall not exceed two inches and no individual segment shall be longer than one-half inch, based on the average of the three test runs. |
| 5. Water Change Test - water soluble dye - polar brilliant blue RAWL. | a) Prepare a concentrated dye solution in the ratio of 30 grams per liter.<br>b) Determine the volume of trap seal by measurement.<br>c) Prepare reference solutions in dilution ratios of 10, 20, 50, 100, 200, 500 and 1000. See detailed instructions in the referenced standard.<br>d) Add concentrated dye solution to the bowl water (1/40 of the measured trap seal volume). Stir the solution in the bowl. Trip the flush release device.<br>e) Extract a water sample from the bowl and compare with known solutions. Clean the bowl to remove traces of dye solution and repeat the procedure until three sets of data are obtained. | A dilution ratio of at least 100 shall be obtained in each initial flush. |

Figure 3. Continued

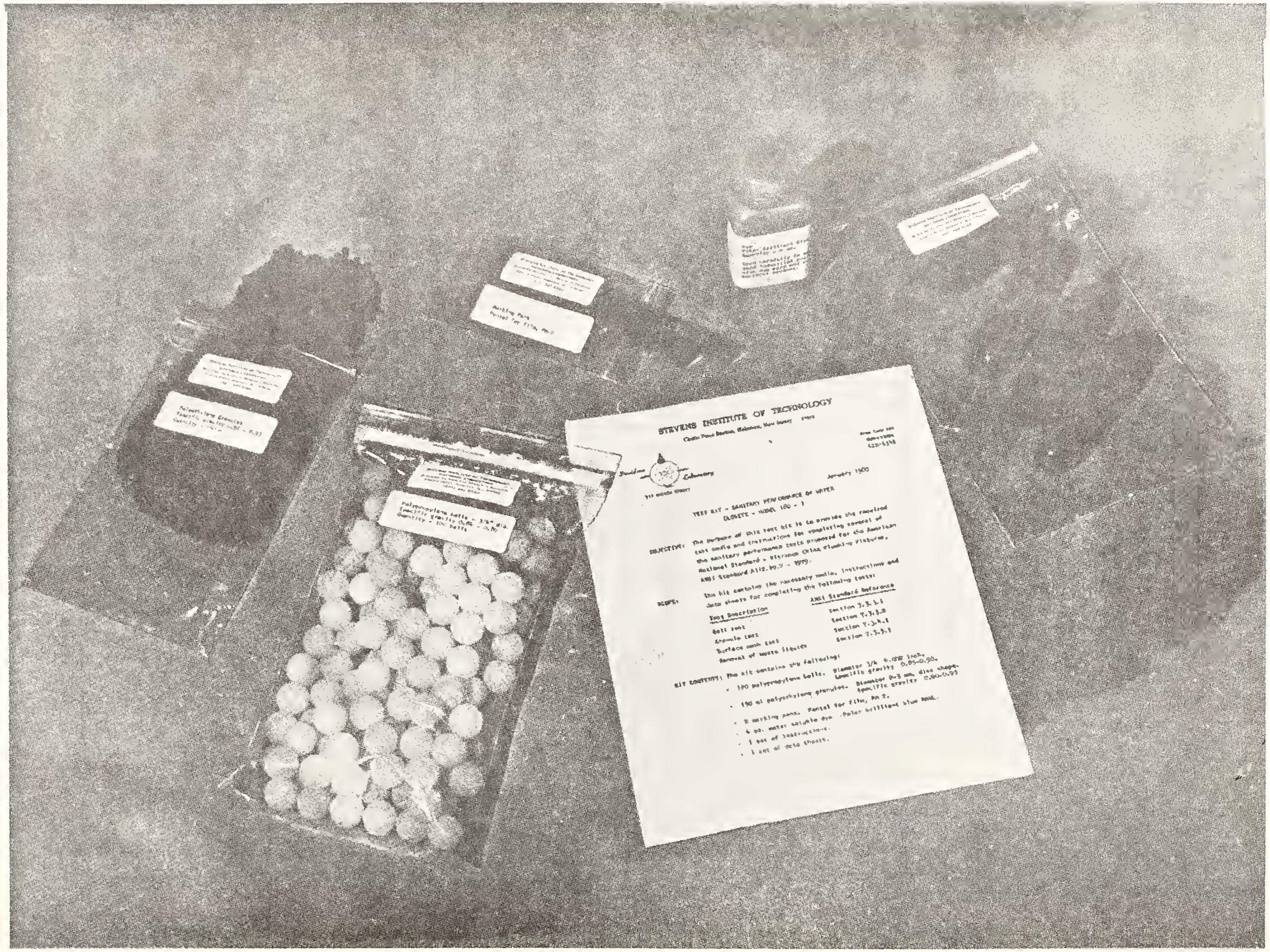


Figure 4. Test kit for determining the sanitary performance of water closets

# EXPERIENCES AND BENEFITS OF THE APPLICATION OF MINIMUM FLOW WATER CONSERVATION HARDWARE

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## ABSTRACT

Minimum flow water conservation is achieved by using hardware and techniques specifically designed around minimizing consumption while maintaining the function, both physiological and aesthetic, of the use as opposed to modification or redesign of existing hardware and fixtures.

These techniques and hardware have been used to significantly reduce water and energy consumption and sewage treatment and disposal problems in both commercial and residential applications. This paper presents results of these applications with over an 80 percent reduction in water consumption in commercial and 60 percent in residential applications. Impacts on sewage systems have been observed and projected for both on-site and central systems. Reductions in plumbing and water heating facilities are also discussed.

The hardware discussed represents an 80 percent to 85 percent reduction when compared to conventional flow reduction techniques.

## INTRODUCTION

Water conservation equipment are generally conventional water fixtures modified to lower flows, but using the same basic mechanisms as their high-use counterparts. The hardware and techniques presented in this paper do not exclude, but are not limited to, modifications of conventional technology. The major fixtures that contribute to the high levels of flow reduction presented here are those designed to provide the same function physiologically and aesthetically, but use mechanisms that minimize consumption. For purposes of this paper, these high levels of flow reduction will be called "minimum flow."

When water consumption is reduced to the levels obtained using these techniques, there are significant impacts on not only water but on energy and sewage. The purpose of this paper is to present the concept of minimum flow; give a brief background of experiences using these techniques; and present a brief analysis of the impacts of minimum flow on an actual planned unit development.

## DOMESTIC WATER USE CHARACTERISTICS

Most of our experience with flow reduction impacts has been in the foothills of northern California. For this reason, the parameters used in the analysis will be those characteristic of that region. Translating the results to other areas can be accomplished by changing the base data to that of the area to be considered.

### Conventional Flows

Based on the analysis of winter flows, when no outside water occurs, and on occupancies for the residential portion of Amador City, Martell, Mokelumne Hill and Murphys, California, an average daily per capita flow of approximately 64 gallons has been obtained. This agrees very closely with the findings of Bailey, et al.(1) in reviewing the work of others. He defined the water use patterns tabulated in Table 1.

Table 1. Average Conventional Flow Water Use

| Fixture | Gal/Use | Use/Day | Gal/Day | Use Rate |
|---|---|---|---|---|
| Toilet | 5 | 5 | 25 | 5 Gal/Flush |
| Bathing | 20 | 1 | 20 | 4 GPM |
| Lavatory | - | - | 2 | |
| Dishwasher | 15 | .25 | 3.75 | |
| Kitchen Sink | - | - | 3 | |
| Laundry | 50 | .18 | 8.75 | 50 Gal/Load |
| Utility | - | - | 1.25 | |
| | | Gallons/Person/Day | 63.75 | |

As can be seen from Table 1, 70 percent of the flow from the household occurs in toilet flushing and bathing. If the laundry is added to the flows from these two uses, 85 percent of the flows are accounted for.

### Modified Conventional Flows

This class of flow reduction includes toilets that use conventional technology, but are basically scaled down, and showers that restrict flow by means of orifices or controllers and are designed for lower flows. This does not include toilet dams or flow restrictors. Table 2 presents flows expected from this class of flow reduction.

### Minimum Flow Fixtures

In order for a flow reduction technique to provide a predictable positive impact on water energy and sewage systems, it must possess the following characteristics:

a) Provide a significant predictable flow reduction
b) Not rely on habit pattern changes
c) Protect public health
d) On-going use must be verifiable

The fixtures we have found to best meet these criteria are the class of water carriage fixtures referred to here as "minimum flow."

Table 2. Average Modified Conventional Flow Water Use

| Fixture | Gal/Use | Use/Day | Gal/Day | Use Rate |
|---|---|---|---|---|
| Toilet | 3.5 | 5 | 17.5 | 3.5 Gal/Flush |
| Bathing | 15.0 | 1 | 15.0 | 3.0 Gal/Min. |
| Lavatory | - | - | 2.0 | |
| Dishwasher | 15.0 | .25 | 3.75 | |
| Kitchen Sink | - | - | 3.00 | |
| Laundry | 50.0 | .18 | 8.75 | |
| Utility | - | - | 1.25 | |
| 20 Percent Reduction | | | 51.25 | Gal/Person/Day |

These fixtures are specifically designed to reduce the use of water in their operation, while providing the same function as their conventional counterparts.

Toilets

Several toilets exist in this category between 1.9 ℓ/flush (0.5 gal) and 3.8 ℓ/flush (1.0 gal). The mechanisms used for flushing vary from wash down bowls at 3 ℓ and 3.8 ℓ, to vacuum and air assist at 1.9 ℓ. One toilet we have used in our applications and will be the basis for presenting the project impact analysis is the air assist toilet.[2]

We have found this toilet to function well in both commercial and residential applications, and to produce significant, predictable flow reduction.

Bathing

The air assist shower[3] uses a flow rate of 1.9 ℓ/minute (0.5 gpm) or 2.8 ℓ/minute (0.75 gpm), depending on the model selected and an air flow rate of 40 cubic feet per minute. We have used this unit in both configurations for commercial and residential applications and have found it to produce the results anticipated.[4]

The forced air assist provides the driving force lost when the water flow is reduced, with no increase in bathing times when compared to conventional 15.1 ℓ/minute (4 gpm) showers, as reported by Shatzburg, et al.[5]

Laundry

A front-loading automatic washing machine utilizes a horizontal axis drum to provide agitation. These machines use approximately 40-50 percent less water than top-loading washers.

Table 3 presents the reductions in flow obtained using minimum flow technology.

Table 3. Average Minimum Flow Water Use

| Fixture | Gal/Use | Use/Day | Gal/Day | Use Rate |
|---|---|---|---|---|
| Toilet | 0.5 | 5 | 2.50 | .5 Gal/Flush |
| Bathing | 2.5 | 1 | 2.50 | .5 Gal/Min |
| Lavatory | - | - | 2.00 | |
| Dishwasher | 15.0 | .25 | 3.75 | |
| Kitchen Sink | - | - | 3.00 | |
| Laundry | 30.0 | .18 | 5.50 | 35 Gal/Load |
| Utility | - | - | 1.25 | |
| 68 Percent Reduction | | | 20.50 | Gal/Person/Day |

APPLICATION EXAMPLES OF MINIMUM FLOW

Several examples of actual flow reduction applications will illustrate the types of problems that have prompted the use of the technology.

Dodge Ridge Ski Area

In 1973, Dodge Ridge was faced with closure due to a continuous surfacing of wastewater from an existing leach field. Installation of 0.5-gallon-per-flush toilets reduced their waste flow from 80,000 gpd to 10,000 gpd. The field has not surfaced since; a periodic water shortage was eliminated; and a $500,000 connection to the Pinecrest community sewerage system, to be made two years later, was not required.

Carlson Residence

In 1979, a home was purchased and a five-person family moved in. Shortly thereafter, they were notified by the health department that wastewater surfaced from the leach field serving their residence each winter, and had prompted numerous complaints from neighbors, due to odors. Rather than replace the leach field, as requested by the health department, 0.5-gallon toilets and .75-gpm showers were installed and no surfacing occurred during two subsequent winters. This winter was above average in rainfall.

Badger Pass Ski Area

In 1976, the Badger Pass Ski Area installed oil flush toilets with a septic tank and leach field system for gray water disposal from the lodge. In 1978, it was determined that the oil flush system had to be removed due to problems discussed earlier in this paper. By installing 0.5-gallon-per-flush toilets, it was shown that the gray water system could handle the total flow from the lodge. Surface and subsurface monitoring of the leach field for two years has proven the validity of the approach.

Red Corral Commercial

One business was served by a small septic tank leach field on a lot where the owner wished to construct seven more non-water intensive commercial spaces. Due to limited area, it was proposed that the existing building be converted to, and the new buildings constructed with, 0.5-gallon-per-flush toilets and spring-loaded faucets. The existing system is now serving the complex and 100 percent expansion area is available.

INTEGRATED WATER MANAGEMENT

A retirement community is currently planned for construction in 1981-82, which will utilize an integrated water management approach throughout. One of the prime objectives of the project is to reduce ongoing costs to the residents. Table 4 presents the type of buildings to be constructed for Pioneer Junction[6] in Amador County, California.

Table 4. Pioneer Junction Construction Types

| Type Construction | Units |
|---|---|
| Cluster Residential | 298 Residences |
| Retirement Apts. | 60 Apartments |
| Medical Clinic | - |
| Offices | - |
| Commercial | - |
| Motel | 60 Rooms |
| Restaurant | 120 Seats |

The following will be a brief summary of the analysis of the impacts of a design utilizing minimum flow technology. Although the development includes other flow reduction techniques, such as proximity control faucets, the major fixture changes involve those shown in Table 5.

Table 5. Fixture Characteristics - Minimum Flow

| | |
|---|---|
| Toilet: | 0.5 Gallons/Flush Air Assist |
| Bathing: | 0.5 Gallons/Minute Air Assist |
| Laundry: | 30 Gallons/Load/Front Load |

The relative cost of these fixtures installed when compared to conventional are shown in Table 6.

Table 6. Estimated Installed Fixture Costs

| | Conventional | *Minimum |
|---|---|---|
| Toilet | $210 | $496 |
| Shower | $110 | $330 |

*Includes Air Equipment

The collection system costs were determined through analysis of conventional gravity and pressure sewer alternatives for both flow levels. The gravity alternative was the least cost project for conventional flows and a pressure collection system for minimum flows.

The treatment plant in both cases is a completely housed fixed film reactor designed specifically for the flows and strengths of each alternative. The waste characteristics for minimum flow were obtained through sampling of actual flows from a minimum flow installation.(7) The plant was selected for its low operating costs and reliability. Effluent disposal is by subsurface discharge.

The capital costs of the least cost alternatives for both flows are shown in Table 7.

Table 7. Water-Related Capital Costs

| | Conventional | Minimum |
|---|---|---|
| Fixtures | $ 235,400 | $ 603,900 |
| Sewage Collection | 417,500 | 341,400 |
| Sewage Treatment | 375,000 | 160,000 |
| Sewage Disposal | 109,000 | 34,700 |
| Total | $1,136,900 | $1,140,000 |

The capital costs are practically the same for both alternatives as can be seen from Table 7. The next analysis was annual operating costs. The only phase of this analysis that may not be familiar to the reader is water heat energy costs. The only energy available at the development is electricity projected at $.088 per kilowatt hours (KWH). Using this energy source at a heating efficiency of 80 percent and a water cost of $1.35 per 1000 gallons, the costs of water used by the various fixtures can be shown in Table 8.

Table 8. Water Use Temperatures and Costs

| Fixture | Temp. °F | Temp. °C | Tempered Cost/1000 Gal |
|---|---|---|---|
| Toilet | Amb. | Amb. | $ 1.35 |
| Bathing | 107 | 42 | 15.26 |
| Lavatory | 105 | 41 | 14.77 |
| Dishwasher | 140 | 60 | 23.32 |
| Kitchen/Other | 105 | 41 | 14.77 |
| Laundry (Ave.) | 105 | 41 | 14.77 |

The resulting annual costs of water-related activities for the community are shown in Table 9.

Since the capital costs are the same, this savings accrues to the owners. In addition to the economic savings, a resource savings accrues as shown in Table 10.

Table 9. Water-Related Annual Costs

| Item | Conventional | Minimum | Saved |
|---|---|---|---|
| Water | $ 35,600 | $ 11,800 | $ 23,800 |
| Water Heat | 179,500 | 80,200 | 99,300 |
| Fixture O&M | -0- | 3,230 | ( 3,230) |
| Sewage Collection | 2,500 | 5,000 | ( 2,500) |
| Sewage Treatment | 36,000 | 13,000 | 22,500 |
| Total | $253,600 | $113,230 | $139,870 |

Table 10. Annual Water and Water Heating Savings

| | Conv. | Min. | Saved | % Saved |
|---|---|---|---|---|
| Water Mil. Gal. | 26.38 | 8.73 | 17.65 | 67% |
| Heat Energy Million KWH | 2.24 | 1.00 | 1.24 | 55% |

The ultimate objective of the project was a savings to the residents. This savings, based on equivalent residential flows, is shown in Table 11.

Table 11. Annual Equivalent Living Unit Costs

| Item | Conventional | Minimum | Saved |
|---|---|---|---|
| Water | $ 73 | $ 24 | $ 49 |
| Water Heat | 359 | 160 | 199 |
| Sewerage & Fixtures O & M | 77 | 43 | 34 |
| Total | $509 | $227 | $282 |

Based on 500 Equivalent Living Units

This project points out that the benefits of significant flow reduction cannot be fully assessed with a complete analysis of the impacts on both capital and ongoing costs to both the utility and the user for, in fact, they are one and the same.

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# TECHNICAL REQUIREMENTS FOR LOW-FLOW DEVICES

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## ABSTRACT

There are many technical problems that we, manufacturers of plumbing products, are aware of. Low flows, pressure fluctuations, pressure regulation, solids transportation, ad infinitum. We, individually and collectively, have some answers to these problems. Some of these answers are available now, to put to use. However, there are some problems that cannot be answered because of the confusion in codes. Where a solution is good in one code area it may not apply in another area. The systems of today do not lend themselves to solutions based on new system types. We, P.M.I. and our individual companies, are ready to work toward the end of conserving water resources. We feel we have the knowledge from experience and the capabilities to contribute to the solution of "our" problem and should be in any and all discussions of the planning and resolution of this gigantic and grave problem.

## INTRODUCTION

I'm here today representing P.M.I. Plumbing Manufacturers Institute, an organization to which my company and I belong, is a trade association of leading manufacturers of plumbing products, including fittings, trim, fixtures and appliances, which is a broad representation of industry manufacturers.

We, the manufacturers, believe we have an obligation to provide safe, sanitary, functional products to the end users. We constantly work on standards committees and with code authorities, bringing different fields of expertise to bear in the preparation of standards which protect the users of our products.

P.M.I. has long been the leader in espousing water and related energy conservation and in bringing rationality to regulation of our products and installation practices for such products. We are performing valuable public service by innovations in the field of resource conservation.

There may be some of you who believe the water problem is a recent one. Quite a number of people have had an interest in this for a number of years. I have been designing faucets for nearly 40 years and at all times the flow rate of 3 gpm was a target for showerheads. While my work with water closets has been mainly from the ballcock/flush valve side, we were always working to get a reduced water requirement flush. Even so, the flow rate for the ballcock was, and is, required to be rather high and noise free.

My point here is that manufacturers of plumbing fittings and fixtures have been aware of and have wrestled with the water resources problem for longer than I can remember. We have a fountainhead of experience and knowledge that is there for the asking.

One of the largest problems manufacturers have is the variety and inconsistency of codes and the numerous certifications required. In addition, there are areas where these codes overlap, causing many problems of compliance to the plumber, contractor, wholesaler and manufacturer.

The second largest problem in achieving a reduction in potable water consumption, to this time, is the general public. People in most areas of the United States have become accustomed to "all I want." So, the manufacturers of fittings have gone along, and in fact, specifications and codes for flow rates have, in the past, been minimum rather than maximum. These flow rates were established long ago, by code and standard formulating organizations, not by manufacturers.

At the moment there are many areas which have flow rate limits while many other areas have no such requirements. Enforcement of the flow rate requirement is not at all well done, where low flows are mandated. However, at the present time, with some areas of the United States requiring flow limiting and with other areas not wanting it, some manufacturers make two versions of each faucet. One, unlimited as they have always been, and another almost identical to the first except that it is flow limited. The flow-limited version is manufactured to a specified flow rate or to a standard adopted by several code agencies. As you can see this requires more paperwork and large inventories are required to be able to ship on time. Without the inventory the product is made to order, which delays deliveries and increases cost -- which, of course, are passed on to the end user. Other manufacturers make all their faucets flow limited. Now this holds down costs and makes for much faster deliveries but, at the same time, it causes field problems. Many, many complaints from irate customers are received because of flow and the manufacturer is constantly defending his product from those who do not understand the consequences of the flow requirement in their area or from persons in areas where no flow requirement is mandated. However, most installers know that the flow-limiting devices are rather easily removed or changed. In areas where flow rates are not limited many of the flow-limiting devices are removed. A lot are removed in areas of low-flow requirements.

Another problem. The water transport system is totally integrated. From source through disposal, one component cannot be appreciably altered without upsetting the system. We, manufacturers, are more than slightly aware of this. One major aspect of this total system is the volume of water required to move solid waste through the drainage component. While fitting manufacturers can produce any variety of low-flow fittings and fixture manufacturers can produce low-volume-usage fixtures, there is a limit to these reductions for adequate drainage through in-place systems. For years it has been possible to make water closets, flush on very little water, in the laboratory. These require more precision in manufacturing and thus are more expensive. However, the D.W.V. systems in place a different environment from the lab and there are as many "environments" as there are installations. This means the water closet must be made to function with the worst average system into which it might be installed.

If the parameters of new systems could be spelled out and all new systems were rigidly held to these parameters, then we could design components toward the goal of reduced water use. It would, of course, leave the problems of present systems to be coped with, but these hopefully will "fade out." There are many innovations which have been looked at by current manufacturers and by independent firms and persons. Some of these are practical with today's systems. Some require a change in our thinking but most are more costly.

There is another large problem which exists in flow limiting of showers. We all, I'm sure, have at least heard of, if not in fact said, "I'm taking a shower, don't anyone use any water." The reason for this is pressure fluctuations. When you go to take a shower, you set the temperature for the shower by allowing a specific proportion of hot and cold water to pass to the showerhead. As pressures in the supply lines vary, the proportion changes and, consequently, the outlet temperature changes. When these occur rapidly, there a shock potential, resulting in sudden reaction by the bather which could culminate in injury. Wide sudden fluctuations can and have resulted in severe burns. This is an historical problem; however, when we limit the flow at the point of easiest access, the showerhead, we have greatly magnified the problem of sudden and drastic temperature changes.

Where before the limiting requirement, a pressure fluctuation of 10 psi, did not cause too much temperature change, that same 10 psi change now can cause as much as a $25^{0}$ F change in outlet temperature. We, as an industry, are having to work and live with this. Each case that comes up has to be handled upon its own merits. The severe cases are caused by poorly designed supply components (of the total system) and/or where the distribution component is totally inadequate. The fitting manufacturer is now expected to come forth with a panacea for multiple component problems.

When the first words were out about flow-limiting showerheads, we, as individuals in our industry and collectively as P.M.I., presented this reality to various code agencies, one of which was California. Their response was, "We have tried the flow restriction in showerheads in several institutions and have had no reporting of such occurrence; therefore, we shall proceed." So here, also, we have a problem in low flows and that is, getting the message across to those in positions to write and specify, that there are specific fluid mechanics problems, all interrelated to the total system. There is, however, an answer now to this pressure fluctuation problem. Even though our industry has for years had pressure-balanced valves which maintain the outlet proportion, irrespective of pressure fluctuation in the supply lines, most users do not know this and specifiers, contractors and plumbers do not recommend these, I presume because of cost. These valves hold the proportion so that the temperature never changes beyond $\pm 3^0$ F. An additional safety feature of pressure-balanced valves is, if one supply fails the nonfailed line is shut down to under 10% of the original flow, which in most showers is a dribble of water from the showerhead.

There are many more specific problems that the manufacturers of plumbing products have been aware of for years. Each of us is doing research or has done research on many of the problems that need to be solved to retain our potable water resources. We are willing and eager to be active in any work that will preserve our country's future.

We, P.M.I. and the total plumbing industry have, collectively, hundreds of people who are astute in their fields of endeavor and can contribute much to the cause and prevent lost time in achieving a viable end. Again, each manufacturer and P.M.I. are available--and who should know more or should be able to contribute more than the manufacturers of plumbing products?

# A MODEL FOR THE TRANSPORT MECHANISMS OF SOLIDS IN BUILDING PIPE DRAINS

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## ABSTRACT

The requirements for potable water conservation have resulted in the introduction of low water usage devices and plumbing fixtures in buildings. Reductions in the quantity of water discharged into the gravity drainage plumbing system can result in inadequate transport of wastes after entry into the drain pipes.

Currently, studies* of the transient partially-filled pipe flow with solids in pitched horizontal drains include analytical modeling of the hydraulic/solids interactions and experiments to develop a data base for validation of design methods or empirical correlations applicable to pipe sizing methods for the plumbing drainage system. Initial results from the research on transport mechanisms for solids required for sweeping solids through pitched drain pipes are presented. The modeling parameters and test data for the flow characteristics, solid size, pipe diameter, and pitch of the pipes are discussed. The dependence of the transport phenomena on the depth of the wastewater stream, the length to diameter ratio of the solids, pitch of the pipe, and wall friction are identified as significant parameters. The computed results from the predictive model for the hydraulic forces are shown to be physically consistent.

## LIST OF SYMBOLS

| | |
|---|---|
| $A_W$ | cross sectional flow area at water depth $\delta$ ($mm^2$) |
| $d_B (=2R_B)$ | diameter of solid cylindrical body (mm) |
| $F$ | resultant body force (gm) |
| $F_B$ | buoyancy force (gm) |
| $F_f$ | friction force (gm) |

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| | |
|---|---|
| $F_{HU}$, $F_{HD}$ | hydraulic head force on base areas of body at upstream and downstream condition respectively (gm) |
| $Fr = \frac{V}{\sqrt{gD}} = \frac{V}{\sqrt{gh}}$ | Froude number based on a reference diameter, or depth, h |
| $F_W$ | body weight force component parallel to centerline of pipe (gm) |
| $F_{WN}$ | body weight force normal to wall of pipe (gm) |
| $F_S$ | Force due to surface shear stress on wetted areas (gm) |
| $g$ | gravitational constant (m/sec$^2$) |
| $H$ | depth of water flow, $\delta$, in reference (6) notation |
| $\ell$ | solid body length (mm) |
| $n$ | Manning coefficient of equations 9a, 9b |
| $\mathring{Q}$ | flow rate of water ($\ell$/s) |
| $N_B$ | numerical buoyancy factor, $0 \leq N_B \leq 1$ |
| $N_H$ | numerical hydraulic head force factor, $0 \leq N_H \leq 1$ |
| $s$ | pipe pitch |
| $R_B$ | radius of cylindrical solid body (mm) |
| $R_H$ | hydraulic radius of water flow of depth $\delta$ (mm) |
| $R_P$ | pipe radius; in reference (6) $D = 2\ R_P$ |
| $x$ | axial distance in drain pipe test rig, reference (6) |
| $\delta$ | depth of water flow in pipe (mm), where subscripts U,D denote upstream or downstream depths, respectively |
| $\mu_f$ | coefficient of friction between solid and pipe wall |
| $\sigma=\rho_B/\rho_W$ | specific gravity |
| $\rho_B$ | density of solid body (gm/cm$^3$) |
| $\rho_W$ | density of water (gm/cm$^3$) |

## INTRODUCTION

The transport of waste solids from plumbing fixtures within gravity-driven building drainage systems is, to a large extent dependent on the maintenance of sufficient wastewater flow depth in the pitched drain pipes. The prediction of waste solids transport under representative conditions for partially-filled pitched pipes requires development of the interrelationships between the controlling transport parameters, e.g., time-dependent wastewater flow rates and depth, the dimensions of the solids, the pipe diameter, pitch and internal surface conditions (which affects the wall friction between the solids and/or film lubrication). Similar partially-filled pipe flow with solids occurs in sewer mains except under "flooded" conditions. The reduction of water discharged from fixtures, such as water closets or appliances, with reduced quantities of stored water or decreased flow rates, can result in lower pipe sweeping velocities or reduced solids carrier capability in conventional sized drain piping. Alternatively, in new building design, smaller diameter drain pipes which maintain satisfactory solids movement with smaller quantities of water are feasible. The study of characteristics of the flow and interactions with solids has become the subject of recent drainage research on effects of reduced water usage in water conservation programs.

A major criteria in design of building drainage systems is to prevent full bore wastewater flow in the drainage network while providing adequate solids waste transport. The requirement for partially-filled pipe flows in the branch drains and building drains (the laterals to onsite treatment systems or the public sewers) is based on a need to retain a clear air passage throughout the pipe network to prevent trap seal failure.

The initial developments of computational techniques derived from theoretical force and momentum equations for solid body transport and surrounding flows was reported in (1,2,3). Although the feasibility of the computational techniques was demonstrated, the lack of agreement between predicted and experimental results indicated the need for further research to refine the preliminary models for the hydraulic and solid body interactions. Experimental measurements were reported for motion of large solids (4) (such as sanitary napkins in long hospital building drains) and the transport of cylindrical waste solid simulants with transient wastewater surge characteristics (5,6,7). The theory and experimental test data indicate that transport with flows (established either from actual water closet plumbing fixtures or laboratory experiments with a controlled discharge tank) in pitched drains cause the bodies initially at rest or introduced with small velocities to undergo an early acceleration followed by a gradual deceleration. Observations of the phenomena show that following the surge peak the depth of the water in the pipe decreases and the solid velocity decreases or the body may be deposited within the pitched drain pipe; subsequent wastewater discharges from the same or other fixtures then can convey the solids to the soil stack or beyond the building through the lateral drain.

Experiments with reduced flows from water closets show flow depth reductions in the drain and indicate enhanced probability of solid depositions in long pipes (4,6,7). It is apparent that under such conditions supplementary wastewater flow is required for solids removal from the building drainage systems and laterals with low flow fixtures. Sources for additional water-borne transport are either repeated flushing of the water closet, other fixture discharges, or by release of stored grey water.

The attenuation of the input surge wave along the length of the drain results in decreased depth of water and an increase in the time interval for passage of the surge wave which reduces the transport effectiveness (sweeping of solids) in long drains (1,8). The prediction and measurement of this phenomena is of significance in the context of evaluation effects of reduced water consumption. Similar effects of reduced flows in sewers is discussed in the summary of experiences (9) during the California 1977 drought. With flow velocity reductions abnormally large grit (solids) load deposits accumulated and were only cleared when storms occurred after the drought; however, a "stronger" older sewage was reaching the plants. With the exception of the cases where infiltration/ inflows into sewer lines from ground waters occurred, some benefits of lowered water usage were identified at the wastewater treatment facility. The provisions for sweeping of solids or establishing a carrier flow to provide waterborne transport is of considerable concern for designers of ultra low flow installations (10); for such applications the projected level of water usage is one-third of that conventionally experienced and under those aggravated conditions new approaches for applications of stored grey water are under consideration to provide sweeping in the drains.

The theoretical approach to solve the problem of solid transport in the waste stream requires simultaneous solution of the governing fluid momentum equation with the continuity equation and the equation of the motion for the solid. Currently, research efforts are focused upon more rigorously defining the model for the forces acting on the solids in the time-dependent partially filled pipe flow. Details of the mechanisms of hydraulic interactions at the solid interfaces are provided from the increase in experimental results to improve the preliminary model adopted in earlier efforts (1,2,3). The derivation of an improved force model is presented for solid cylindrical simulated waste bodies applicable to: (a) the general computer program (3) for time dependent motion of solid materials; (b) for analytical determination of the breakaway of a deposited solid (incipient motion from rest); (c) for steady motion of the solid. The parameters investigated are the interrelationship of flow rate, pipe size and pitch with the length to diameter (fineness) ratio of the cylindrical bodies, the water depth to body diameter ratio and the wall friction.

This report presents a summary of:

(i) considerations involved in modeling forces on solids for the pipe flow regimes likely to be encountered in drains

(ii) typical experimental data for understanding the hydraulic-solids interactions

(iii) the results of a detailed modeling study

(iiii) the application examples for determining pipe sizes and waste water flows required for incipient motion of the body.

HYDRAULIC-SOLID BODY INTERACTION

In order to solve the equation of motion for solids transported in partially-filled drain pipe flow requires the analytical development of a model for the forces acting (on the body) due to hydraulic interaction and pipe wall friction. The description of the forces acting on the body for coupling the fluid momentum effects derived from the surrounding flow conditions is analytically complex. Swaffield (3) developed a simplified model of the body forces for large solids, (see Appendix). The force model was included in a general computer programs for subcritical and supercritical pipe flows. The capability of establishing the boundary condition at the moving surface of the solid and obtaining numerical solutions based upon the forces assumed acting was demonstrated, however, agreement with experiments was not satisfactory. The need for refining the model or introduction of empirical factors was recommended in order to bring the predicted results into agreement with laboratory tests.

The numerical solution of the hydraulic parameters is based upon the method of characteristics. In this technique, the (characteristic) waves intersect at a point which is dependent upon the flow regime. Classification of the flow regimes for unsteady and steady state is based upon the Froude number (with possible modification for hydraulic dimensions in partially-filled pipe flow):

$$F_r = \frac{V}{\sqrt{gD}}$$

For partially-filled pipes the flow regimes may be identified that affect the initial conditions on which subsequent solutions may be based.

(1) Subcritical flow, Froude No. = $\frac{V}{\sqrt{gh}} < 1$

Here the local wave speed in surge type flows exceeds the flow average velocity, thus waves may be propagated both upstream and downstream in the flow, i.e., $c > V$.

(2) Supercritical flow, Froude No. = $\frac{V}{\sqrt{gh}} < 1$

Here the local wave speed in surge flows is less than the average flow velocity at that section and hence waves cannot be propagated upstream, i.e., $V > c$.

The flow regime applicable to any partially-filled pipe flow may be determined by a comparison of the flow normal and critical depths (2). The tracing of the body motion for both location and velocity will depend upon a pseudo-characteristic line in the space coordinate and time variables.

Parametric modeling for the forces acting on the solids resulting from hydraulic interactions may be based upon (i) flow energy exchange and energy losses, or (ii) the derivation of the detailed pressure head acting over the upstream nose area and downstream base area, as well as the shearing flow streaming past the wetted (immersed) surfaces, or (iii) defining the net forces as an appropriate force or drag coefficient thereby "lumping" all fluid velocity effects without details of pressure and shear stress distributions. To represent the relative velocity of the water with respect to the solid (to define the "leakage" or streaming past the solid) the description of the flow passing the body must be analytically developed; that flow and surface shear stress on wetted surface areas of the body can be applied in (ii) or (iii).

For unsteady motion, the time-dependent depth of the upstream (approach) flow to the solid(s) must be considered for the depth less than, equal to, or exceeding the height of the body. Also, the geometrical representation of the characteristics of the solid(s) mass for regular or irregular cross sections as a basis for determining reference areas (over which pressure and shear stresses act) or as reference areas in applying nondimensional force coefficients must also be developed.

Three possibly distinctive conditions related to the initiation of motion of the body from rest may be identified: (i) the water surge (wave) is large and scoops up the body and carries the solid along the wavefront as a "floating" waterborne object with negligible flow energy losses; (ii) impulsive forces are initially developed due to a rapid momentum exchange (impact) between the water and solid(s) over a small time interval followed by the continued buildup of water and solid interactive set of transport forces; (iii) a gradual buildup of transport forces resulting from interactions of hydraulic head due to water depth, shear and buoyancy forces, with the friction and weight component forces as shown in figure 1, which results in the initial solid(s) acceleration. When the upstream flow approaching the solid inundates the body (i.e., complete submergence condition where buoyancy forces tend to be equivalent to the weight for specific gravity near unity) the dominant dynamic forces are due to the hydraulic head forces and possibly shear stresses on the surface of the solid.

The forces shown in figure 1 are due to the hydraulic pressure distributions, shear and friction, buoyancy, and weight components. Discussion of the derived model for the solid body analysis is presented in (11) with the analytical derivations which include body size, pipe diameter, and pipe-body wall surface friction and the pitch of the pipe; the model is generally applicable to the flow regimes described above with the pressures properly described when the depth exceeds the body diameter.

For the general case of building drainage systems, two types of solid motions must be considered in an analytical development. Those are: (i) the motion of the solid subsequent to injection into the flow with a downstream velocity to be representative of water closet discharges; and (ii) the motion of the deposited solid(s) from the condition of the body initially at rest (to represent one or more depositions along the length of the drainage pipe). With very low water usage, solids can be transported over successive intervals over arbitrary pipe lengths and be redeposited on the pipe wall; the flow from any plumbing fixture discharged can be the wastewater source to initiate the motion.

The conditions considered in this report represent both the breakaway of a solid from rest (as the forces gradually build up) and also the case of steady motion. The initiation of motion for the deposited stationary solid case represents the severest set of conditions (as compared to the solid injected with finite velocity) relative to the effectiveness of wastewater flow for transport purposes. Since the body is at rest initially, the forces causing acceleration are required to increase to the level which causes breakaway; that situation corresponds to the change from static equilibrium with the larger static friction force than that which exists after motion occurs when a reduced "lubricated" film friction contact condition exists. Consequently, to initiate motion, larger forces are required as compared to the condition for maintaining the body in motion; development of the larger forces require a greater amount of water. In the case of the stationary solid, as well as a moving solid, the body acting as an obstacle to the flow causes an increase in the water depth upstream which increases the possibility of the surge developing into an instantaneous full bore flow condition (closure of the pipe diameter). If the flow becomes full bore (plug flow), then significant air pressure reductions can occur in the drain causing a loss of trap seals.

## EXPERIMENTAL RESULTS

Laboratory experiments with surge flows and nearly steady uniform flow contribute insights useful in the derivation of a simplified solid body force model of the hydraulic and solids interaction phenomena. Results from tests in a 75 mm diameter pipe are reported (5,6) and laboratory tests in a 100 mm pipe are continuing to develop data for a wide range of flow and solids parameters. Additional compilations of test results and details of development for data analysis are presented in (12).

In long partially-filled drainage pipes the shape of the input surge wave is altered due to energy dissipation during passage along the conduit. In the absence of any downstream inflow from other branch connections the depth of water decreases, i.e., the wave attenuates, and the time for the surge to pass any station increases indicating a reduced flow rate in the downstream direction. The analysis and the computer program for numerical solution for flow attenuation (8) provides the capability of determining the flow properties. The favorable comparisons of the predicted results with test data are shown in figure 2 for the case of pipe surge flow without solids. The laboratory test data was obtained in the 5 meter length instrumented test facility* (5,8).

Local disturbances in the surge flow profile or steady flow profile (observed and measured) result from the presence of a solid body acting as an obstacle to the flow. When the solid is stationary or moving with a velocity less than the water velocity the flow depth is locally increased at the upstream end and decreased in the wake downstream of the body (as shown in the sketch, figure 1). Test results obtained in a 100 mm diameter pipe are shown in figures 3 and 4. In figure 3, the effect of two different solid bodies on the surge profiles where the depth changes across the body have locally altered the flow is shown for a two liter tank discharge volume. The change in depth across the solid in the case of (nearly) steady flow is shown in figure 4 for three different solids. The test data indicates that the change from upstream to downstream depth is a function of the fineness ratio of the body ($\ell/d_B$). Since the water velocity exceeds the solid velocity a wake region appears ahead of the body with a smaller depth than upstream.

The velocities of various bodies for several flow conditions in a 100 mm diameter pipe are shown in figures 5, 6, and 7 and in table 1. The effects of the several variables, such as volume of water discharged, the pitch of the pipe, the location of the solid in the pipe and associated water depth, the specific gravity of the solid, as well as the fineness ratio are illustrated. Figure 5 shows the dependence of the velocity on water volume discharged and stations along the pipe length (with implied change in water depth). Typical results in figures 6 and 7 show the strong dependence of the solid velocity on body size, specific gravity and distance (or time) for the two types of flows considered, surge and near steady conditions.** In these examples the solids were initially at rest close to the pipe inlet. Gradual acceleration from the static equilibrium condition at rest is displayed; the experiments show that acceleration to peak velocity requires one to two meters (an almost instantaneous impulsive reaction would be characterized by a stepwise acceleration). The observations and test measurements provide a basis for assuming the gradual force buildup conditions in the derivation of the breakaway and near equilibrium modeling for both surge and nearly constant velocity conditions. The quantity of flush ahead of the solids, when the solid cleared the drain, ranged from 10 percent to 40 percent in the data associated with table 1. Those quantities of water which stream past the solids are then no longer serving in the transport mechanisms. In table 1 and figure 8 typical results are shown for the stoppage of the solid bodies

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* Plumbing Research Laboratory, National Bureau of Standards.

** Test results from the 15 meter 100 mm diameter pipe were obtained from the collaborative NBS program with the Drainage Research Group, Brunel University, United Kingdom.

Table 1. Solid Velocity and Distance Traversed for Cylindrical Solids in 100 mm Diameter 15 Meter Length Drain*

| Pipe Pitch | Solid Size $d_B x \ell$ (mm) | Water Closet[1] Flush Volume($\ell$) | Average Velocity[2] (m/sec) at Station | | | Distance Traversed (m) |
|---|---|---|---|---|---|---|
| | | | 2(m) | 4(m) | 6(m) | |
| 1/300 | 37X80 | 10.5 | 1.436 | 1.201 | - | 13.5 |
| 1/150 | 37X80 | 10.5 | 2.004 | 1.288 | 0.765 | Cleared |
| 1/80 | 37X80 | 10.5 | 1.937 | 1.372 | 0.927 | Cleared |
| 1/40 | 37X80 | 10.5 | 1.944 | 1.637 | 1.208 | Cleared |
| 1/300 | 37X80 | 6 | 1.715 | 0.872 | - | 8.785 |
| 1/150 | 37X80 | 6 | 1.806 | 0.921 | - | 9.79 |
| 1/80 | 37X80 | 6 | 1.797 | 0.989 | 0.571 | 11.53 |
| 1/40 | 37X80 | 6 | 1.739 | 1.218 | 0.950 | Cleared |
| 1/150 | 37X42 | 10 | 2.083 | 1.283 | 0.818 | Cleared |
| 1/80 | 37X42 | 10 | 2.115 | 1.405 | 1.039 | Cleared |
| 1/40 | 37X42 | 10 | 2.112 | 1.584 | 1.234 | Cleared |
| 1/150 | 37X42 | 6 | 1.762 | 0.982 | 0.539 | 11.83 |
| 1/80 | 37X42 | 6 | 1.776 | 1.073 | 0.713 | 13.39 |
| 1/40 | 37X42 | 6 | 1.817 | 1.292 | 1.052 | Cleared |
| 1/150 | 25X80 | 10 | 2.197 | 1.389 | 0.933 | Cleared |
| 1/80 | 25X80 | 10 | 2.309 | 1.532 | 1.095 | Cleared |
| 1/40 | 25X80 | 10 | 2.195 | 1.686 | 1.228 | Cleared |
| 1/150 | 25X80 | 6 | 1.868 | 1.199 | 0.661 | 12.94 |
| 1/80 | 25X80 | 6 | 1.890 | 1.236 | 0.822 | Cleared |
| 1/40 | 25X80 | 6 | 1.934 | 1.373 | 1.132 | Cleared |

( )[1] European washdown water closet.
( )[2] Solid initially at rest 0.8 m from inlet to drain. Average of 10 tests.
Note: Specific gravity of solids - unity.

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* From test series of collaborative program at Brunel University. Drainage Research Group, Uxbridge, U.K.

which did not clear the drain. The potential for blockage when multiple solids are transported with reduced flow in the drain pipe is one of the concerns in the efficiency of solid transport with reduced flow and is the subject of future research.

## FORCE MODEL FOR SOLID - RIGID RIGHT CIRCULAR CYLINDER

The model developed for forces on a rigid right circular cylinder within a pipe, as shown in figure 1B, is based upon the observations and derived results of the testing program. The simplified model for such solids assumes that a gradual change in water depth adjacent to the body occurs; no impulsive forces are assumed, and no angle of attack force loads from the body, tilted with respect to the stream, occur. The body is assumed to maintain contact with the pipe wall and the orientation of the centerline of the body and pipe remain parallel. Details of the derivation of the equations for the force model and discussion of the assumptions, e.g., neglecting the shear of water streaming past the body, are discussed in reference (11). The forces considered are:

$F_{HU}$, $F_{HD}$ - hydraulic head due to upstream and downstream water depths

$F_B$ - buoyancy force, normal to wall of the pipe

$F_N$ - weight force component normal to the wall of the pipe

$F_W$ - weight force component parallel to the centerline of the pitched pipe in the direction of motion

$F_f$ - friction force at the wall parallel to the centerline of the pipe determined from the product of friction coefficient, $\mu$, for static (dry) or lubricated film condition and the sum of the forces ($F_N - F_B$) perpendicular to the wall

$F_S$ - surface shear force on the solid due to the stream stresses on immersed (wetted) body area; subsequently assumed to be negligible

The appendices of (11) provide the detailed derivation of the force equations; only the final equations are summarized below.

<u>Buoyancy force</u> - The buoyancy force through the center of gravity, $F_B$, is determined from the volume of water displaced and is, therefore, independent of the specific gravity of the solid.

$$F_B = \int_{o}^{\delta} \rho_w d(Vol) \qquad [1]$$

Carrying out the integration and simplifying to a nondimensionalized form, the result is:

$$\frac{F_B}{2\rho_w \ell R_B^2} = \frac{\Pi}{4} + \frac{1}{2}\left[\left(\frac{\delta}{R_B} - 1\right)\sqrt{\left(2 - \frac{\delta}{R_B}\right)\frac{\delta}{R_B}} + \sin^{-1}\left(\frac{\delta}{R_B} - 1\right)\right] \qquad [1a]$$

It is assumed that the body is immersed at uniform depths, $\delta$, over the length, $\ell$; however, a correction factor based upon test observations of nonuniform depth must be introduced. With the body velocity zero, or with the body in motion at less than the water velocity, the water level varies over the body length; as the body approaches the velocity of the water the immersion depth tends to be uniform. In order to take into account the variation of depth across the length on the buoyancy force, the numerical factor, $N_B$, reduces the total buoyancy force (below that for uniform depth) in calculations, where $0 \leq N_B \leq 1$. Since the depth variation along the body length is generally unknown, this calculation procedure provides a method for parametrically determining the effects of the variable depth. An exact solution for displaced water volume would require an integration over the length of the body with known depth profiles from measurements or other analyses. The term $N_B F_B$ will be introduced in the equation (6a) for determining the resultant force acting on the solid.

Hydraulic head forces - The hydraulic forces, $F_{HU}$, $F_{HD}$, on the base areas are obtained by integration of the water pressure distribution over the wetted base surface area to the respective depths, $\delta_U$, $\delta_D$, for the upstream and downstream conditions.

$$F_H = \int_0^\delta pd \text{ (Area)} \qquad [2]$$

Completing the quadrature and simplifying to a nondimensionalized form results in:

$$\frac{F_H}{2\rho_w R_B^3} = \frac{1}{2}\left(\frac{\delta}{R_B} + 1\right)\left[\left(\frac{\delta}{R_B} - 1\right)\sqrt{\left(2 - \frac{\delta}{R_B}\right)\frac{\delta}{R_B}} + \sin^{-1}\left(\frac{\delta}{R_B} - 1\right) + \frac{\Pi}{2}\right]$$

$$+ \frac{1}{3}\frac{\delta}{R_B}\sqrt{\left(2 - \frac{\delta}{R_B}\right)^3 \frac{\delta}{R_B}} \qquad [2a]$$

The exact expressions for hydraulic forces on the upstream area, $F_{HU}$, and downstream area, $F_{HD}$, are obtained by inserting the appropriate values of $\delta_U$, $\delta_D$. The terms, however, may be combined to obtain the net resultant force to simplify the parametric calculations. Those forces act in opposite directions and appear as $F_{HU}-F_{HD}$ in obtaining the resultant force acting on the body. The term $N_H F_{HU}$ will be introduced in equation (6a) as the parametric formulation for the hydraulic base area resultant force. The numerical factor, $N_H$, between zero and unity, scales the value of $F_{HU}$ and thereby parametrically determines the influence of the pressure head force terms. Accurate base area immersion depth data has not been determined for most experiments. For a constant depth this force cancels out (the numerical factor set to zero) and for varying upstream and downstream depths as in figures 3 and 4, the factor $N_H$ is less than unity.

Friction force - The friction force resulting from the forces normal to the pipe wall surface and a coefficient of friction, $\mu_f$, either static (assumed to be the value for "dry" conditions) or for lubricated film conditions is given by:

$$F_f = \mu_f (F_{WN} - F_B) \qquad [3]$$

Body weight force components - The body forces are resolved into two components, one normal to the pipe wall, $F_{WN}$, (aligned through the center of gravity with the buoyancy force) and the other parallel to the pipe wall, $F_W$. For the small angular pitch of the pipe the approximations of $\cos(s) = 1$ and $\sin(s) = s$ are introduced in resolving the weight in terms of the density, $\rho_B$, and volume, $\Pi \ell R_B^2$, as:

$$W = \rho_B \Pi \ell R_B^2 = \sigma_B \rho_W \Pi \ell R_B^2 \qquad [4]$$

with the specific gravity, $\sigma_B = \rho_B / \rho_W$.

Under conditions where the body is completely submerged, then depending on the value of the specific gravity, one or more forces may vanish, e.g., for $\sigma_B \leq 1$, $F_{WN} = F_B$, and then the friction force vanishes.

The summation of forces on the body in the direction parallel to the pipe wall becomes:

$$\Sigma F = F_{HU} - F_{HD} + F_W - \mu_f (F_{WN} - F_B) + F_S \qquad [5]$$

With $F_S = 0$ (assumed to be negligible) the equation of motion for the solid is:

$$\frac{W}{g}\frac{dV_B}{dt} = \Sigma F = F_{HU} - F_{HD} + F_W - \mu_f \left(F_{WN} - F_B\right) \qquad [6]$$

and upon introduction of the parametric factors $N_H$ and $N_B$ the equation becomes:

$$\frac{W}{g}\frac{dV_B}{dt} = N_H F_{HU} + F_W - \mu_f \left(F_{WN} - N_B F_B\right) \qquad [6a]$$

The zero acceleration condition for "breakaway" or steady motion is that the resultant force, $\Sigma F$, equals zero. Three cases correspond to the zero acceleration state:

(i) The body is initially at rest and remains at rest until initiation of motion; this is the "breakaway" condition. The body remains in static equilibrium until that instant when the sum of the forces in the direction of impending motion increases and overcomes the retarding forces in the upstream direction.

(ii) The body has undergone an acceleration to a steady velocity (an occurrence with steady flow in partially-filled pipe or alternatively an instantaneous peak solid velocity in a varying surge flow).

(iii) The body comes to rest in the pipe when the available flow can no longer sustain the body motion (i.e., the retarding forces on the body have decreased the solid velocity).

Short duration small volume surge discharge tests indicate that the three conditions can occur during different time intervals in experiments, figures 6A, B, C, and D. Near-steady flow test conditions show a trend toward the condition (ii), figures 7A, B.

For either conditions (i) or (ii) to initiate or sustain body motion, the resultant force term $\Sigma F$, of equation [6A] is set equal to zero and after simplification yields:

$$\frac{\ell}{d_B} = \frac{\ell}{2R_B} = \left(\frac{N_H}{\sigma_B}\right) \text{X}$$

$$\frac{\frac{1}{2}\left(\frac{\delta}{R_B}+1\right)\left[\left(\frac{\delta}{R_B}-1\right)\sqrt{\left(2-\frac{\delta}{R_B}\right)\frac{\delta}{R_B}}+\sin^{-1}\left(\frac{\delta}{R_B}-1\right)+\frac{\Pi}{2}\right]+\frac{1}{3}\frac{\delta}{R_B}\sqrt{\left(2-\frac{\delta}{R_B}\right)^3\frac{\delta}{R_B}}}{\Pi\left[-s+\mu_f\left\{1-\frac{N_B}{\sigma_B\Pi}\left(\frac{\delta}{R_B}-1\right)\sqrt{\left(2-\frac{\delta}{R_B}\right)\left(\frac{\delta'}{R_B}\right)}+\sin^{-1}\left(\frac{\delta}{R_B}-1\right)+\frac{\Pi}{2}\right\}\right]} \qquad [7]$$

where the factors $N_H$ and $N_B$ represent the aforementioned numerical factors for hydraulic and buoyancy forces respectively with values between zero and unity and $\delta$ is understood to be the upstream depth. Although $N_H$ and $N_B$ are interrelated, they are treated as separate parameters in this study; the variation of depth along the solid is required to develop such an equation.

Examination of equation [7] leads to several deductions based upon the force model adopted. For $N_H = 0$, it is implied that the upstream and downstream base areas have equal depths and in this case $N_B$ should be unity, i.e., the depth about the solid is constant. Hence, the weight force component in the direction of motion is balanced by the wall friction force since equation [7] was obtained by setting $\Sigma F = 0$. This can be recognized from equation [6a] when the quantity $F_W - \mu_f (F_{WH} - N_B F_B)$ is set equal to zero and collecting terms to yield

$$\frac{\ell\Pi}{2R_B}\left[-s+\mu_f\left\{1-\frac{N_B}{\sigma_B\Pi}\left(\frac{\delta}{R_B}-1\right)\sqrt{\left(2-\frac{\delta}{R_B}\right)\frac{\delta}{R_B}}+\sin^{-1}\left(\frac{\delta}{R_B}-1\right)+\frac{\Pi}{2}\right]=0 \qquad [8]$$

Since $\frac{\ell}{2R_B}$ an take on any value, the term in the brace of equation [8] vanishes; the remaining terms are proportional to the weight component and friction force. The condition for $N_B = 0$ represents vanishingly small buoyancy force, possibly due to a sharp drop in water depth along the length of the body or as a result of trickle flow; then the friction retarding is not significantly reduced by the buoyancy force term (due to displacement of the water volume). The change in friction coefficient, $\mu_f$, from a value for dry static condition to a film lubrication condition with a reduced value can be assessed by substituting decreasing values of $\mu_f$. When the weight component force and friction force approach each other and cause the value of the denominator to vanish, then except for $N_H = 0$, the body length to diameter ratio becomes increasingly large. Under that condition there is no retarding force (assuming $F_{HU}>F_{HD}$) to inhibit motion of the body and any finite level of hydraulic pressure force in the direction of motion will cause the body to be set in motion or continue in motion down the pipe. The buoyancy term is negligibly small when bodies of very high specific gravity, $\sigma_B$ factor tends to make $\ell/2R_B \to 0$, i.e., the hydraulic forces are insufficient to initiate motion. A range of numerical examples for various values of the ratio $\delta/R_B$, $\ell/2R_B$, $\mu_f$, $N_H$, and $N_B$ are presented in the following section.

## DISCUSSION OF RESULTS

The calculated effects display the trends anticipated, e.g., a larger friction factor requires greater hydraulic forces to establish the condition for breakaway. The numerical examples provide the quantitative differences as each parameter is changed. The results of calculations and the effects of each parameter indicate that expected effects of varying one parameter at a time computed from equation [7] are shown in figures 9 and 13. Extended results of calculations for a wide range of variable parameters as well as the application to pipe sizing are presented in (11). In the figures, the areas to the right of the curves are regions where the sum of forces acting are positive and will accelerate the body. Those domains to the left of the curve are rejected since the sum of forces are negative (do not reach the null value of $\Sigma F = 0$). The physical explanation is that for any value of $\ell/d_B$ as the as the depth $\delta/R_B$ increases (a) the hydraulic base force in direction of impending motion increases, (b) the increase in buoyancy force reduces the friction force acting in the direction opposite to impending motion. At the points on the curve obtained from equation [7] the resultant forces vanish and for any greater value of the depth the resultant force exceeds zero. The intervals of time required for the forces to attain the levels required for incipient motion will vary depending on the water flow rate profiles as well as the body and pipe characteristics. The effect of increased pipe pitch shown in figure 9 results in a decreased depth of water for the breakaway conditioning. The effect of increasing the friction coefficient shown in figure 10 with all other conditions remaining the same results in a lower water depth for breakaway.

The figures indicate that for the pipe pitch values of s = .02, .04, the increase in friction coefficient requires a greater depth of water for incipient solid motion (breakaway) or sustained constant velocity. The physical interpretation is that the increase in the retarding friction force must be overcome by greater hydraulic and buoyancy forces (associated with greater depth) before the solid can be set into motion or to maintain the solid in motion. When the solid is already in motion then the (lubricated) coefficient of friction may be reduced from the static (dry) equilibrium value (moving from a curve of higher to lower value of $\mu_f$); correspondingly, under that reduced friction level a decreased depth of water is required for a solid with a constant value of length to diameter ratio; that is indicated by shifting from the higher $\mu_f$ value to lower $\mu_f$ value curve on figure 10.

The effect of changes in specific gravity shown in figures 11 and 13 (as expected) indicates that solids of higher density (increasing values of $\sigma$) require a greater depth of water and with reduced density require a lesser depth. The friction retarding force increases with increasing $\sigma_B$, therefore, in order for motion to be initiated or maintained, a greater depth is required to increase both the hydraulic driving force and buoyancy forces. Similarly, in figure 12, when the buoyance factor $N_B<1$ is applied the required depth increases since the friction force increases. Observations from tests show variations of depth along the length of the solid (those results suggest that $N_B$ values ranging from 1/4 to 2/3 may be applicable). Decreasing the effective hydraulic driving force, by reducing $N_H$ in figure 13, increases the depth required. Here, a reduced value of $N_H$ represents the influence of an increase of the depth on the downstream base area of the body relative to the upstream depth (but less than the upstream value) thereby increasing the pressure head force acting opposite to the direction of motion (i.e., a reduction of the resultant hydraulic force in direction of motion). In figure 13, the effect of changes in the specific gravity (1 and .5) and hydraulic factor (1 and .5) is illustrated. In principle, the values of $N_H$ and $N_B$ are interrelated since these parameters represent the influence of varying water depth from one end of the solid to the other end which simultaneously changes the pressure head and buoyancy forces; that interrelationship is required to be developed from further studies. The introduction of the complete force model of equation (6) into the computer programs for the hydraulic-solids interaction has been completed. The initially computed results show very satisfactory agreement between experimental and predicted velocities of the solids (14). That indicates the force model discussed herein has resolved the problem of lack of agreement between theory and experiment.

The applications of the results obtained to pipe sizing are illustrated in figure 14. From the widely accepted empirical equations for water flow velocity and flow rate (simplified by the use of the constant pitch, s, for the pipe)

$$v = \frac{R_H^{2/3}\ S^{1/2}}{n} \qquad [9a]$$

$$\mathring{Q} = \frac{A_W R_H^{2/3} S^{1/2}}{n} \qquad [9b]$$

where the hydraulic radius, $R_H$, and water flow cross-sectional area, $A_W$, are functions of water depth. Then for any given Manning coefficient, n, the assumed constant value for the empirical factor indicating the pipe roughness, the requirements for water velocity and flow rate for breakaway or maintenance of constant velocity in the pipe can be calculated. The problem of developing a correlation between n and $\mu$ requires extensive efforts since the empirical constant n is not only a factor indicative of pipe roughness; it also serves as an adjustment to include other unknowns, e.g., Reynolds number dependency. In figure 14, results are shown for 50, 75, and 100 mm diameter pipes.

From the relationship $\delta/R_B = 2(\ell/d_p)(d_p/d_B)$ the corresponding $\ell/d_B$ values of the solids can be determined from the figures 9-13. For example, for values of $\delta/d_p = 0.1$, $s = .02$, $d_p/d_B = 2$, the size of solids which are at the breakaway from the rest in 50 mm and 100 mm diameter pipes are shown in table 2. For the same water depth and other parameters as shown for each pipe, the listed values of body fineness ratio $\ell/d_B$, represents the upper limit of sizes at breakaway.

Table 2. Body Sizes and Water Flow Requirements (from figures 9-13) $s = .02$, $\delta/d_p = 0.1$, $d_p/d_B = 2$, $\delta/R_B = .4$

| | | | 50 (mm) diameter | | | | | 100 (mm) Diameter | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\sigma$ | $\mu_f$ | $\ell/d_B$ | $\delta$ (mm) | $d_B$ (mm) | $\ell$ (mm) | V (m/s) | $\mathring{Q}$ ($\ell$/s) | $\delta$ (mm) | $d_B$ (mm) | $\ell$ (mm) | V (ms) | $\mathring{Q}$ ($\ell$/s) |
| 1 | .1 | 2 | 5 | 25 | 50 | .3 | .04 | 10 | 50 | 100 | .84 | .21 |
| 1 | .3 | 0.7 | | | 17.5 | .3 | .04 | | | 35 | .84 | .21 |
| .9 | .1 | 2.5 | | | 62.5 | .3 | .04 | | | 125 | .84 | .21 |
| 1.1 | .1 | 1.8 | | | 45 | .3 | .04 | | | 90 | .84 | .21 |

Design charts (intended to serve as a guide for pipe sizing) over a wide range of variables, based upon the breakaway condition, are to be prepared and published as a part of the continuing research program.

## CONCLUSIONS AND RECOMMENDATIONS

A simplified model for the forces acting on a rigid cylindrical solid in partially-filled transient pipe flow was developed. The experimental results provided guidance and insights to understand the hydraulic/solids interactions in deriving the force model. Results of computations for effects of the parameters of pipe pitch, assumed wall friction factors for stationary body conditions and lubricated film conditions, the water depth the solid body fineness ratio and specific gravity are physically consistent. An application of the results illustrates a technique to construct pipe sizing tables or charts. Further development of the method to establish a comprehensive set of design charts is to be undertaken. Additional research is required to accurately define the values of friction coefficients, $\mu_f$, of lubricated flow conditions; that can be accomplished by computing $\mu_f$ from equation [7] with experimental input for constant solid velocity conditions with the depths adjacent to the body precisely measured. The application of the model to obtain the simultaneous solutions for partially-filled time dependent surge flow equations of momentum and continuity with the equation of motion for the solid, following the technique in (3) logically follows. The computer program for the numerical method of solution to determine flow properties and velocity of the solid was modified to include the model presented. The "exact" solutions for the general problem of the transport mechanisms throughout the range of solid velocities thereby eliminates the restrictions to the breakaway or constant velocity set of conditions.

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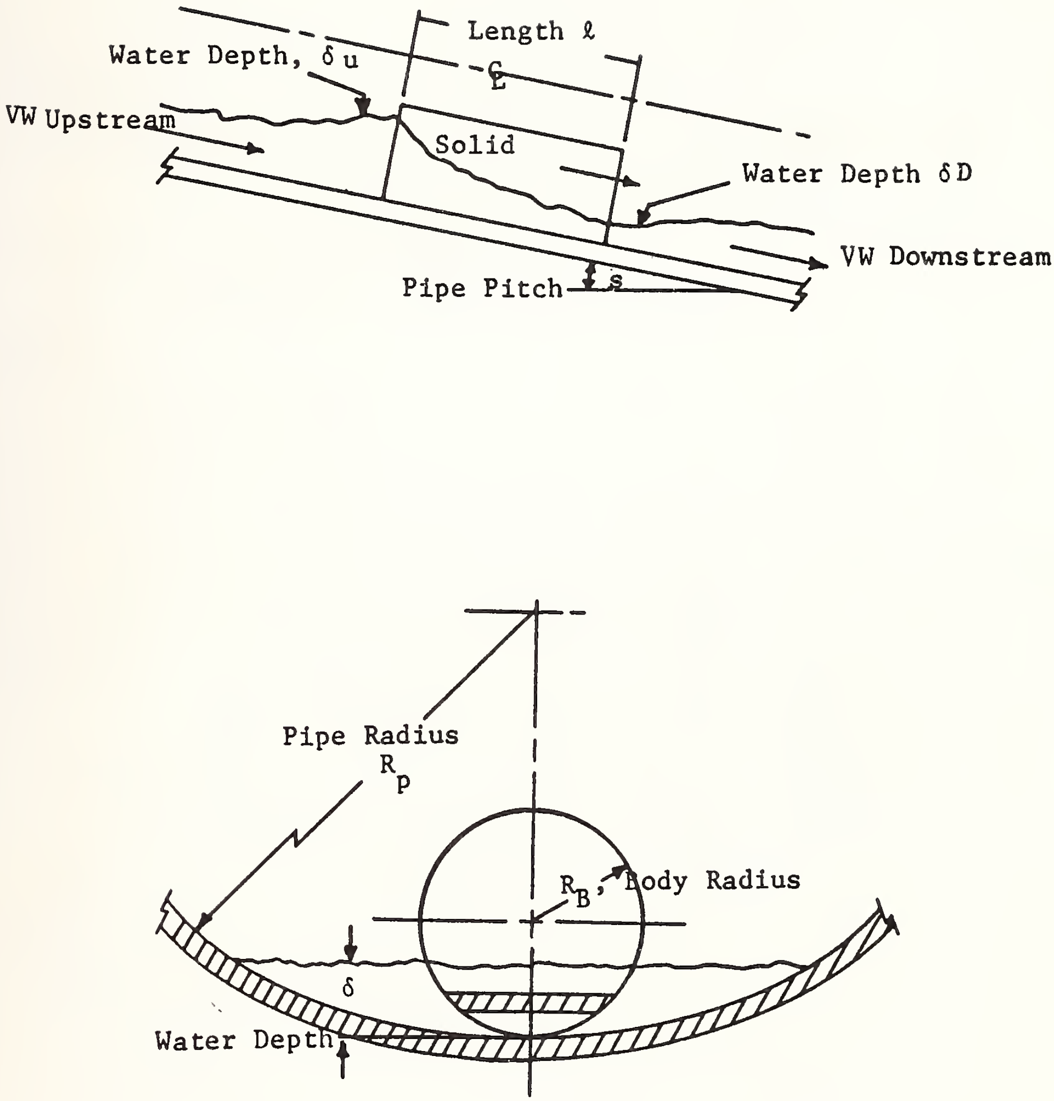
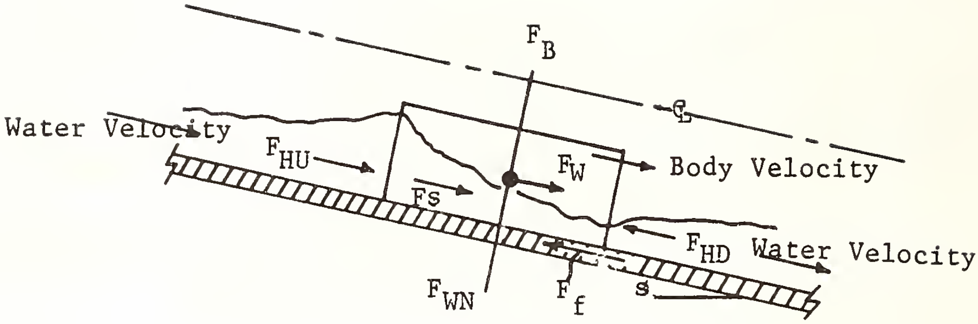



Figure 1-A. Cylindrical solid body in partially filled pipe flow




$F_W$ Weight Component in Direction of Motion

$F_{WN}$ Normal Weight Component

$F_{HU}$ Hydraulic Force Upstream

$F_{HD}$ Hydraulic Force Downstream

$F_B$ Buoyancy Force

$F_f$ Friction Force $= \mu\ (F_{WN} - F_B)$

$\mu$ Coefficient of Friction

$F_s$ Surface Shear Force

Sum of Forces in Direction of Motion

$$\Sigma F = F_W + F_{HU} - F_{UD} - F_f + F_s$$

Figure 1-B. Body force system

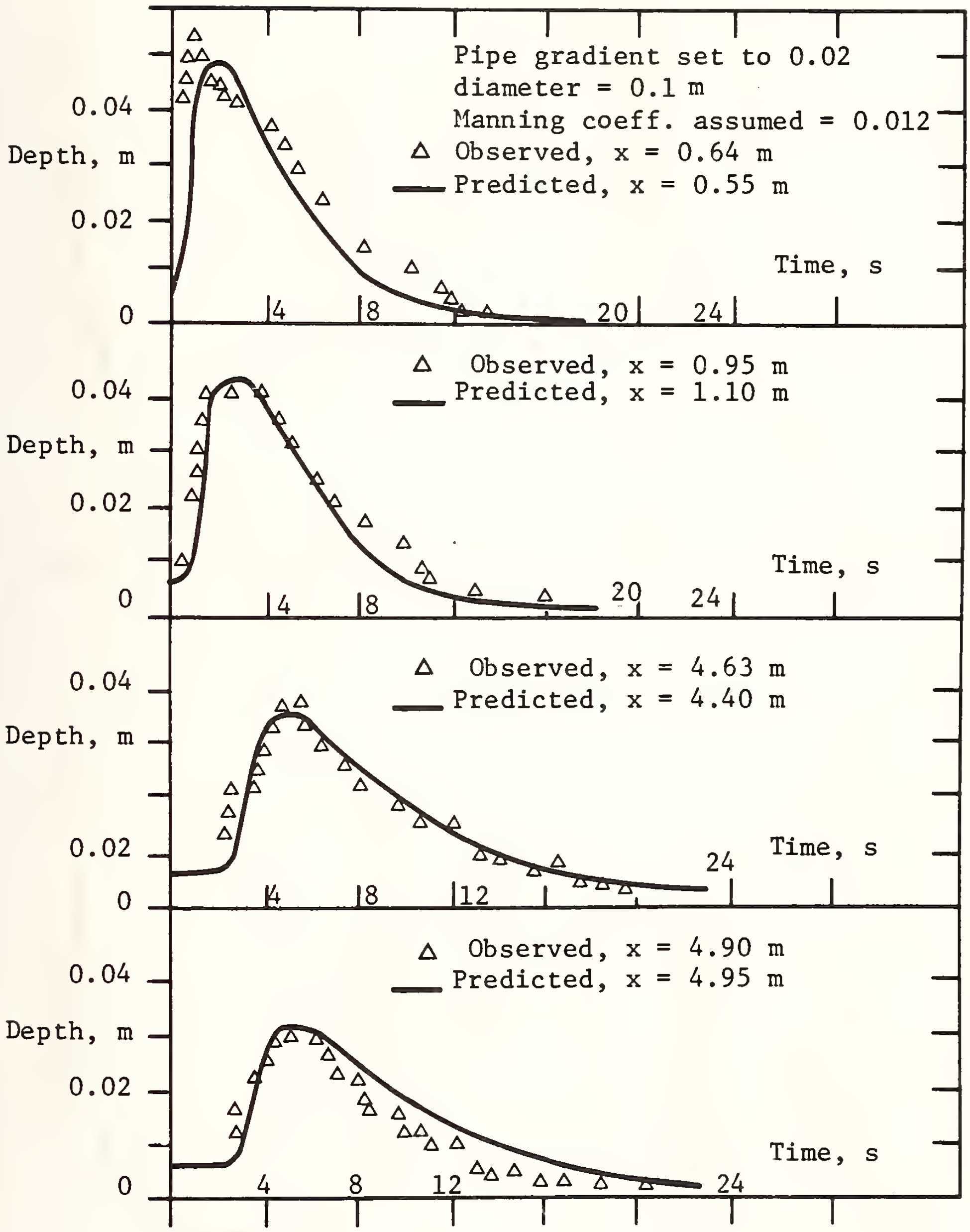



Figure 2. Comparison of observed and predicted water depth vs. time profiles

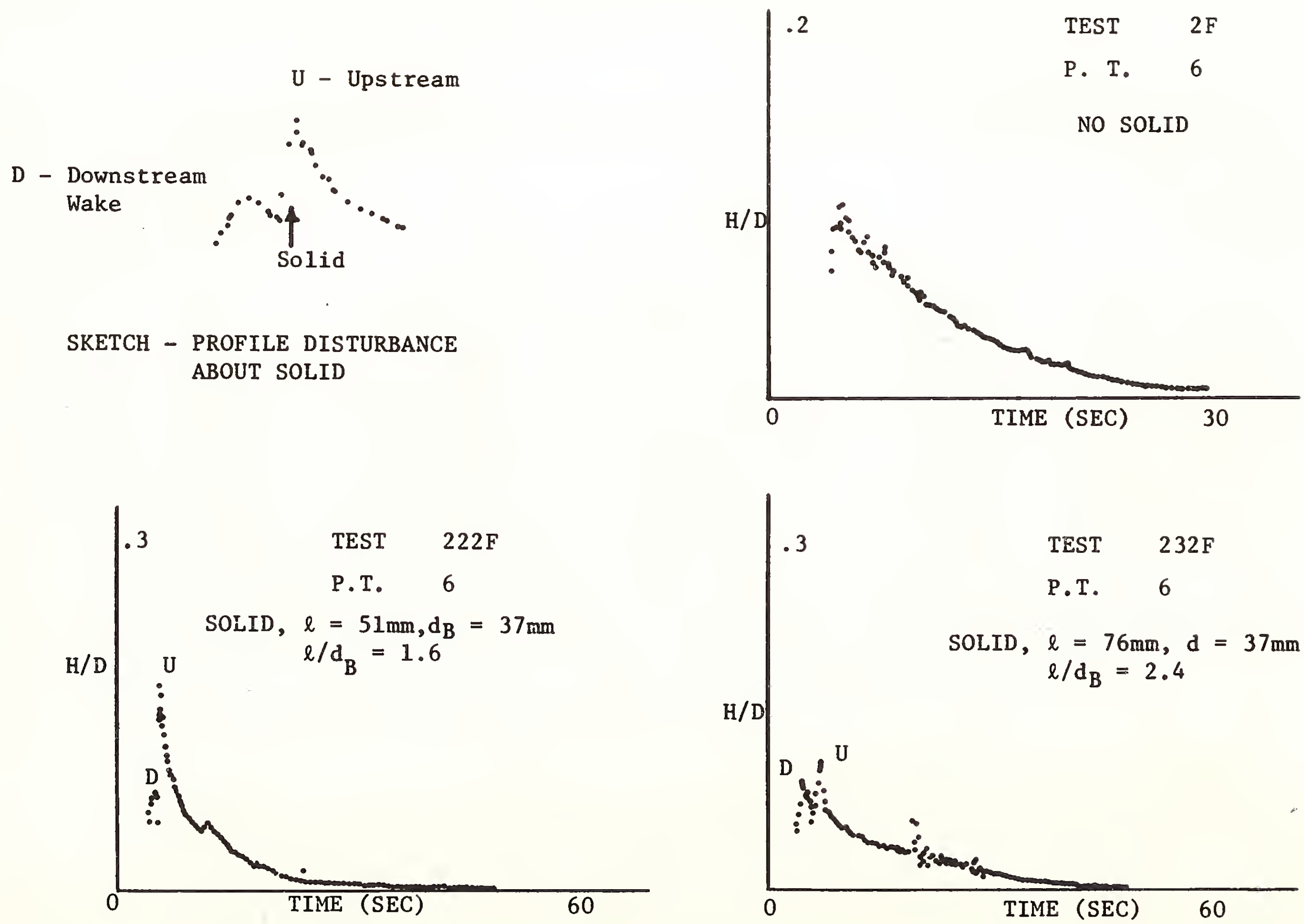



Figure 3. Two liter discharge depth profiles with & without solid at station 4.2 meters, 100 mm diameter pipe, s = .02

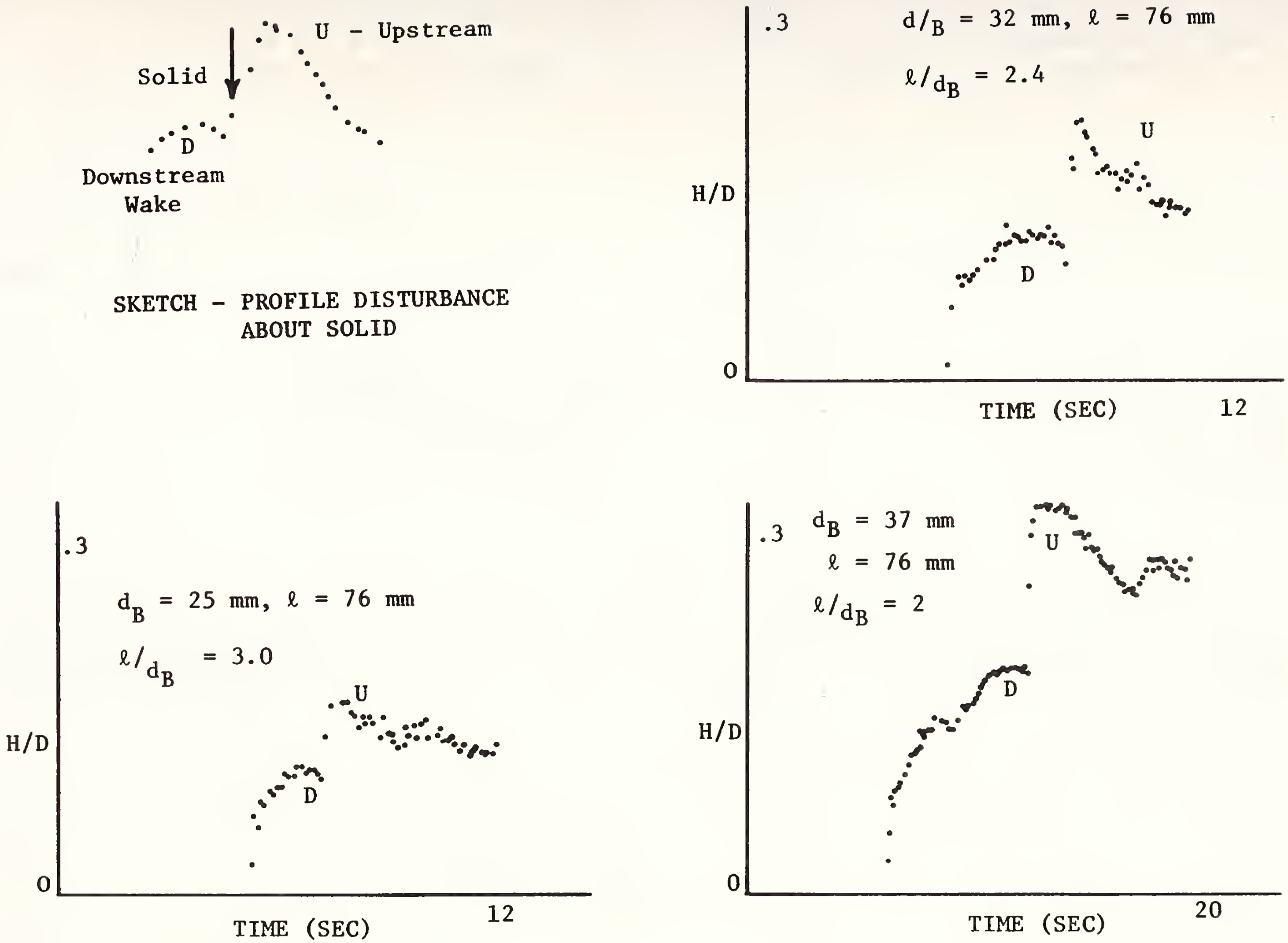



Figure 4. Near steady flow depth profiles at station 4.2 meters in 100 mm diameter pipe, s = .02, 0.5 liters/sec

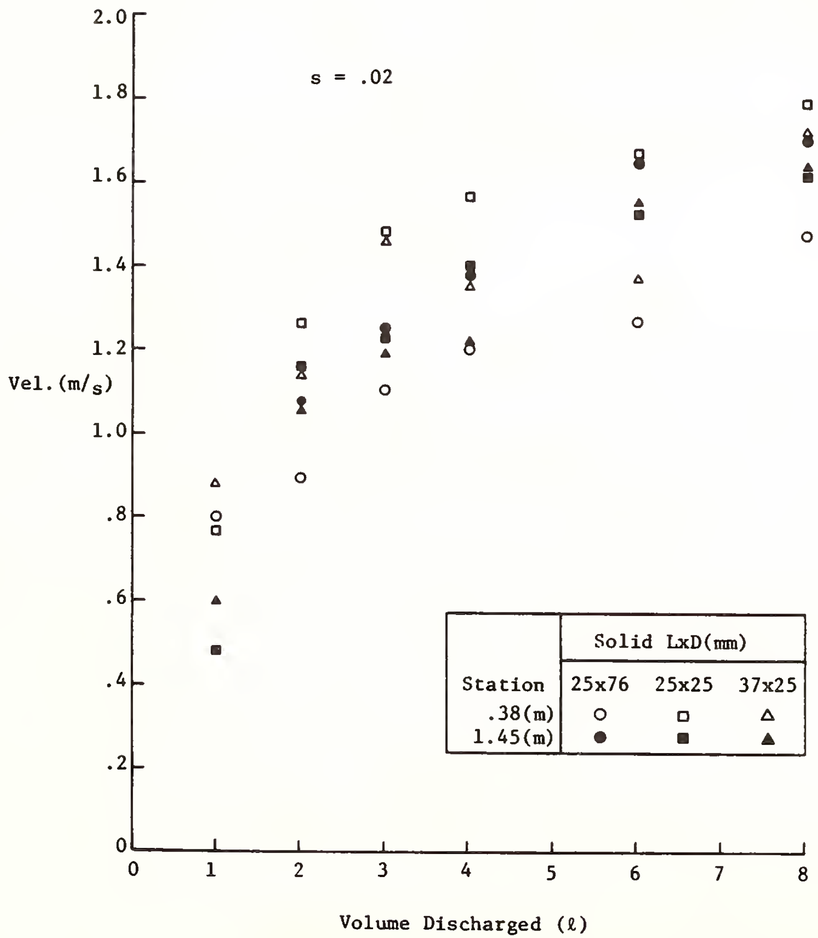



Figure 5-A. Solid velocity in surge flow for s = .02

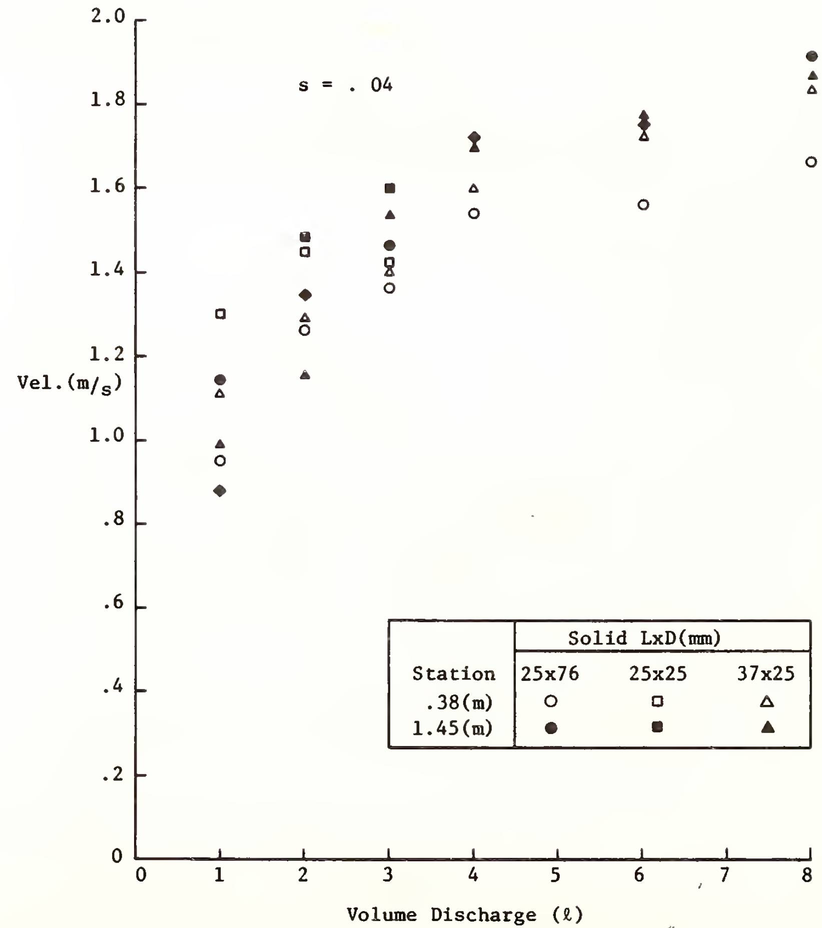



Figure 5-B. Solid velocity in surge flow for s = .04

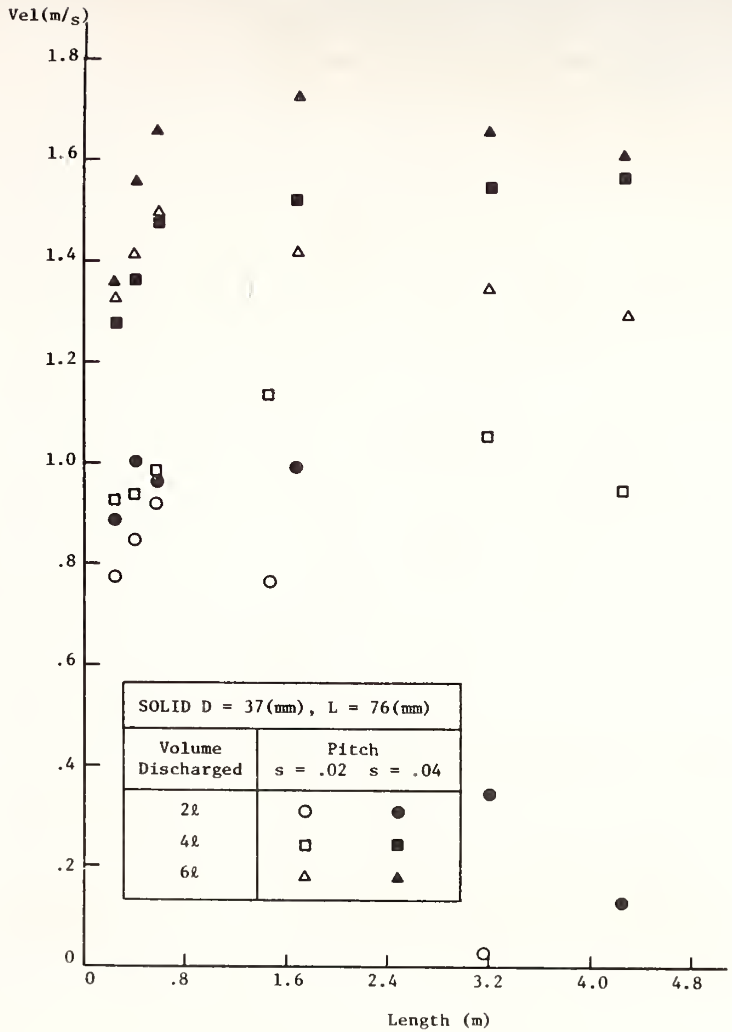



Figure 6-A. Effect of Discharge volume & pitch, surge flow, 100 mm diameter pipe

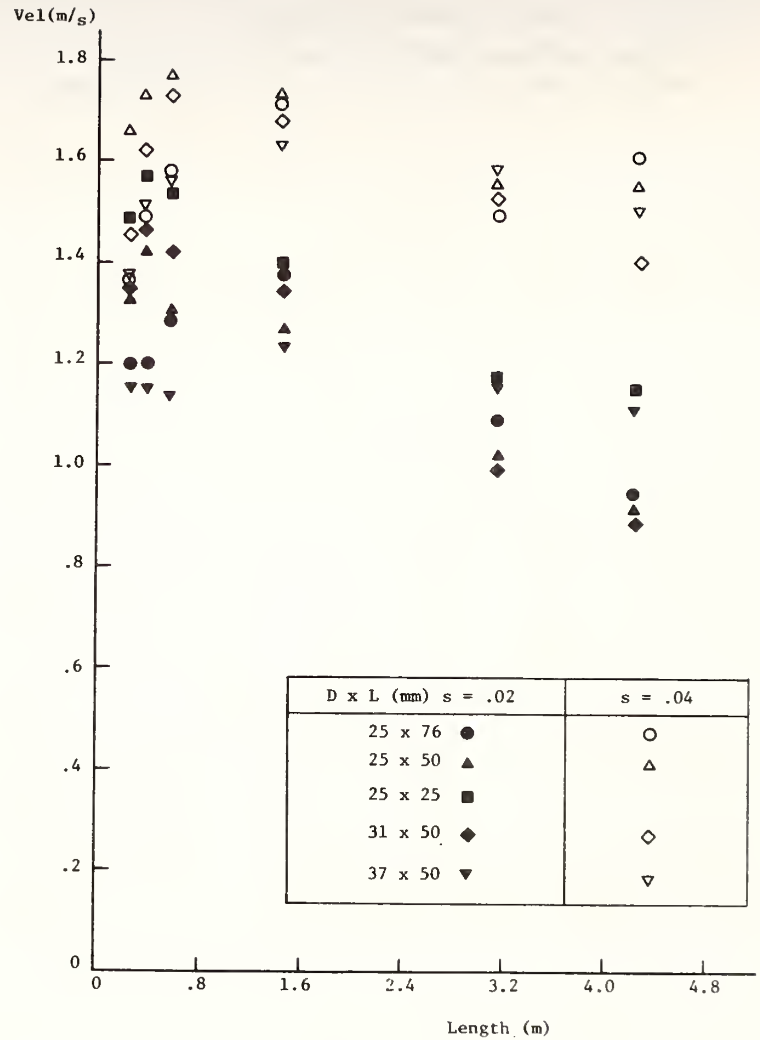



Figure 6-B. Effect of body size & pitch - surge flow, 100 mm diameter pipe

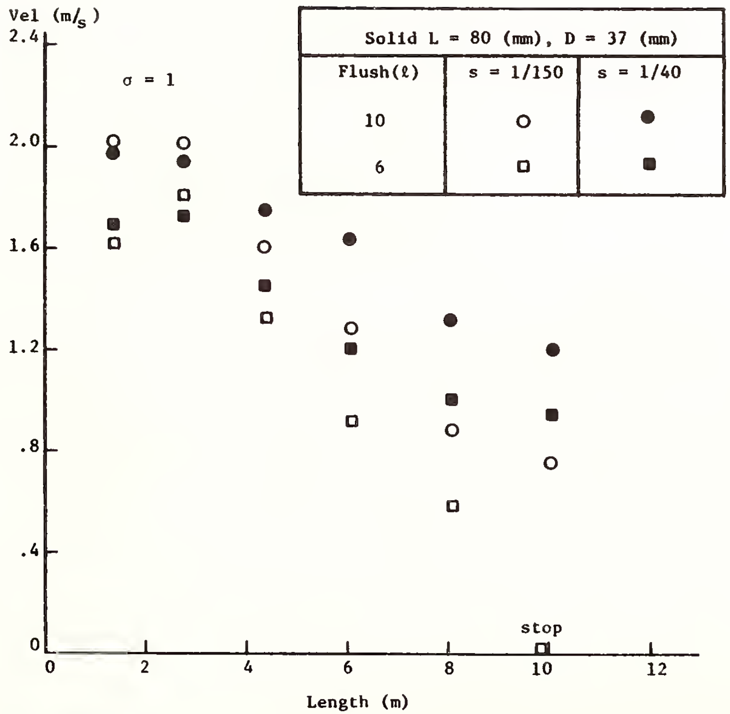



Figure 6-C. Effect of W. C. flush volume & pitch on solid, σ = 1, 100 mm diameter pipe

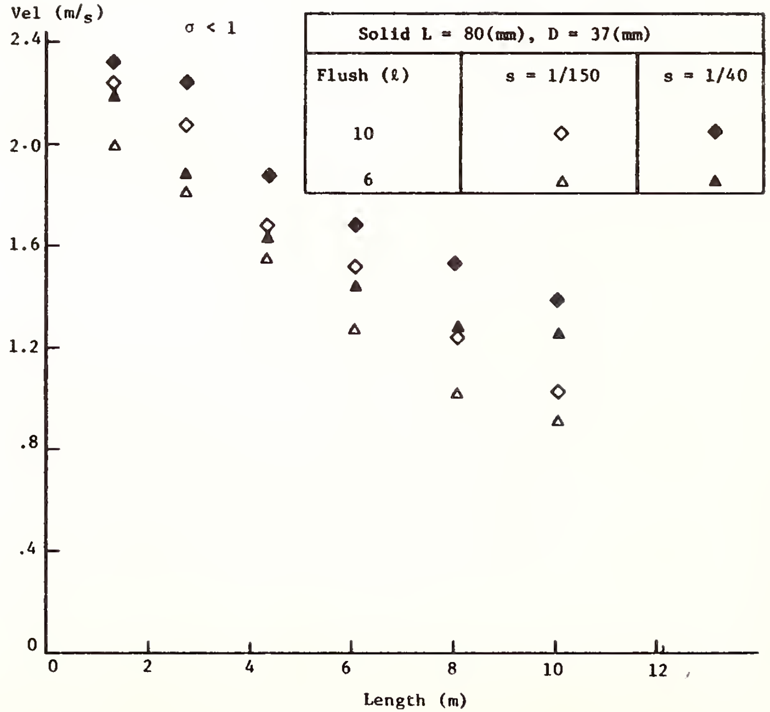



Figure 6-D. Effect of W. C. flush volume & pitch on low density solid, 100 mm diameter pipe

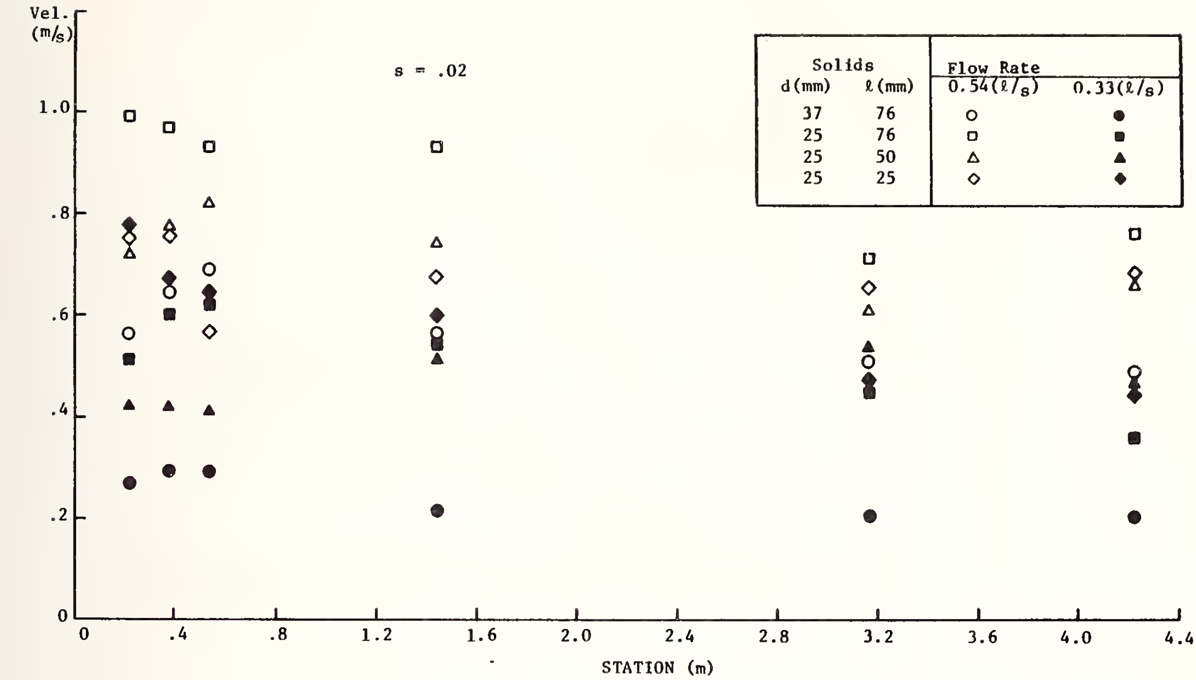



Figure 7-A. Solid velocity in 100 mm diameter pipe, near steady flow

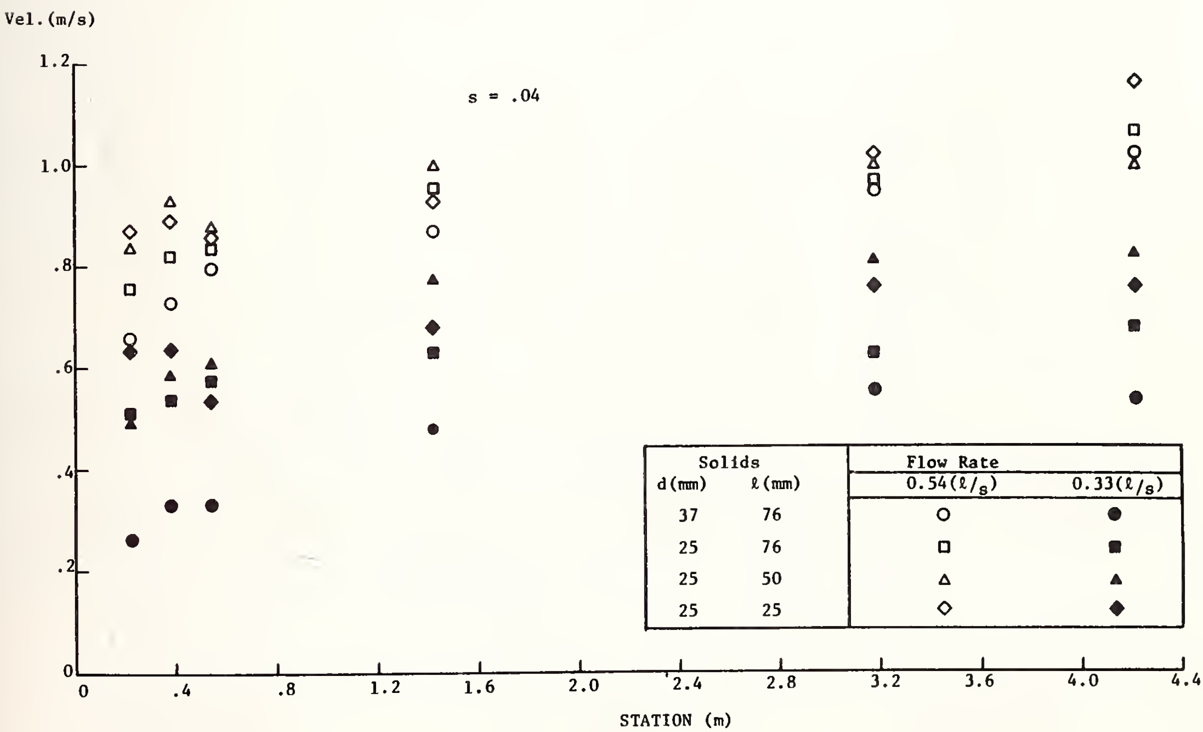



Figure 7-B. Solid velocity in 100 mm, diameter pipe, near steady flow

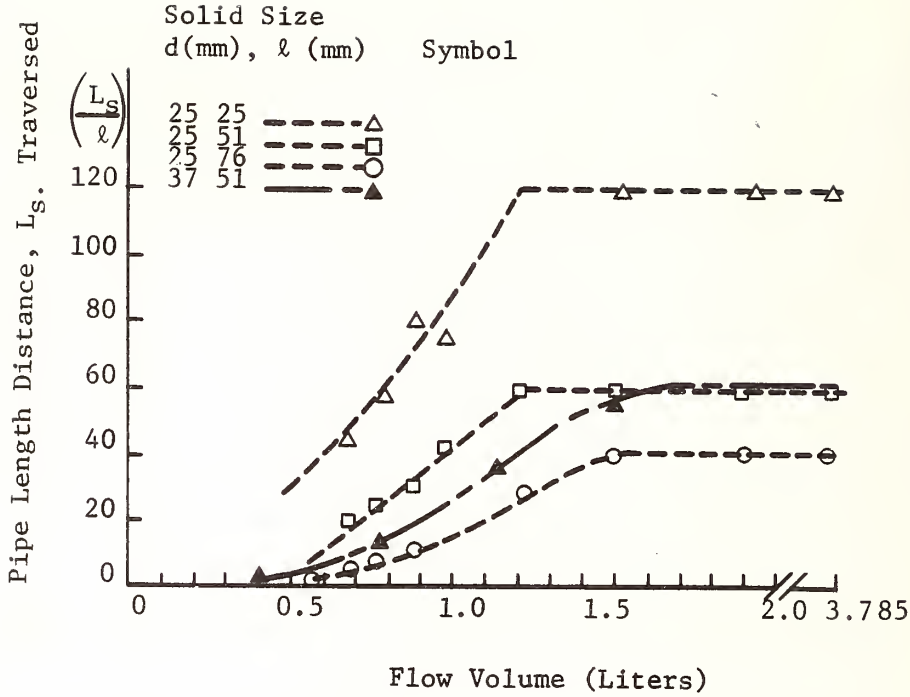



Figure 8. Distance traversed by solids in drain pipe

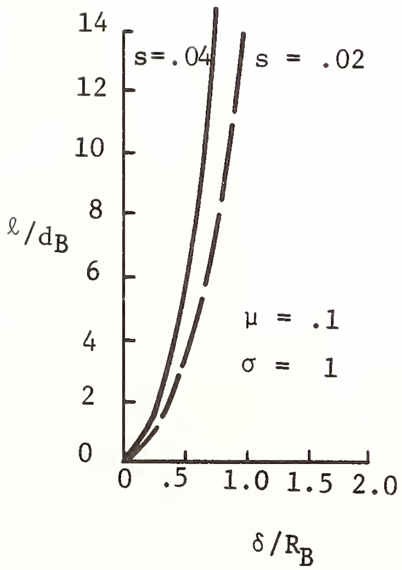



Figure 9.
Effect of
pipe pitch

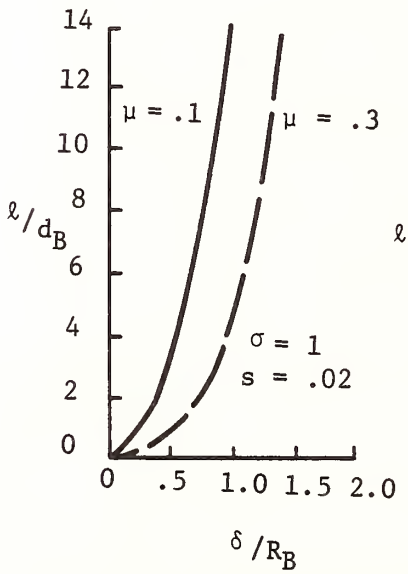



Figure 10.
Effect of
friction
coefficient

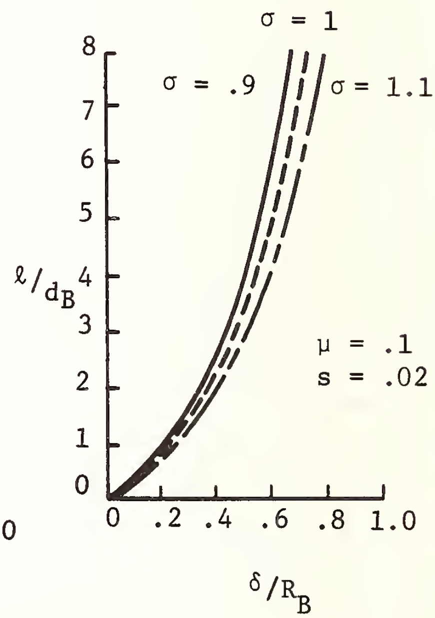



Figure 11.
Effect of
specific gravity

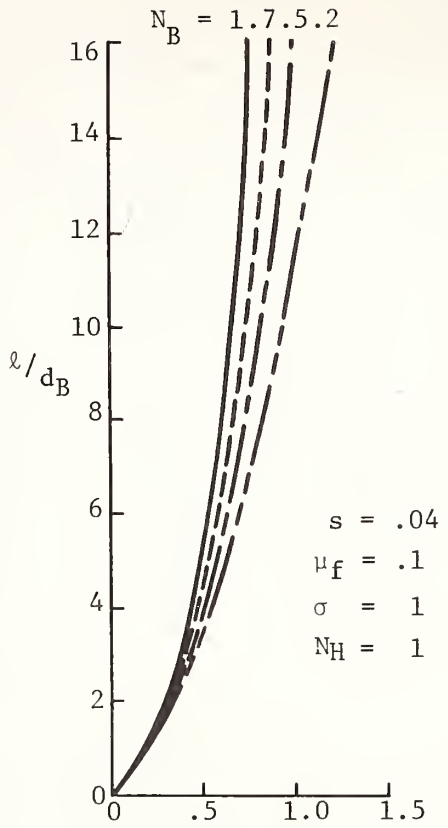



Figure 12. Effect of buoyancy parameter

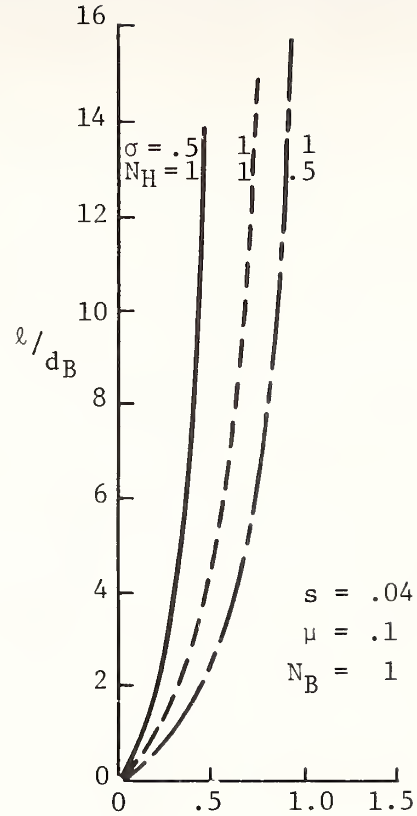



Figure 13. Effect of hydraulic force parameter & specific gavity

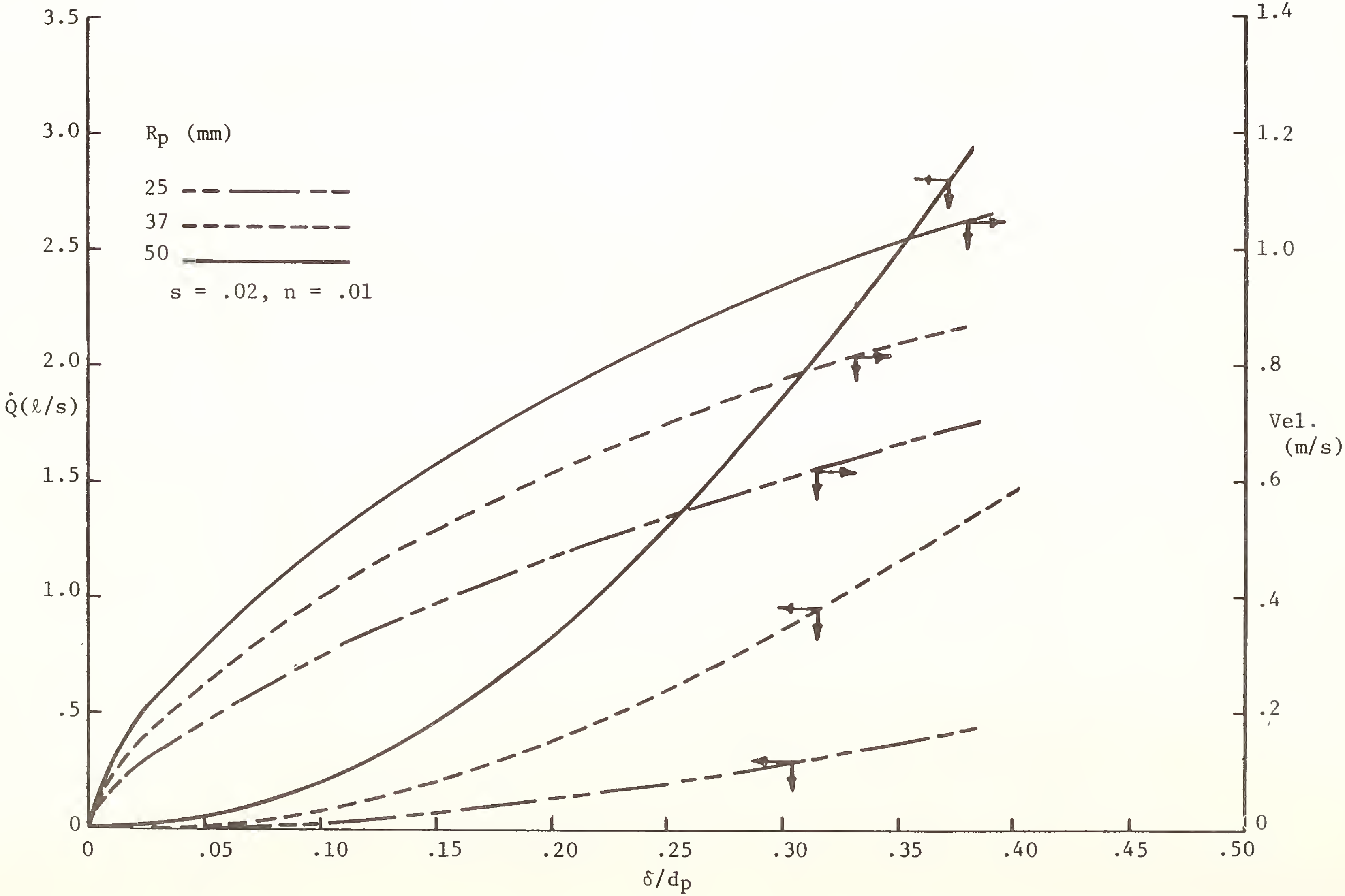



Figure 14. Water flow rate & velocity for various pipe sizes

APPENDIX

The model adopted for the large body analysis (3) was developed for consistency with the laboratory experiments with sanitary napkins conducted at Brunel University which, due to their flexibility, tend to adopt their contour to the curved pipe wall and cause a relatively large blockage factor. Those deformable solids are composed of materials which become saturated with water and therefore will tend to provide an additional degree of lubrication which reduces the surface to pipe wall friction as compared to a rigid cylindrical solid. The upward lifting force with buoyancy force term is difficult to estimate due to the angle of attack and curvature of the solid and pipe wall boundaries. The extensive test series conducted in the laboratory of Brunel University (13) showed that for bodies with large base areas the flow obstruction causes the depth to build up to a large extent behind the body thereby increasing the hydraulic pressure force on the body; the flow streaming past the body (termed "leakage past the body") is low. Consequently, the shear stress force term due to the relative flow velocity with respect to the body is assumed to be negligibly small and neglected in the force balance for the body. That simplifying hypothesis results in elimination of a major theoretical difficulty for formulation of the force due to the shear stress between the liquid and body surface. Figure A-1 presents "napkin" solid velocity results plotted against the $\sqrt{L}/G$ term for pipe slopes from 1/40 to 1/300, where L is length along the pipe and G the gradient. The predicted results from the computer program for the large solids/hydraulic interactions are shown in figure A-2 and figure A-3 and indicate that the solid velocity in each case is linearly dependent on $\sqrt{L}$ over the major portion of the pipe length. The dependence on the pipe gradient term is present and would have an index greater than -1/2 in the theoretical model. Probably the differences between experiments and predictions are due to such factors as the uncertainty of the friction coefficient and the lifting force. The computed results show the general trends of the experimental solid velocity curves.

Case iron pipe tests ○; UPVC pipe tests △

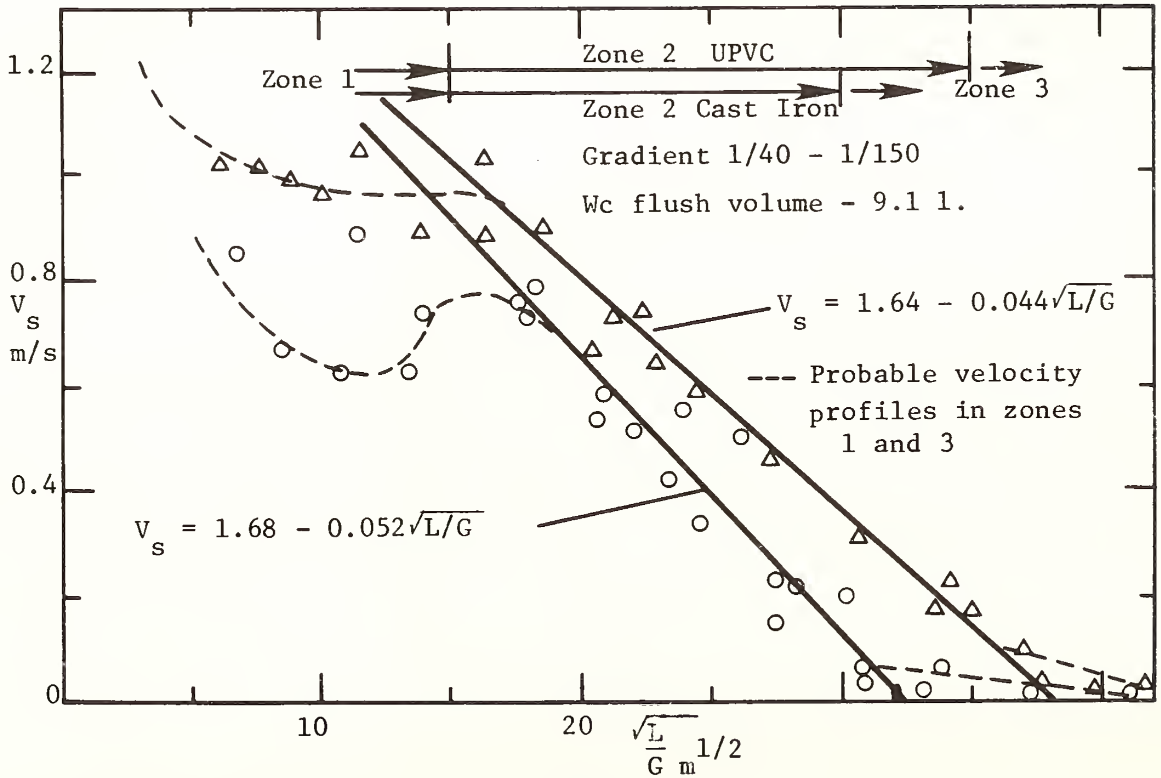



Figure A-1. Comparison of maternity pad transport in UPVC or Cast iron 100 mm diameter pipe

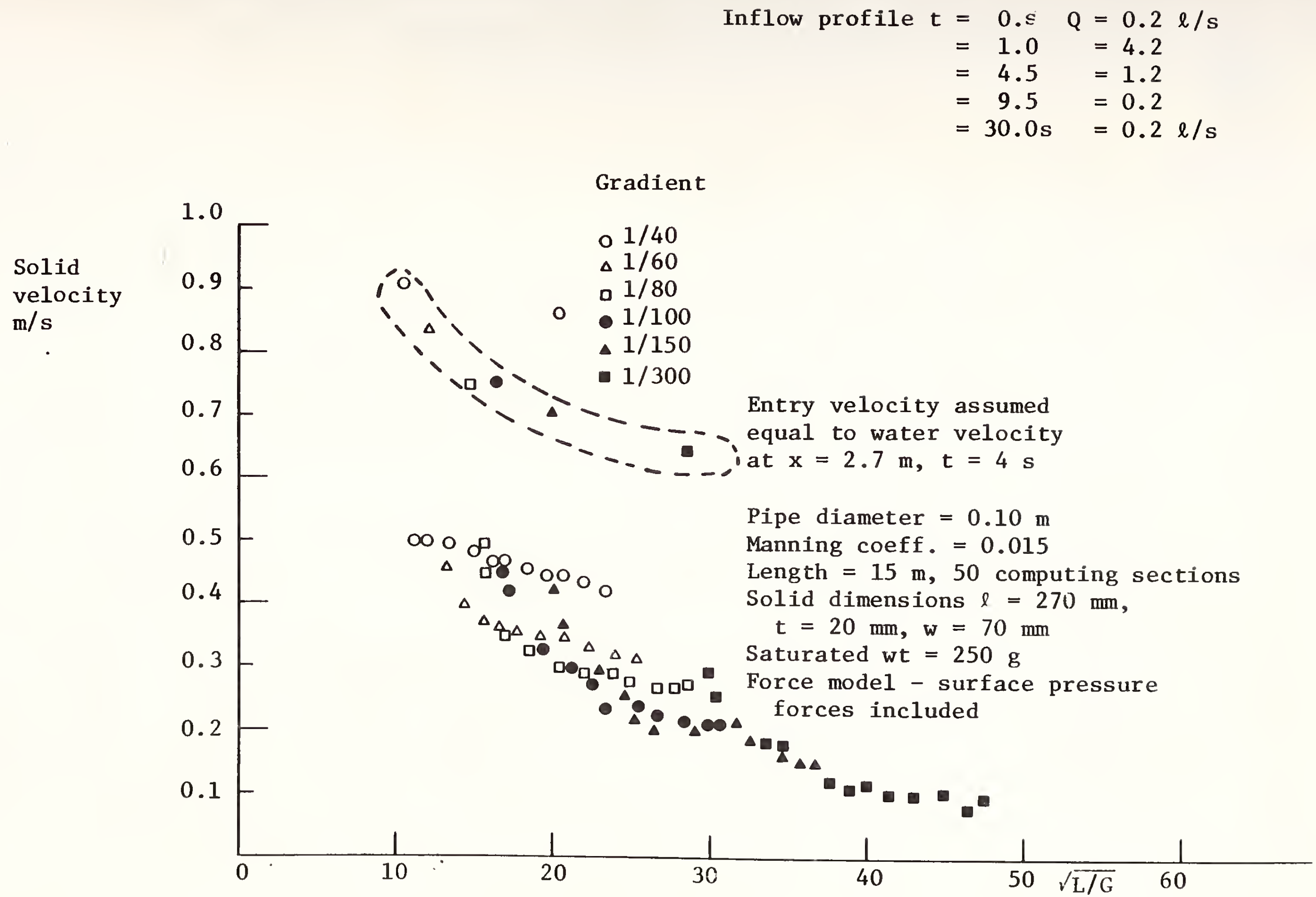



Figure A-2. Predicted solid velocity vs $\sqrt{L/G}$ various slopes

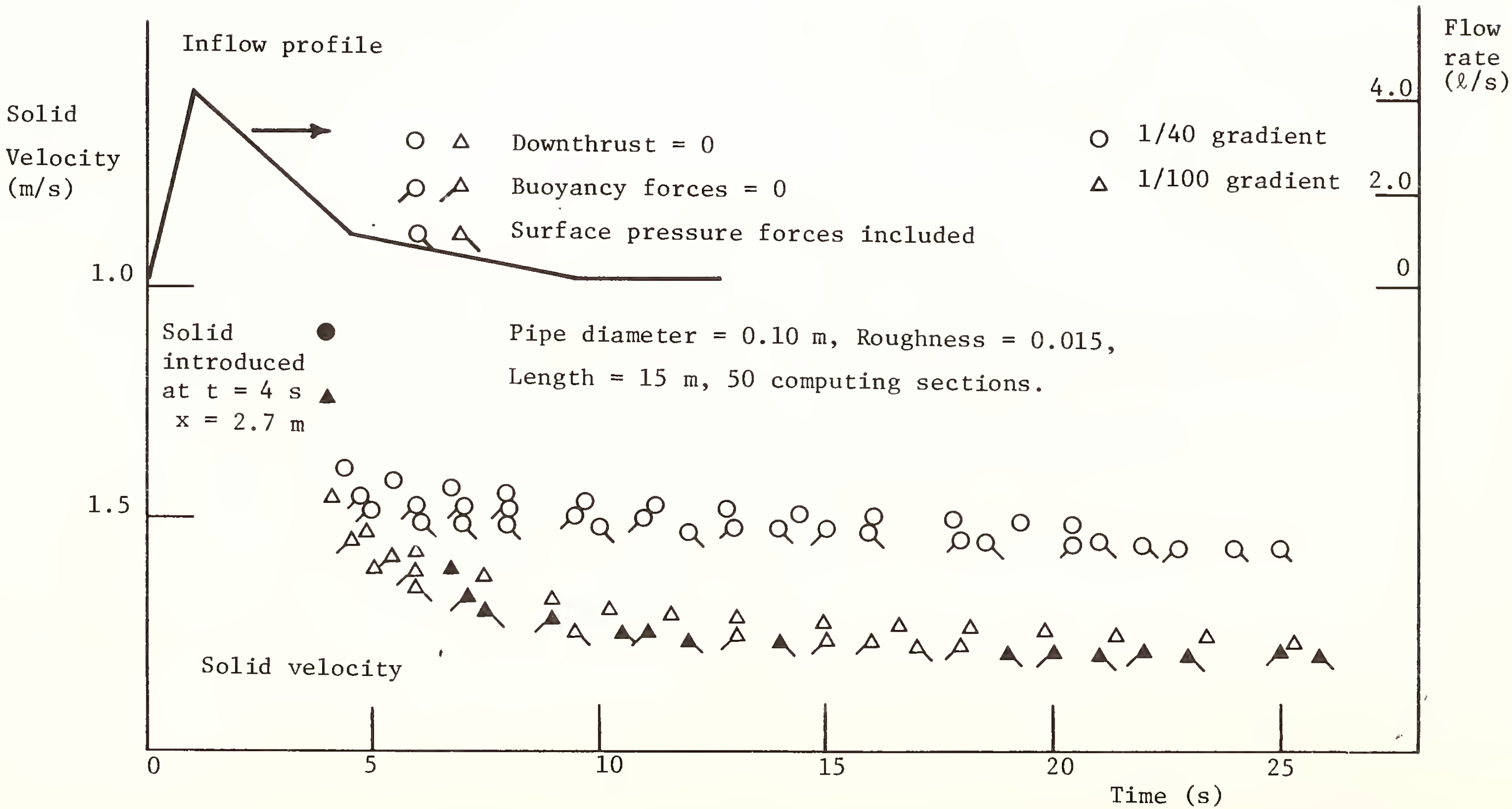



Figure A-3. Influence of force model on the predicted solid velocity

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'81 A NATIONAL CONFERENCE

# Demonstration Projects/Data Collection

# DEVELOPING DATA FOR RESIDENTIAL WATER SAVINGS

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## ABSTRACT

Demonstration projects are being conducted for the U.S. Department of Housing and Urban Development (HUD) to document water savings in actual homes. Arrangements to conduct demonstration projects have been made with the City of Atlanta Bureau of Water, Denver Water Board, Los Angeles Department of Water and Power, and the Washington Suburban Sanitary Commission. Projects were selected on the basis of estimated water savings, need for field data, cost, and other factors.

The following demonstration projects were selected: studies of contemporary and advanced low-water-using bathroom fixtures; a study of water- and energy-efficient homes; the effect of retrofitting on hot water and energy use; the effect of metering; the effect of a pressure change; a nationwide leak detection survey; nationwide surveys of water-using fixture use and shower water use characteristics; and the long-term effectiveness of retrofitting in various cities. Each project involves a test group of dwelling units, equipped with the water conservation device, and a control group for comparison. Results will be published in 1982 and 1983.

## INTRODUCTION

In early 1980 the Office of Policy Development and Research, U.S. Department of Housing and Urban Development, funded a $500,000 project to collect data on water-saving devices in actual homes. In September 1980, after a competitive procurement process, Brown and Caldwell was authorized to proceed on a 3-year project. This paper reviews previous demonstration projects, describes how projects to be conducted under this contract were selected, and summarizes the purpose of those projects which are now under way.

## RESULTS OF PREVIOUS RESEARCH

Although there have been a large number of water conservation studies, those which have documented water savings are limited. Some data has been collected on devices for new homes, retrofitting, low-water-use landscaping, water-use characteristics, metering, public education, pressure reduction, leak detection, and response to drought. Availability of data is summarized below.

## Devices for New Homes

Although several demonstration projects have been completed, they have not been scientifically designed. Most projects have involved more than one device, making it difficult to isolate savings from individual devices such as a low-flow showerhead or a low-flush toilet. The largest study to date has involved only 15 homes and in general the sample sizes have not been large enough to establish statistical significance. Recent and ongoing projects funded by the U.S. Environmental Protection Agency (EPA) have primarily studied conservation as it relates to failing on-site disposal systems. EPA is currently funding a number of rather small studies involving installation of minimum-flow fixtures (air-assisted showers and toilets) in homes with failing on-site systems (1).

## Retrofitting

There have been two major landmark demonstration projects involving retrofitting. The California Department of Water Resources' "Pilot Water Conservation Program" yielded much information regarding methods of device distribution and installation rates(2). Water savings resulting from the program, however, are estimated and there is no documentation of a use reduction resulting from the program. The other major retrofit program was the Washington Suburban Sanitary Commission's (WSSC) "Cabin John Project"(3). This program involved installation by the utility of retrofit devices in over 2,000 homes, with distribution of devices to the rest of the service area. The project has been reviewed and interpreted differently by a number of authors. In addition to these two major programs, a number of smaller programs have been implemented which have ranged from single installations to mandatory retrofitting by utilities.

The primary limitation in all of the retrofitting projects, however, has been that the results have been influenced by other factors. The California project was implemented shortly after the worst drought on record and was undoubtedly influenced by lingering drought consciousness. WSSC's project was accompanied by rate increases and an extensive public education program. As a result, it is impossible to attribute benefits directly to retrofitting. The key pieces of missing information regarding retrofitting are long-term effectiveness and public acceptability.

## Low-Water-Use Landscaping

Although several guides to low-water-use landscaping have been written, very little work has been done which quantifies water savings with this type of landscaping.

## Water Use Characteristics

Studies to determine water use characteristics are limited. The work of Linaweaver, et al., published in 1967 (4), is the major landmark study of residential water use and is still widely referenced. As part of water utility planning, a number of more recent studies have investigated factors affecting water use, ranging from climate to socioeconomic effects. Although total use and the factors affecting it have been well defined, assumptions regarding how the water is used are unsubstantiated. Key questions concern how much water is used for flushing toilets, bathing, laundry, etc. Although estimates abound, there is no documentation, and accurate numbers are critical to projecting water savings through conservation practices.

## Metering

The fact that metering results in an initial water use reduction in areas with outside water use is well accepted. Estimates of water savings ranging from 20 to 45 percent on a community-wide basis have been measured after meter installation. Long-term reductions from metering, however, have been questioned. The basic controversies surrounding metering regard its cost-effectiveness and political feasibility.

## Public Education

A wealth of water conservation education materials have been prepared by a number of organizations, notably the East Bay Municipal Utility District, the Los Angeles Department of Water and Power, the Denver Water Board, the Washington Suburban Sanitary Commission, and the American Water Works Association. Although these materials have been widely distributed, resultant water use reductions have not been documented.

## Pressure Reduction

Pressure reduction is a widely accepted water conservation method. Unfortunately, the savings from pressure reduction have not been measured. Building codes specify minimum and maximum water pressures for new homes and once an area has been built out, there has been little incentive to reduce pressure on an experimental basis.

## Leak Detection

Published studies of leak detection programs adequately describe the procedures, costs, and water savings. However, these studies have been specific to the utilities where the programs were implemented. The costs and benefits of leak detection have been highly variable between particular utilities.

### Response to Drought

Reductions of water use during drought are probably the best documented aspect of water conservation. Unfortunately, little of this information is transferable to long-term water conservation programs.

## SCREENING POTENTIAL DEMONSTRATION PROJECTS

From the onset it was clear that there were many more good demonstration projects than could be funded. A list of 37 potential projects were defined, evaluated, and ranked in order of priority. The ranking enabled the worth of the data to be optimized subject to funding limitations. The complete screening process is described in Reference 5.

### Potential Demonstration Projects

The list of demonstration projects included many applicable to new construction or rehabilitation. Projects focused on new water- and energy-saving measures, low-water-using appliances, and drought-tolerant landscaping.

Retrofitting of existing dwelling units was also investigated and projects proposed to focus on the methods of retrofitting and the long-term water savings. Projects isolating changes in water pressure, pricing, metering, public education, leak detection, and other community scale programs were proposed. Surveys on frequency of use for certain water-using fixtures and on shower use characteristics were developed.

### Screening Criteria

In deciding which projects to implement, the following questions were asked:

1. Does the project have nationwide applicability?

2. Is the cost of the project reasonable?

3. How practical is the water conservation method to be tested?

4. What magnitude of water savings are expected?

5. Is the measure cost-effective when implemented on a large scale?

6. Will the results be useful to others?

7. Will the project provide new data?

8. Does the project also document energy savings?

9. Is the measure publicly acceptable?

10. Can the demonstration project be implemented relatively easily?

Project Ranking

The 37 projects fell into three groups after they were subjected to the above questions. Projects were ranked high, medium, or low priority. Available monies from HUD could only fund the highly ranked projects described below.

## SELECTED DEMONSTRATION PROJECTS

Projects were selected which dealt with installation of water-saving devices in new homes, retrofit of old homes, and community scale projects.

### Projects Applicable to New Homes

Three projects applicable to new homes were selected. One of the projects will be repeated in three locations because of its importance.

1. Low-Flush Toilets and Low-Flow Showerheads and Lavatory Faucets: A comparison of water use in homes equipped with low-flush toilets and low-flow showerheads and lavatory faucets (in accordance with new plumbing codes) with similar homes not equipped with these devices will be made. Test and control groups of houses within the same city have been selected. Tests will be conducted on comparable single-family subdivisions, garden-type apartments, and high-rise apartment buildings in different cities. The cities of Atlanta and Los Angeles, and the Washington Suburban Sanitary Commission have identified housing units that will be tested.

Monthly water use records will be compared for test and control groups during the winter when outside water use is minimal. Sample size for the groups has been selected so that water use reductions will be statistically significant at more than the 90 percent confidence level.

2. Water- and Energy-Efficient Homes: This study will compare total water use and energy use from a subdivision in Denver that is completely equipped with water- and energy-saving devices, fixtures, and appliances, and also are heavily insulated, with an older subdivision of similar homes without these devices but constructed by the same builder. Included are low-flush toilets, low-flow showerheads, low-flow lavatory faucets, and water-efficient dishwashers. The new

subdivision is a part of Denver's $ECH_2ONERGY$ rating program for the energy and water efficiency of new homes. The program is described in Reference 6.

3. Comparison of Toilet, Shower, and Lavatory Devices: A new 120-room dormitory at the Stevens Institute of Technology in Hoboken, New Jersey, will be constructed and occupied by June 1982. Each room will have two beds and its own bathroom. It is proposed that 10 rooms with currently available water-saving fixtures be compared with another 10 rooms fitted with Microphor toilets, Minuse showerheads, and very low-flow lavatory faucets. Monthly water use data and frequency of fixture use data will be collected for each group of rooms over a 1-year period.

Retrofit of Existing Homes

Three projects applicable to existing homes were selected.

1. Effect of Residential Water Audits: The Los Angeles Department of Water and Power has started making water and power audits for customers who request it. They visit homes, advise customers how to reduce water use, and give them a retrofit kit and encourage them to install it. There is already a waiting list for this service. In the later part of 1981, there should be enough customers who have had this service to allow an evaluation of water use reductions.

2. Retrofit Case Studies: Compilation of statistics on all major retrofit programs conducted in the U.S. will be made. Several will be selected as case studies. Each program will be described in detail and, if necessary, a limited follow-up survey made to determine long-term effectiveness. On the order of ten case studies will be done to achieve a broad geographical representation, covering the different types of devices (i.e., toilet dams versus bags), and the different methods of distribution (mass mailing, door-to-door, or depot). Programs will be selected from those that have been conducted in California, Missouri, Illinois, New Jersey, and Maryland.

3. Detailed Study of Shower-Use Characteristics: Data will be developed on average shower duration, frequency, desired temperature, and average flow rate using flow restrictors and low-flow showerheads. Water and energy savings will be monitored. The project will be conducted with a group of volunteers in cities across the country.

Community-Scale Projects

Four projects were selected as applicable to the community as a whole and three of them involve action that a water utility could take.

1. Effect of Metering: Water-use records for specific subdivisions before and after water meters were installed will be analyzed. Short-term and long-term reductions should be identified. Denver is currently identifying test and control groups which can be monitored.

2. Effect of Water Pressure: The Atlanta Bureau of Water has identified a subdivision for which they will install a pressure reducer. For these 80 homes pressure will be reduced from 100 pounds per square inch (psi) first to 80 psi then to 60 psi in two steps. Changes in water use will be measured. The City of Los Angeles has several hillside developments for which pressure was increased by installation of a water tank at a higher elevation. Data on changes in water use after pressure increases is available and will be analyzed and compared with the pressure reduction data from Atlanta to develop a curve of relative change in water use versus change in pressure.

3. Survey Frequency of Fixture Use: Groups of volunteers will be used to obtain data on the average number of laundry loads, dishwasher loads, and toilet flushes in a household. A sample of approximately 1,000 households will be used, drawn from various areas of the country. The survey will be conducted over a several month period noting specific appliance model, number of adults and children in the household, number of people working or in school, general income level, and other relevant factors that could be used in correlating results. This data can then be used to estimate water savings from use of more water-efficient appliances.

4. Leak Detection: A nationwide survey of leak detection in a large number of different water systems across the U.S. will be made. The amount of water saved will be statistically related to the leak detection method, the miles of pipe surveyed, the age of the pipes and type of material, and other relevant factors. Six water agencies, which have demonstrated expertise in this area, will develop transferable information on leak detection methods.

## DEMONSTRATION PROJECT DESIGN

The principal design parameter in setting up a demonstration project is the sample size. That is, how many homes should be in the test and control groups so that the measured water savings have statistical validity? The Students' t-test can be used to establish the sample size for a stated confidence level. This technique assumes a normal distribution of per capita water use data in both sets of homes and prior knowledge of the mean and standard deviation. The parameters of the distribution are usually not known ahead of time but can be estimated. Review of residential water use data in Brown and Caldwell's files revealed that water used inside the home is usually in the range of 60-70 gallons per capita per day (gcd) with a standard deviation of about 15-20 gcd.

For water conservation measures that produce a water savings on the order of 20 percent, a sample size of approximately 100 test homes and 100 control homes is appropriate for a 90 percent confidence level. If the projected savings is only 5 percent then the sample size should be at least 500 homes in each group.

Once the sample size was determined for each selected project, efforts were directed at locating suitable homes. This was a time-consuming process requiring several months in each city. After the homes were selected, arrangements to collect water-use data for a 2-year period were made with the participating water utility. In cities where a significant amount of water is used for outside irrigation, monthly water-use data will be collected from the customers' water meter. The evaluation of the data at the completion of the project will include a formal statistical data analysis with assignment of a confidence level associated with the measured water savings.

## CONCLUSIONS

A research project designed to collect data from actual homes requires a considerable amount of advance planning. In this case, 6 months was required to develop the project, line up the test groups and control groups, and make arrangements with participating water utilities to collect the data.

Data from actual homes subjected to a water conservation program has been limited in the past. This project funded by HUD promises to provide a large amount of worthwhile data on a number of water conservation measures. The results from the selected projects will be published in 1982 and 1983.

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HOW TO IMPLEMENT A WATER CONSERVATION PROGRAM - THE DENVER EXPERIENCE

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The need for Water Conservation in the Denver metropolitan area is nothing new.

We have experienced water scarcity problems with all of the other semi-arid states of the West throughout our history.

The average yearly precipitation for the Denver area is about fifteen inches a year. Some areas of our country would consider that amount only a reasonable monthly average. Another important point to keep in mind is that most of our moisture comes in the late spring before the irrigation season really starts. Summer, fall and winter are usually extremely dry. Therefore, the foundation of our conservation program in the West is construction of dams and reservoirs so that spring snow melt can be captured and stored for use throughout the year.

Denver residents receive high-quality water from a complex, well-planned system. Some of the water travels as far as 120 miles through tunnels by gravity flow under the Continental Divide before reaching our treatment plants.

This vast and complex mountain system does not deliver a major amount of the State's water to Denver; on the contrary, the entire metro Denver area uses only 1-1/2 percent of the total annual State yield. But, just collecting that small amount requires engineering skill and long-range planning often not required in other sectors of the country and, of course, considerable expenditure in dollars.

Even though Denver has expanded this excellent water system through the years to increase the supply, water conservation has been a watchword through the years as residents struggled to create some of the amenities of an urban environment -- every tree, bush and blade of bluegrass had to be planted. You can get a good feel of what Denver would be like without our landscaping by observing the natural flora as you travel back from this conference to your homes. Observe the natural vegetation 25 miles out of Denver in most any direction. This was done, even though Denverites have lived under water-use restrictions for more years than they have not.

During the Dust Bowl days of the 1930's, trolley cars in Denver carried big signs saying: "Water is Denver's Greatest Natural Asset -- Please Don't Waste It."

So, when the Denver Water Board decided about five years ago to step up its conservation program, it was building on a firm foundation of water-saving programs that had been advanced for more than half a century.

Working on the theory that "preaching" water conservation may fail because people don't respond to a long list of "do's and don'ts," the Denver Water Department produced a 7-minute animated film aptly named "Water Follies." The colorful animation with a catchy sound track, using no words, has proved universally popular. Judging from the agencies and utilities from all over the world that have acquired a print, the best decision made during production was to avoid a script. The sound of a flushing toilet or a dripping faucet is universally recognized. Since there is no conversation during the entire film, no translation is required for foreign countries. To date, about 750 prints of this film have been distributed throughout the United States and in many foreign countries. "Water Follies" won four national awards.

As a companion piece to the film, Denver produced a colorful brochure listing 44 ways to "be water wise." Most of the worthwhile water conservation ideas for the semi-arid West are listed. It has been furnished on request to areas far beyond our service area.

Three years ago, the Department's Public Affairs Department hired a certified teacher and now offers a complete classroom program for any fifth or sixth grade and high school class in the metro area. The youngsters enter wholeheartedly in discussion and experiments on water.

A speakers' bureau prepares programs for civic groups, garden clubs, service clubs and neighborhood associations utilizing the film, brochures and a speaker with a conservation message.

Actually, it would be difficult for any of the one million people served not to be water wise -- or at least water conscious. This is the fourth summer irrigation season they have been on water restrictions due to a short fall in treatment capacity.

Customers, divided into three parts according to the last two digits of their street addresses, are allowed to water only every third day from May through September. During the drought year of 1977, the watering time was limited to three hours every third day. Since then, there are no hourly rules, but everyone is urged to water no more than necessary. Due to this year's drought, we may again be forced to implement hourly restrictions in conjunction with the every-third-day program.

A water calendar designating all water users as diamonds, squares or circles is now in its fourth year of use. Sometimes, social events and outings are determined by watering days, with two couples of squares finding it easier to socialize the same evening than trying to mix with another symbol that may be busy watering the yard.

Residents with addresses ending zero-30 are designated "diamonds"; those with addresses ending with 61-99 are "circles." The same symbols are now in their fourth year. Once a square, always a square. One never becomes a scintillating diamond -- without moving to another house.

Customers are cooperative; most understand that treatment capacity fell behind through no fault of the Denver Water Department. Voter approval was obtained for the new Foothills Water Treatment Plant in 1973 - that was seven years ago - and it was expected to be on line in 1977. Instead, construction has been delayed five years because of environmental issues, Federal permit requirements and lawsuits. These have been resolved, the project has been bid, is under construction, and should be completed in 1982. I would be remiss if I did not point out that the five-year delay experienced increased the costs to our customers for the project over 100 percent, from $70 million to $170 million, and didn't change a thing.

The history of the Department's attempts to begin construction of the Foothills treatment complex is a long and involved one. It's a story of the frustration and problems that grow out of yesterday's philosophies of the water utility trying to serve its customers in a timely way and the more recent philosophies or attempts on the part of a few to utilize Federal requirements to frustrate plans to meet the customer demands of a rapidly growing area. But the Denver Water Department had to pay a price, other than construction dollars, for this badly needed treatment plant. Our customers who actually pay the costs for these delays will have to pay tremendous project cost increases to obtain the water they agreed to pay for in 1973. This often makes them irritable when talking conservation.

Arguments put forth by some against water works development because of costs seldom equate the costs of unnecessary delays such as we experienced when arguing the dollar benefits that may be realized through conservation.

To obtain the necessary permits, the Department had to agree to many conditions including a formalized water conservation program. The conservation program has a goal of reducing average annual consumption within the Department service area from 209 gallons per capita per day to 203 gallons per capita per day by January 1, 1982, and to 199 gallons per capita per day by January 1, 1984; the five subsequent years call for a further reduction of 3 to 5 percent from the goal of 199 gallons per capita per day and, after 1989 and over the following 10-year period additional reductions in the range of 5 to 10 percent. This and other mandated stipulations make the Denver Water Department and its customers unique citizens in our Nation. We know of no other city in the United States with these federally imposed requirements, especially when not one Federal dollar is involved.

Building on its existing conservation program, the Department will attempt to meet these goals through a program that will include:

- An expanded public education and information program utilizing electronic and printed news media.

- Expansion of the highly successful school program, carrying the conservation story directly into the classrooms to our customers of tomorrow.

- Affixing of water consumptive use indices to all plumbing fixtures and water-using appliances sold in the Denver Water Department Service Area. I would like to point out that it is almost impossible to purchase a water closet that uses more than 3-1/2 gallons per flush from local plumbing supply houses in the Denver area. The plumbing industry deserves tremendous credit for these efforts to reduce water consumption.

- Identifying water requirements of landscape nursery stock sold in the Denver Water Department Service Area and indicating that water requirement to purchasers. I would like to point out that most Denverites do not want to part with their gardens and lawns as a means to conserve water. They consider the vegetation around their homes as psychologically necessary, as well as important in dust and air pollution control and an important factor in reducing the costs of energy necessary for air-conditioning.

- Developing an informational bar graph for television to inform the public of lawn and garden irrigation needs on a daily basis in various areas of Denver.

- Using Water Bills sent to customers to advise them of water consumption on an individual basis for comparison with the same period the year before. It is important, however, to be aware that dryer-than-normal years could alter the value of these comparisons significantly.

- Promoting with the Denver metro area home builders and the Public Service Company of Colorado, a demonstration "energy saving" show home that opened in September of 1979 for 5-6 months. The home demonstrated techniques on how customers could inexpensively retrofit their homes. Over 40,000 people toured the home. The program won the national award from the Home Builders of America.

  The Echonergy Home, as we called it, was so successful as a teaching aid that all three of the sponsors, i.e., the Metropolitan Home Builders, the Public Service Company of Colorado, and the Denver Water Department, created a follow-up program called the Echonergy Builder Tie Inn Program. Over 85 percent of the metro area builders are enrolled in the program at present.

  The Tie Inn Program utilizes a rating sheet based on the house footprint or configuration and profile. Points are accumulated for energy- and water-saving features. These points are totaled on a rating sheet verification form that is given to the potential home buyer; thus the purchaser can compare the utility efficiency of one builder's home against that of another builder. These points are then applied to a rating graph. The more points, the less cost the purchaser will pay in utility costs. This program received approval from the Federal National Mortgage Association, the Veterans Administration, and the Department of Housing and Urban Development.

  The home buyer can qualify for home purchase of an Echonergy Home more easily than that of a home with a lesser energy and water efficiency rating since he will have less costs in utility bills and can more easily afford the debt service on the home. We have noticed this phenomenon carrying over to the used home market to some extent. Our feeling is that with the ever-increasing costs for utilities, the home-owning public as well as the rental market will see the practical savings in dollars that can result from a new home purchase of an energy- and water-efficient home as well as the advantages to the home owner that retrofits his home. The landlord certainly is aware of the necessity to reduce operating overhead since he is interested in increasing after-cost cash flow. The program is designed to appeal to the public rather than legislating to the public.

- Expanding the use of the widely acclaimed "Water Follies" film, including showings by indoor and outdoor motion picture theaters.

- Considering a retrofit program for showers, toilets, lavatory and kitchen sinks to reduce water flows.

- Working with architects, builders, remodelers and the plumbing and real estate industries to effect plumbing code changes directed toward conserving water.

- Instituting a formalized leak detection program to further reduce leaks in the system and finding and eliminating leaks in privately and publicly owned structures.

- Continuing our investigation of the feasibility of a selective pressure equalization program in various geographical areas but not risking the very favorable fire insurance rates Denver customers enjoy. This is a research program.

- Resolving the $20 to $30 million problem of requiring water meters for existing 1- and 2-family residential structures and customers on flat rates, possibly through the use of Federal rehabilitation grants for low- and moderate-income customers.

- Persuading all levels of government to retrofit their own leased and owned structures as an example of public concern for water conservation and calling for attention to this concern in their future bids.

- Proceeding with design, construction, and operation of a 1 million-gallon-per-day reuse demonstration plant. Within 10 years this plant will be expanded to 100-mgd capacity, increasing the water supply for domestic purposes.

- Reviewing traditional rate-setting policies to determine how rates can fit in with conservation goals without undue cost, penalty or change of life-styles to customers.

I would say, however, we feel it is ultimately self-defeating to impose severe increased rates on our customers as a penalty for trying to maintain a pleasant urban environment.

We want to eliminate unnecessary waste of water but not drastically alter life-styles as surveys indicate this is perceived by the general public as totally unrealistic and unnecessary.

We believe a water conservation program must be dedicated to the elimination of water waste and the wise use of water and not to forcing customers to lowering their standard of living through harsh, unrealistic and unnecessary restrictions.

The Denver Water Department and water utilities in general have always been willing to pay for their water development projects with rates charged for water.

Our industry likes its independence and consistently resists efforts of the Federal Government to reduce that independence through the insidious means of Federal financing which results in Federal control. Does avoiding Federal financing guarantee our continued independence? I don't believe so. Let's examine the regulatory nightmare that our sister utilities in the gas and electric energy fields have been subjected to with the passage in 1978 of the National Energy Conservation Policy Act. The act sets forth a national policy for bringing energy conservation into the homes of 100 million Americans and utilities are required--not asked--to go beyond their traditional roles of merely being the supplier.

Final rules and regulations are scheduled to be adopted by the Department of Energy in the near future, but already gas and electric utilities have to:

1. Inspect customers' homes to determine the type of energy conservation improvements that are most effective.

2. Inform customers of recommended improvements and estimate costs of energy savings likely from these improvements.

3. Arrange, at the customers' request, financing for such installations.

4. Who really pays for all of these requirements?

If water utilities were faced with these requirements, they would share the fears of gas and electric utilities--reduced revenues, liability for damages caused by installation of faulty equipment, services and materials and utilization of financial resources for such activities.

Water utilities are in a position, through adoption of realistic conservation programs on their own initiative, to avoid this type of Federal mandate.

That is our challenge. That is our opportunity.

We must recognize the conflicting and frustrating demands being placed upon us. We must understand that our customers want quality water but modest rates. We must realize that some segments of our society are demanding that water utilities act as instruments of social change while other segments argue vehemently that role can only be played by our duly-elected public officials as provided for in the Constitution.

We must understand that we are caught squarely in the middle, but that it would be fatal to sit on the sidelines and watch the struggle.

The water industry should view this as an opportunity to demonstrate that we, better than Federal bureaucrats, elected officials or opportunistic environmentalists, know the water business and can meet these challenges.

We will devise excellent and practical water conservation programs because we know it is in our best interest and the best interest of the customers we serve, and we will do it as efficiently and as economically as possible.

What works in one area of the country as a conservation measure will not necessarily work in another sector of the country. What one customer living in a humid climate with a relatively constant supply of water from a large river will accept and understand as an acceptable conservation technique is quite often not acceptable or practical in an arid climate.

All water used in Colorado, as an example, originates here since we are the top of the Nation. The people of Colorado are becoming increasingly aware that severe conservation requirements that may be imposed on them, thus letting water they are rightly entitled to use flow downhill out of the State to be put to beneficial use by Lower Basin States, are unfair and not acceptable.

We can and will address our own problems, develop our own supplies of water, handle our own financing and, in doing so, will win public support and understanding.

Therefore, it is essential that we view conservation not as a philosophy being forced on us but as an opportunity to demonstrate our expertise in providing our citizens with a continuing, safe supply of water at the lowest possible cost.

This has always been our mission.

It continues to be our mission and our charge. Conservation is part of it. That has been and will continue to be the Denver experience.

MANAGEMENT INFORMATION SYSTEMS FOR WATER RESOURCES*

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I'm pleased to join this select panel and discuss briefly some of the continuing research and development that I am directing on management information systems for water resources. As I reflect on the remarks of earlier conference presenters, I note the frequent reference to the concepts of equity, efficiency, fairness, need, public education, and conservation. As a social scientist I welcome the new attention to these concepts but suggest that there is still much confusion and conflict over the application of these concepts in water resource management. Part of the problem is the lack of necessary data and information.

Water utility managers are confronted repeatedly with difficult decisions which require a good information support base. Attempts to increase efficiency in water resource utilization through conservation will generate even further demands for information to track program efforts in consumer education, leak detection, regulation and enforcement, pricing, emergency allocation, and comprehensive planning to name only a few. Unless we are prepared to meet these informational prerequisites of management on a broad scale, efforts to boost efficiency through conservation will surely fizzle.

Several large metropolitan and suburban water systems have led the way in development of sophisticated information systems, computer models, and information specialists. Reports of their experiences suggest that the payback to systems in reduced cost of development and operations is attractive. Yet most large systems have not followed this lead and conservation remains the stepchild of water management activities. Furthermore, for smaller water systems these models are simply not applicable given their special information needs and their severe constraints of system resources. With this in mind, we have surveyed water agency personnel to identify efficient sets of information for water systems (large, medium, and small) on which water management can confidently

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develop and operate programs including water conservation--at minimum cost.

Two major objectives guide our research program which are particularly relevant to this conference.

1) identify management problems from the different perspectives of local water utility, industry, and citizens--as a first step toward targeting management information to State and local problems;
2) identify an efficient set of information elements--to support water utility management and their affiliated consultants in planning, operations, rate setting, allocation, public participation, staff training, and conservation programs.

Perceptions of Water Problems

Needs for water are shaped by the patterns of living and development of the area--the result in North Carolina is a perceived need somewhat less than the mean per capita consumption, 150 gd, and compares with as little as 5 gd for many less developed countries.

Identification of local water problems is similarly affected by point of view. In our research we have conducted over four hundred interviews with water management and their residential and industrial users in 54 communities across North Carolina. Communities were stratified by size and region so we could look at any possible differences as a function of hydrological conditions and population demographics.

We have found that water management, residential, and industrial users have somewhat different concerns about their local water systems (see Table 1). The highest ranking problem for both residential and industrial water users was quality. Management, however, was more concerned with water supply expansion and difficulties in relating with State and Federal water authorities. For management, quality concerns were considered along with costs of water, office management, planning, waste treatment expansion, supply system maintenance, and general supply problems but without special priority consideration. While it is not entirely surprising that water professionals have a different view of water problems than water users, it is important that water management understand those differences. Our evidence suggests that such understanding is lacking and that management would benefit from community relations training with particular focus on appraisal of community goals, needs, and problems.

The following examples illustrate the need for this kind of training:

1) We asked management what percent of their residential and industrial customers have taken actions in their homes and firms to conserve water. Management predicted only 31 percent of residents and 56

Table 1. Biggest Problems Facing Water Systems

| Problems | Residential N=269 Percent | Residential Rank | Industrial N=122 Percent | Industrial Rank | Management N=47 Percent | Management Rank |
|---|---|---|---|---|---|---|
| Cost of water | 7.06 | 5 | 2.46 | 8 | 4.65 | 7 |
| Demand for treatment | ---- | 16.5 | .82 | 13 | ---- | 14.5 |
| Demand for supply | 1.49 | 11.5 | ---- | 16 | ---- | 14.5 |
| Land use | 1.49 | 11.5 | .82 | 13 | ---- | 14.5 |
| Management (local) | .74 | 14 | 1.64 | 10 | 4.65 | 7 |
| Management (State, Federal) | .37 | 15 | 4.10 | 6 | 20.93 | 2 |
| Planning | 2.23 | 10 | 1.64 | 10 | 4.65 | 7 |
| Quality | 22.68 | 2 | 12.30 | 2 | 4.65 | 7 |
| Waste treatment expansion | 3.35 | 7.5 | .82 | 13 | 4.65 | 7 |
| Water supply expansion | 7.44 | 4 | 10.66 | 3 | 30.23 | 1 |
| Waste system maintenance | ---- | 16.5 | ---- | 16 | ---- | 14.5 |
| Supply system maintenance | 3.35 | 7.5 | 1.64 | 10 | 4.65 | 7 |
| General supply problems | 4.46 | 6 | 5.74 | 5 | 4.65 | 7 |
| General treatment problems | 2.60 | 9 | 3.28 | 7 | ---- | 14.5 |
| None | 26.77 | 1 | 46.72 | 1 | 13.95 | 3 |
| Don't know | 14.87 | 3 | 7.38 | 4 | ---- | 14.5 |
| Other (not applicable) | 1.12 | 13 | ---- | 16 | 2.33 | 11 |

percent of industries had taken actions to conserve water. In fact, 66 percent of residences and 68 percent of industries report having so conserved. This represents a significant underestimate of the willingness of water users to adopt conservation practices.

2) We also asked management to rate the effectiveness of various incentives to control water use for both residential and industrial groups. Price was consistently over-valued as an incentive and community involvement consistently under-valued. Earlier we heard about the benefits in Orange County of having customers read their own meters and the importance of citizen involvement on community boards in the Washington Suburban Sanitary District. We also have found these and other community-spirited activities to have a positive effect on water usage beyond the expectation of most water managers and consequently we recommend their use.

3) Another unexpected result was the extent to which residential and industrial consumers accepted responsibility for contributing to problems of water shortage. Managers predicted both groups would attribute water shortages to the vagaries of the weather, when in fact responsibility was assigned rather evenly to industrial excesses, public excesses, poor planning, and poor management of local resources and weather. It is encouraging to find citizens and industries accepting their appropriate responsibility for excesses in water use.

4) Finally, management overestimated residential and industrial desire to build and pay for more water and waste treatment capacity. When given a choice among several development options, a plurality of both user groups preferred a strategy of conservation so that present facility capacities could accommodate new growth and development.

In sum, misperceptions of community interests on some fundamental issues of water management are the basis of many local problems. With better information and training, managers can identify the priorities and preferences of citizens and industries and therefore be better prepared to deal with problems when they arise.

Management Information

Most communities across the country have limited informational resources. Managers of these community systems are not going to pursue water conservation if they perceive implicit risks to revenue or severe informational requirements. With this in mind, we have sought to identify an efficient set of information on which water management can confidently develop and operate a modern water management system including a water conservation component--at minimum cost.

While the fundamental dependency of management on information is generally accepted, presently there exists no systematic approach in North Carolina or elsewhere, except as represented in our research, to develop information systems appropriate to the new and emerging water management problems of the 1980's and beyond. What information is available now reflects the past concerns and priorities of the local water utility. These traditional systems vary tremendously from community to community. They are systems that are familiar but unsuited to the demands of a modern management approach including conservation.

Our first steps toward systematic development of a modern water management information system (WMIS) included:

1) Enumeration of all information elements potentially relevant to water system planning and operations. Staff were guided in this task by information elements identified by review of community records, information inventories, model systems, e.g., Washington Suburban Sanitary Commission, East Bay Municipal Utility Districts, Dallas Water Utility, and Atlanta Regional Commission among others.

2) Categorize information elements according to general systems concepts--inputs, throughputs, outputs, feedback, environment, etc.

3) Submission of categorized information elements to our sample of 54 water system managers for evaluative ratings. In particular, ratings were made for each information element on importance (I), primary use (P), frequency of use (F), updating requirements (U), and current adequacy (A).

$$I = \{i_1, i_2, i_3 \dots i_x\}$$

$$P = \{p_1, p_2, p_3 \dots p_x\}$$

$$F = \{f_1, f_2, f_3 \dots f_x\}$$

$$U = \{u_1, u_2, u_3 \dots u_x\}$$

$$A = \{a_1, a_2, a_3 \dots a_x\}$$

From these data, a detailed picture of management information needs (N) was revealed where:

$$N = f\ (I \cap \bar{A}).$$

A summary of information needs by general system categories is presented in Table 2. Overall information to support comprehensive planning is most needed. Other high-ranking information needs relate to technical assistance, regulation and enforcement, and water conservation. Small water systems also singled out waste treatment as a most needed information category.

Table 2. Measured Need for Water Management Information by Category

| Category Number | Category Name | Overall (Small, Medium, Large) Systems | | Small Systems | | Medium Systems | | Large Systems | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Rank | Mean | Rank | Mean | Rank | Mean | Rank |
| 1 | Water service population | .407 | 12 | .197 | 12 | .715 | 11 | .289 | 12 |
| 2 | Treatment service population | .515 | 10 | .504 | 9 | .770 | 9 | .329 | 11 |
| 3 | Water supply system | .439 | 11 | .350 | 11 | .595 | 12 | .420 | 9 |
| 4 | Water treatment system | .589 | 9 | .702 | 1 | .708 | 10 | .380 | 10 |
| 5 | Supportive information systems | .821 | 5 | .590 | 7 | 1.034 | 5 | .780 | 7 |
| 6 | Emergency preparedness | .786 | 7 | .418 | 10 | 1.016 | 6 | .872 | 4 |
| 7 | Comprehensive planning practices | .937 | 1 | .678 | 2 | 1.167 | 1 | .927 | 1 |
| 8 | Pricing practices | .695 | 8 | .521 | 8 | 1.088 | 4 | .486 | 8 |
| 9 | Billing practices | .322 | 13 | .184 | 13 | .616 | 13 | .158 | 13 |
| 10 | Technical assistance | .898 | 2 | .638 | 3 | 1.110 | 3 | .884 | 3 |
| 11 | Regulation and enforcement | .873 | 3 | .591 | 6 | 1.128 | 2 | .845 | 5 |
| 12 | Water use | .806 | 6 | .593 | 5 | .957 | 8 | .833 | 6 |
| 13 | Water conservation | .843 | 4 | .630 | 4 | .964 | 7 | .898 | 2 |
| | | $\bar{X}$ .687<br>SD .208 | | $\bar{X}$ .507<br>SD .171 | | $\bar{X}$ .912<br>SD .204 | | $\bar{X}$ .623<br>SD .281 | |

The same information on information needs was also categorized by discipline to identify the professional specialties best prepared to assist with regard to the needed information. As seen in Table 3, the greatest needs can be addressed best by consulting specialists in planning, management, water law, and social sciences. Clearly then, if priority information needs are to be met, community and regional water systems must not be the exclusive turf of the consulting engineers. A multidisciplinary approach will best serve the goal of effective water resource management.

Table 3. Mean Need Value of Information Elements by Professional Areas

| Professional Areas | Need Value |
|---|---|
| Planning | .968 |
| Management | .919 |
| Legal | .873 |
| Sociology | .835 |
| Engineering | .644 |
| Hydrology | .608 |
| Economics | .603 |
| Accounting | .564 |

Finally, the data were used to identify information sets where information need (N) was minimized subject to cost constraints (C) where

$$C = f\ (U).$$

Similarly information waste (W) was minimized subject to need constraints N where

$$W = f\ (A \cap \overline{I}).$$

These results, too extensive to report here, will be forthcoming in our final technical report.

Future generation projects now beginning will develop further some of the most promising ideas gained from this research experience. In particular we are working with industries as they plan for various water shortage contingencies, consider water reuse, process modifications, employee training, and modernization. Also, we are working with local municipalities as they assess their current management practices and consider improvements. We are to a point now where conservation is a proven management option--many more can benefit by its adoption.

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'81 A NATIONAL CONFERENCE

# Keynote Address

KEYNOTE ADDRESS

Major General E. R. Heiberg, III
Director of Civil Works
Department of the Army
Office of the Chief of Engineers
Washington, D.C.

## INTRODUCTION

It is a pleasure to be here to discuss this very important and timely topic of water conservation and to present to you some of the Army's initiatives in water supply and conservation.

The U.S. Army Corps of Engineers (Corps) is not a novice in the business of providing water supply for municipal and industrial (M&I) use. The first general authority for inclusion of water supply storage in Corps projects was enacted in 1958. However, storage for water supply was authorized in projects prior to 1958 on the basis of individual project proposals. The Water Supply Act of 1958 (Public Law 85-500, Title III) introduced a period of joint-venture development of water resources by federal and non-federal interests. Development for traditional federal purposes, such as flood control and hydroelectric power, was teamed with development of M&I water supplies at non-federal expense. The Water Supply Act of 1958 carefully avoided a shift of responsibility from non-federal interests to the federal level of government. Corps reservoir projects included substantial amounts of storage for water supply. Approximately 8 million acre-feet (10 billion cubic meters) of storage in 94 projects is under contract. An additional 12 million acre-feet (15 billion cubic meters) of storage in 84 projects is either included in existing projects or will become available if all authorized projects are constructed. The existing contracts obligate non-federal interests to repay more than $400 million of federal investment costs.

Title I of Public Law 89-298, October 27, 1965, authorized a federal and non-federal cooperative study to prepare plans to meet the long-range water needs of the Northeastern United States. The legislation also authorized federal construction, operation, and maintenance of certain major facilities that had previously been the responsibility of non-federal interests. This study has produced several water supply proposals; however, the appropriate federal role in implementation of these plans has not yet been established.

Water supply continues to be an important part of water resources studies by the Corps. The fiscal year 1981 budget included funds for about 58 feasibility studies that have M&I water supply as one of the purposes to be studied.

## WATER CONSERVATION - A CHANGE

A new phase began with President Carter's announcement in May 1977 that water conservation would be the cornerstone of his revised water policy. A comprehensive review of water policy was initiated during the summer of 1977 that culminated in the President's Water Policy Message of June 6, 1978, and by a series of directives to the federal agencies in July 1978.

The focus on changes to national water policy is not expected to end. The new administration is acutely aware of the physical and financial impediments to a water policy focusing solely on development, when conservation and demand management may be equally cost efficient. The Corps of Engineers is expected to continue to focus on a balanced approach to water supply and demand management under our new Assistant Secretary of the Army for Civil Works, Bill Gianelli. His experience (Director of the California Department of Water Resources, private consultant in a state hit hard by the 1977 drought, and being on the front line of western water issues) will be a great asset to the Nation in the years ahead.

Why is water conservation an objective worthy of emphasis as a national objective? The basic reason is that new supplies often place demands on other scarce resources that are not adequately reflected in the evaluation of, and price for, water. These scarce resources include energy, environmental resources, agricultural land, ground water resources, capital, and the beneficial uses of instream flows. Policy reforms are not designed to preempt state or local responsibilities. On the other hand, the thesis of a new water policy should be that federal programs will not foster inefficient use of the water resources of the Nation.

Rationally applied conservation measures provide the opportunity for increased local action reducing the need for Federal cost-sharing and reducing the overall cost of meeting water demands.

Water is an essential resource. It is an important ingredient in all of the major challenges we face--production of food and fiber, energy, pollution control, transportation, and environmental quality. The growing scarcity of water is well documented. Our ingenuity and skills will be tested to find ways to satisfy the increasing demand for water. Water conservation has to be a key element in addressing these demands.

In March 1978, the Corps initiated efforts to integrate water conservation into its activities. The strategy called for the Corps to:

1. define water conservation within the context of the Corps program;

2. develop a plan of action for integrating water conservation into all aspects of the Corps program; and,
3. develop principles and specific procedures for evaluation of water conservation as part of M&I water supply.

## DEFINITION OF WATER CONSERVATION

Water conservation is not a new term; however, its use has been so varied that a universal definition has not evolved. Water conservation is different from other forms of conservation. Energy conservation is usually thought of in terms of nonuse, so that the resource will be available at a future time. Fish and wildlife conservation provides for use of the resource, but in a manner that preserves and protects the regenerating capability of the resource. Nonuse of water does not automatically ensure its availability at a later time, and the regenerating process (hydrologic cycle) is pretty much beyond our ability to manage at this time. The challenge was to develop a water conservation definition and evaluation process that will permit us to make a consistent trade-off between increments of new supplies and measures that result in more efficient use of existing supplies.

The temptation to adopt the "wise use of resources" definition of water conservation was avoided. Such a definition would be comprehensive, but open to varying interpretations. Perspectives would range from not using the water resource unless it is essential, to using the water resource as many times as possible between the time it falls as rain until it is lost or flows into the ocean.

To be helpful, the definition of water conservation must possess two attributes: it must be precise, and it must be practical. Review of numerous publications on conservation lead to the conclusion that the only way that water conservation can be separated from water supply in a precise and practical manner is to consider conservation as management of the demand function. The required attributes can be satisfied on this basis via the following definition:

"Water Conservation is any beneficial reduction in water use or in water losses."

Based on this definition, water management practices constitute conservation only when they meet two tests:

1. Their purpose is to conserve a given supply of water through reduction in water use (or water loss); and

2. Their total national economic and environmental benefits outweigh their total national economic and environmental costs.

Water use is the withdrawal of water from a supply or other action which denies the availability of that water to another user. Uses range from human consumption to support of fish and the natural environment associated with streams. A reduction in water use is beneficial if the aggregate of all beneficial economic and environmental effects resulting from implementation of the water management practice exceeds the aggregate of all adverse economic and environmental effects occasioned by such implementation. Recognizing that, just as in the case of augmenting supply, conservation measures may deplete other scarce resources (such as energy), the above definition of beneficial reductions will assure that all scarce resources are conserved.

Water supply and water conservation, as defined above, have much in common. Neither can be implemented without making demands on other scarce resources, and the merits of both must be evaluated using the same basic criteria. In addition, the fact that not all new supplies should be considered desirable is also applicable to water conservation measures. The evaluation of the adequacy of existing water supplies and the measures needed to address future water needs requires an assessment of:

1. demand reduction practices;
2. more efficient utilization of existing supplies; and
3. need for new supplies.

## IMPLEMENTATION - PLAN OF ACTION

The national emphasis on water conservation can be separated into two major categories with respect to the Corps water resources program. Sound conservation principles must be applied to the use of water in Corps activities, and water conservation must be an integral consideration in Corps planning to satisfy future water supply needs. This second category translates primarily into an assistance role to state and local governments as a part of studies addressing the adequacy of existing supplies and the need for additions to those supplies.

The Corps issued its first plan of action on May 8, 1978, and a revised edition was issued in May 1980. The plan addresses the relationship of water conservation to the planning of projects and their subsequent construction, operation, and maintenance, as well as the regulatory program. There are five major activities that constitute the water resources program of the Corps.

## PLANNING

The planning role of the Corps represents the greatest opportunity to reduce the demand for additional supplies of water through water conservation practices. While the immediate purpose of water conservation is to better utilize existing supplies, the ultimate effect is to alter water supply planning and use practices. The fact that existing supplies are utilized more efficiently has the effect of either postponing or reducing the scale of projects designed to augment supply, or both.

A consistent and balanced approach to trade-offs between water conservation and new supply results in changes in the scope of the Corps planning role. Urban areas have been considered traditionally as a unit in water supply studies. Past trends of water use on a per capita or production basis have been projected into the future using general growth predictions. Consideration of water conservation requires a thorough analysis of water supply, treatment distribution, use, and wastewater treatment process for the study area. Greater effort and more precision in forecasting demands are required. It will be necessary to separate forecasts into the components of domestic, commercial, and industrial sectors so that conservation measures may be evaluated accurately. It will also be necessary to estimate seasonal water uses separately, and to forecast use in all sectors in terms of several explanatory variables, including price. The Corps should therefore become much more familiar with the interworkings of urban water sytems than has been the case in the past. This increased involvement will be accomplished through cooperation with non-federal interests rather than federal usurpation of local prerogatives.

The procedures manual discussed earlier in the conference describes the concepts, procedures, and measurement techniques for evaluating water conservation proposals applicable to M&I uses of water. Efforts are underway to improve this manual and to complete several case studies using these procedures.

Non-federal interests will be asked to implement conservation measures incorporated into water supply/conservation plans proposed for construction. The past administration directed that development of water conservation programs will be a condition of contract for storage or delivery of M&I water supplies from federal projects. The new administration has indicated that it will be reviewing the extent to which the federal government will require (rather than urge) such a condition.

## DESIGN AND CONSTRUCTION

The potential for water conservation associated with design and construction is expected to be project and site specific to the point that generalized standards or techniques will not be appropriate. This potential breaks down into two categories: (1) measures that reduce the use of water; and (2) measures that influence the availability of water (location and/or time).

All Corps field agencies have developed procedures to implement water conservation in the design and construction of Corps projects. A review of the design and construction features of projects will be accomplished during pre-authorization studies, post-authorization planning, and design. The water conservation review will be made by an interdisciplinary team of involved professionals with expertise in planning, design, construction, and operations. The objectives are to determine whether changes in the design or construction of the project would produce:

1. additional beneficial water savings; and

2. beneficial improvements in the availability of water.

## DROUGHT CONTINGENCY PLANNING

Corps projects provide storage for purposes other than water supply. In fact, only a small percentage of the 263 million acre-feet (324 billion cubic meters) of storage in existing Corps projects is dedicated to water supply. Flexibility associated with this storage represents a valuable resource for responding to short-term water shortages in the areas where the projects are located.

The Chief of Engineers has adopted a policy that Corps projects should respond to public needs during droughts to the extent possible under current administrative and legislative authorities. To accomplish this, a two-step approach will be taken to pre-drought planning. The first step will evaluate and establish the limits of flexibility under existing authorities to modify project operations and to use existing storage to respond to short-term periods of water shortages. During droughts, the Corps is asked for information about how its projects can be more responsive to the needs of the public. The second step will establish options for modification of project authority that would permit a progression of additional measures to increase a project's capability to respond to droughts.

The Corps commitment to this advanced planning to deal with drought has already been effectively used in the Delaware River Basin and is ready for implementation should the need arise in the New England states.

In FY 1982, studies will be undertaken on seven of our reservoirs. The selected projects will provide study experience for a range of drought conditions from the far Southwest, through the Plains Region, to the Northeast. Experience gained from this sample will permit better definition of the review program with regard to both program costs and expected results. This could be a significant investment for the future, and the cost will be relatively low.

## OPERATIONS AND MAINTENANCE

All Corps field agencies are developing a water conservation plan which addresses each project, shop, floating plant, and other separate facilities operated and maintained by the Corps. The plan will be directed toward reductions in water use or water losses. The objectives of the plan are to produce beneficial water savings and beneficial improvements in the availability of water. Consumptive uses will be examined, and conservation measures that can be implemented will be analyzed. Modifications to facilities or methods of operation found to meet the two tests associated with the definition of water conservation will be programmed for accomplishment.

REGULATORY

Water conservation is a part of the public interest review for the regulatory program. The question of how water conservation is to be considered in the public interest review is incorporated into the revised regulation, 33 CFR 320 thru 329, that will be published as a draft for comment. Water supply and conservation has been included as one of the specific factors relevant to the public interest review. It recognizes the need for efficient use of water resources in all actions that involve the use of water or that affect the availability of water for alternative uses. Full consideration will be given to water conservation as a factor in the public interest review, including opportunities to reduce demand and improve efficiency in order to minimize new supply requirements. The detailed procedures for evaluating water conservation in Corps planning activities will be available for use in any evaluation required to support the public interest review.

FUTURE CHANGE?

The Corps is a unique organization that was established during the Revolutionary War. Its water resources responsibilities have evolved over a long history of service. The technical expertise of the Corps has been used in the broadening federal interest in water resources, natural disaster and emergency activities, and special missions. There is no reason to believe that the role of the Corps in water resources will remain static, but the exact nature of future change is uncertain. Potential changes related to the federal role in water supply are under active consideration in both the executive and legislative branches.

Certainly, the Corps, with its nationwide organization accustomed to dealing with water resources problems which cross state boundaries, can offer its expertise to coordinate the resolution of water resources problems, to provide the technical assistance to transfer successfully applied technologies from one area of the country to another, and to lend a consistency of approach to the continuing resolution of complete water supply and conservation issues.

President Carter's Water Policy Message of June 6, 1978, called for the creation of an Intergovernmental Water Policy Task Force as a means of continuing the review of water-related problems. Three problem areas were identified by the task force for special study: (1) cost sharing; (2) advanced funding for waste treatment plants; and (3) urban water supply. A subcommittee, under the leadership of the Secretary of the Army, was established to address the problems of urban water supply. The subcommittee was directed to: (1) inventory existing federal programs that have potential for assisting urban water systems rehabilitation or new construction; (2) evaluate the institutional and financial problems surrounding the supply and distribution of municipal water; and (3) assess policy or program changes that might be indicated at the federal, state, or local level in order to address the problem. The subcommittee completed its report in June 1980.

On the basis of the subcommittee findings, the following five possible policy approaches were set forth for consideration in response to the problems:

1. Status Quo - This approach would retain existing financial, regulatory, and institutional relationships to continue full local responsibility for water supply.

2. Modified Policies and Programs - Modify existing policies and programs to increase federal technical and planning assistance and condition existing direct federal, grant, and loan programs (used for urban water supply) on state review of urban water system utility rate and investment policies.

3. Federal/State Water Banks - Create federal/state water banks to make capital investment funds more easily accessible to urban water systems. Conditions could be attached loans requiring conservation to reduce future capital investment practices. Interest subsidies also could be provided for particularly distressed urban areas.

4. Financial Assistance - Implement increases in existing programs or add new programs of federal financial assistance providing grants, loans, or loan guarantees, conditioned upon the establishment of conservation programs to reduce future capital investment needs and establishment of self-sustaining rate and investment practices.

5. Single-Purpose Water Supply - Remove existing policy prohibitions against single-purpose water supply in federal water projects and allow direct federal construction of single-purpose water supply projects. Change federal policy to permit the inclusion in federal projects of wellfields, purification and distribution facilities, as well as reservoir source development and major conveyance projects. Change federal policy to permit repair and rehabilitation as well as major reconstruction of such facilities. States would determine, with local input, water supply priorities, and costs would be repaid over time in accordance with the Water Supply Act of 1958.

The subcommittee indicated that selection and implementation of any one or combination of policy approaches by policymakers should occur in conjunction with a more detailed study of urban water resource problems to reduce uncertainties as implementation proceeds. Such a study should be designed to: (1) relate urban water supply problems and solutions to other urban infrastructure problems; (2) inventory, on a case-by-case basis, urban water system needs; and (3) provide a basis for review of, and "mid-course" correction to, the approach or approaches selected.

Because of the broad inputs from representatives of states and cities as well as federal agencies, the study should prove highly useful to the Administration, Congress, and other interested parties as present policies are reassessed.

The Congress has also taken a special interest in the water supply problems facing the Nation. Numerous bills have been introduced to the 96th Congress that would, if enacted, modify the Corps role related to water supply/conservation.

The impact of such changes would be to extend the direct federal assistance role into all facets of water supply augmentation, treatment, and distribution. The Reagan Administration has already expressed a deep interest in examining any such provisions.

SUMMARY

The water resources program of the Corps of Engineers has made a tremendous amount of water supply storage available to non-federal interests. About 8 million acre-feet (10 billion cubic meters) of storage is under contract, and another 12 million acre-feet (15 billion cubic meters) is part of existing and authorized projects. The President's declaration of a national emphasis on water conservation has resulted in changes in water supply planning that will improve the Nation's economic welfare and enhance its environment. The Corps has set forth a definition, principles, and procedures for evaluating water conservation that will ensure consistent and balanced treatment of water conservation and supply augmentation. The Corps is implementing a plan of action that will integrate water conservation into all aspects of its civil program. The water resources program is seldom static, and active consideration is being given to potential changes in the federal role in water supply/conservation. The pressures to expand the federal role are being met with strong resolve by others to retain or even reduce the present federal role. Additional time will be required before the complex critical issues associated with this question can be resolved and the federal role of the future established.

We stand ready to provide the necessary planning, engineering, and construction expertise to assist states in providing comprehensive solutions to regional water supply problems.

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# Federal Perspectives–Programs/Incentives

# COMPARISON BETWEEN WATER CONSERVATION PRACTICES IN THE UNITED KINGDOM AND THE UNITED STATES

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## INTRODUCTION

During recent years, there has been a growing awareness, on both sides of the Atlantic, for the need to conserve resources. In the specific case of water conservation, there has been little exchange of information and, as a result, ideas have largely developed independently. The purpose of this paper is to draw comparisons between conservation activities as practiced in Britain and in the United States. Its intention is to cover both aspects of water conservation; namely, demand management and supply management, with a view towards acquainting the readership with British practices as adopted by the Thames Water Authority, and to suggest reasons for the differences between the United Kingdom and the United States in terms of attitude, emphasis, and outcome.

Obviously, any comparison of this nature is bound to be superficial; in this particular instance, the tenuity is compounded by our limited knowledge of American culture and practices. Nevertheless, the apparent difference in terms of per capita consumption is so marked that the lack of precise detail should be incidental.

## DEMAND MANAGEMENT

### Policy

Bearing in mind that water resources are renewable and assuming they are not overexploited, the objective of demand management is to suppress, rather than restrict, the demand on the system, thereby not only reducing operational costs but also deferring the need for capital expenditure and other scarce resources such as land. However, most demand management options will incur some expenditure, and it is essential to ensure that such measures are cost-effective and not pursued for their own sake.

This, of course, begs the question as to whether water undertakings should have any direct involvement in demand management. It could be argued that matters related to demand should be left entirely to consumers and water authorities should meet those demands in the most efficient way they can, taking into account cost, environmental considerations, and so on. However, in reality, it would be hard for water authorities to avoid at least some degree of involvement, since dividing lines between waste, misuse, and extravagance are not clear cut and waste prevention regulations have been enforced since the last century. The question is perhaps not whether demand management should be exercised but to what extent. This argument is liable to come under public scrutiny whenever there is an inquiry into proposals to develop a new resource.

Pricing Structure

In the United Kingdom, the present method of charging for domestic water services is closely akin to a property tax. Charging by meter is seen as more equitable but, at least up to now, too expensive. Without domestic metering, the scope for introducing a pricing structure that encourages prudent use of water is limited to industrial and some commercial consumers who are currently metered. However, these represent a small percentage of the total supplied. Moreover, the sensitivity of demand to the existing pricing structure appears to be small.

Bylaw Legislation

Under relevant United Kingdom legislation, water undertakings are empowered to enforce local bylaws to prevent waste, undue consumption, misuse, or contamination of water supplied. The nature of these bylaws is such that they are directed at the users of water rather than at the manufacturers of pipework, fittings, and appliances. However, under more recent legislation, a national scheme has been established for the assessment and testing of water fittings to asscertain whether they comply with bylaw regulations.

As a result of bylaw legislation, 9-liter flush toilets have been standard in Britain for many years. Similarly, in many areas, a storage tank is required in the roof space to feed nonpotable supplies such as toilets, hot-water cisterns, etc., thereby reducing the effects of peaking on the distribution network. These and other such measures have effectively either reduced or smoothed the demand for water without most consumers even being aware.

Leakage Prevention

It is difficult to be precise about losses from a distribution network, particularly without universal metering. Leakage in the United Kingdom is thought to average about 25 percent of the total put into supply, with isolated instances in excess of 50 percent. Not surprisingly, the reduction of leakage has a high priority in most water authorities where more effort and improved leak-detection equipment are being employed.

## Education

In times of crisis, the public has always shown its willingness to cut back on water use when appeals have been made: the difficulty is sustaining that reduction for more than a few weeks. One of the weaknesses of the present method of charging is that the benefits from using less water do not accrue to the individual apart from any incidental saving on heating costs. Even though it is always possible to put more effort into educational campaigns aimed at schools, it is regarded as an ongoing, long-term proposition.

# SUPPLY MANAGEMENT

## Policy

The traditional aim of water undertakings in Britain and elsewhere has been to provide the consumer with an adequate supply of wholesome water at minimum cost. More recently, with the growing awareness of environmental issues, this objective has been tempered to minimize both visual and ecological impact. For instance, Thames Water has deliberately pursued a policy of seeking less controversial sites for the inevitable new resources. This has included derelict industrial areas such as disused gravel workings, noise-polluted areas surrounding an international airport, etc. Similarly, ground water has been exploited for both direct supply and river regulation on the basis that it is not only economic but it also has minimum visual impact on the landscape.

## Assessment of Resources

In recent years, a more realistic approach has been adopted for the assessment of water resources. Instead of sizing single reservoirs to withstand a hypothetical "design drought," water resource systems are now objectively designed on an integrated basis to meet specific performance criteria that depend on tolerable frequency of restrictions on demand. The techniques developed take into account conjunctive use of resources, which in many instances has resulted in uprating the reliable output of the system, thereby enabling further capital investment to be deferred.

## Alternative Resources

For many years, a significant portion of Thames Water's potable supply has come from indirect effluent reuse: conurbations including Swindon, Oxford, and Reading all abstract water for local use and return treated effluent to the river for subsequent use downstream. Strict catchment control and robust water treatment systems ensure that high-quality water is supplied throughout the Thames basin.

Artificial recharge of aquifers is being practiced on a pilot scale, utilizing surplus water treatment capacity during winter months. If successful, the expectation is that recharge will make an increasing contribution to the water resources of the London area.

### Water Distribution

Faced with the problem of supplying increasing quantities of water in the London metropolitan area, Thames Water has decided in principle to base its future distribution network on a ring-main concept. In all probability, this will take the form of a low-pressure, wedge-block tunnel, supplied by the more efficient of the existing water treatment works. Water will be pumped out and distributed locally by a conventional high-pressure network. However, with bulk supplies of treated water being conveyed by a low-pressure tunnel in impervious clay, overall losses from the distribution network are expected to be significantly lower than at present.

## COMPARISON WITH THE UNITED STATES

### Objectives

It would seem that the underlying motives of water conservation are similar on both sides of the Atlantic: The aim of demand management is to influence consumer habits, thereby encouraging more prudent use of water; the aim of supply management is to provide adequate quantities of wholesome water at minimum overall cost to the consumers and to the environment. There are, however, differences in climate, culture, and standard of living that would suggest that there is no unique combination of measures that is universally optimal.

For example, in Britain where rainfall is usually plentiful throughout the year, garden watering forms a small portion of domestic consumption. Secondly, when it comes to personal hygiene, bathing is more common than showering. Although this may involve a larger quantity of water, the relative frequency of showering is liable to make the latter more expensive in overall water usage. Thirdly, the standard of living, as reflected in the ownership of water-using appliances, is higher in the United States, and automatic equipment is invariably harder on water use than are manual methods.

### Institutional Aspects

The water industry in England and Wales was reorganized in 1974 to form 10 regional water authorities responsible for all aspects of water supply and sewage disposal. Consequently, it is probable that the introduction of model bylaws and the adoption of national standards for fittings/appliances are easier to achieve than in the United States where water services are more fragmented. Similarly, with sewage treatment and pollution control being charges of the same organization responsible for water supply, it must be easier to contemplate effluent reuse in Britain.

## Procedural Aspects

Although Government imposes certain restrictions and fixes the capital expenditure ceiling, water authorities are financially independent of Government. With no prospect of attracting central funds, the initiative for water conservation tends to be regional rather than national. As a result, procedures for water conservation would seem to be less formal than in the United States, with each region pursuing what it believes to be the more effective measures.

## Effectiveness

Results of domestic metering experiments carried out by various water authorities thoughout England and Wales suggest that, in 1978, the typical household demand was approximately 120 liters per head per day, comprising:

| | Liters/Head/Day |
|---|---|
| Toilet flushing | 40 |
| Personal hygiene | 30 |
| Laundry | 14 |
| Washing up | 12 |
| Outside use | 4 |
| Drinking, cooking, cleaning, etc. | 20 |
| Total | 120 |

When the total amount of water put into supply is averaged over the whole population, the corresponding figure is 301 liters per head per day, comprising:

| | Liters/Head/Day |
|---|---|
| Household demand | 120 |
| Nonmetered commercial use | 20 |
| Miscellaneous demand | 1 |
| Unaccounted-for water | 71 |
| Metered industrial use | 89 |
| Total | 301 |

# CONCLUSION

## Current Progress

Although consumption rates in Britain are significantly lower than in the United States, there is no room for complacency. Consequently, all water authorities now have, or will soon have, bylaws that make dual-flush mandatory for the washdown type of toilet in all new dwellings. Similarly, some water authorities have ongoing programs of research to establish the effectiveness of variable-flush toilets, pressure-reducing valves, flow-limiting valves, automatic flushing control, etc.

## Prospects

It has been recognized for some time that there is a need to review the whole framework of model bylaws in England and Wales with the aim of promoting more prudent use of water. In the near future, the expectation is that proposals will be put forward to the National Water Council and the Department of the Environment for consideration on a national basis. Although the potential savings from the measures proposed in the new model bylaws cannot be quantified with any certainty, they will provide a climate conducive to creating a water-conscious society.

FEDERAL WATER RESOURCE AGENCY PLANNING REQUIREMENTS AND IMPLICATIONS FOR WATER CONSERVATION

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ABSTRACT

The 1978 executive water policy reform message was not a radical departure from earlier policy directives. However, its specificity about the role of conservation in water planning and management, its applicability to wider ranges of water activities, and its urgency for immediate response have differed from previous water policy statements.

Federal agencies dealing with water-related programs or projects were mobilized to initiate prompt action to address water program issues. Federal agencies have responded with a variety of changes and proposed measures. The Principles and Standards were revised by the Water Resources Council to integrate water conservation into project and program planning and to widen the range of options considered to include alternatives that Federal, State, or local entities might implement.

The Water Resources Council's State Conservation Planning Guide (October 1980) reflects the increased emphasis on State responsibility to implement conservation measures. State grant applications to support water conservation actions reflect a wide range of conservation measures that are planned or currently being implemented.

The Federal Government has created incentives for and obviated disincentives for water conservation. Instead of a monolithic pattern of resource management and planning, States can work with the Federal Government to tailor measures to meet local needs and economies.

During the past 80 years, our national concept of water conservation has shifted focus to reflect current economic conditions and contemporary attitudes toward environmental resources. Distinctions in political philosophies have often blurred when the Government takes action on water conservation. Economic conditions, national emergencies, or natural disasters such as droughts frequently play a greater role in public evaluation of resources than does any specific party-line attitude. The definition of water conservation and the role it plays in water resource planning generally changes with the changing times, particularly when there is a drastic change in the economy.

The 1901-1914 progressive movement had for its theme the "wise use of natural resources." Led by Theodore Roosevelt, this conservationist attitude set the stage for ensuing water resources programs and policies. During that era, however, conservation of natural resources was viewed as a way of preserving the great outdoors for the enjoyment of future generations. Later, however, the New Deal planners of 1933-43 saw conservation primarily as a way to stimulate economic recovery, even though planners insisted that all water projects be coordinated with plans for the comprehensive development of an entire river basin. The "new deal" multiple-purpose public works projects were hailed as experiments in democracy. They shifted water power development from "power trust" monopolies to the public, and they combined regional economic growth with widespread distribution of benefits among the people. The projects introduced benefit-cost analyses and eventually added social benefits as evaluation criteria.

During the next 20 years water policy generally supported construction projects that were to guarantee water supply for beneficial uses. Federal agencies supporting water construction projects expanded and water projects multiplied. After World War II, the growing leisure class forced attention on environmental issues, but again these were chiefly to support recreational opportunities. Along with recreation, however, municipal and industrial water supplies for the growing metropolitan areas were introduced as valid purposes in water resources planning. Slowly but surely, the objectives of planning shifted. The question was no longer how the Federal Government could equitably distribute funds to foster regional development. The emerging question was how it could equitably apportion a scarce natural resource. In 1955, President Eisenhower's Advisory Committee on Water Resources Policy reported:

> The basic elements of a sound policy are clear. That policy must look toward an adequate water supply for our people, prevent waste of water, provide for a greater reuse of water, reduce water pollution to the lowest practicable level, provide means for the useful and equitable distribution of available water supply and take steps to check the destructive forces of water which threaten to injure or destroy land, property, and human life.

In the 1970's, water conservation *per se* earned a more central role in water policy. The 1978 Executive water policy reform message put water conservation equal to and in some ways more important than construction in water planning. In the 13 followup Executive memoranda to Federal agencies, seven dealt directly with water conservation measures.

On June 6, 1980, precisely 2 years after the 1978 reform message, the Secretary of the Interior reported on the first phase of Federal agency followup to the Executive mandate. His report lists an array of specific changes to underpin water conservation in the agency program objectives and to induce non-Federal entities to adopt conservation plans and practices. The actions range from intensified conservation research to technical on-site assistance with specific conservation measures. The preliminary report, issued November 9, 1978, listed 18 agency research programs that could enhance conservation research. The final report, however, indicated that agency research is reaching out in two ways: Federal agencies are cooperatively developing information on common areas of conservation applications and are integrating and supporting research by non-Federal entities. For example, Housing and Urban Development, Veterans Administration, and Farmers Home Administration cooperatively evaluated 50 possible ways to reduce residential water use, and scheduled seven for prompt program implementation as a condition of Federal financial assistance.

Five agencies--Farmers Home Administration, Economic Development Administration, National Oceanic and Atmospheric Administration, Environmental Protection Agency, and Department of Housing and Urban Development--examined their legal authority to promote conservation in water supply and wastewater treatment grant programs. All five agencies have one or more of the following common prerequisites to grants: installation of meters, increased leak detection programs, modified rate structures to promote conservation, consideration of flow reduction measures rather than facility expansion, public education programs, and conservation design in new sewer and supply systems.

The Bureau of Indian Affairs is using the Soil Conservation Service's technical assistance to identify conservation measures for Reclamation and Indian irrigation projects. The Department of Agriculture, the Department of the Interior, and the Environmental Protection Agency set up a cooperative plan to improve irrigation efficiencies.

Agencies are also extending their use of non-Federal groups. For example, Agriculture is using the Hatch funds for university research on improved irrigation timing and water application, reduced soil moisture losses, and increased moisture absorbency and retention in soils. It is also using State Cooperative Extension Services and Land Grant Colleges to develop and to disseminate water conservation technology and management practices.

Agencies have also stepped up their own internal coordination in conservation research and applications. The Corps of Engineers has introduced and is pursuing an across-the-board focus on conservation. Efforts include: (1) a synopsis of general conservation literature and case-study measures for Corps planners and field personnel use; (2) an interdisciplinary team is developing procedures to implement conservation measures in civil works during the preauthorization, planning, and design phases; (3) a proposed Engineer Regulation to improve reservoir regulation, including drought contingency plans and possible storage reallocation, has been sent to all field operating agencies for review; and (4) conservation planning will be developed by all Corps field offices for each project, shop, floating plant, or any separate facility operated by the District.

In addition to the increased agency cross-pollination and the intensified internal coordination of conservation activities, agencies have also widened their support of non-Federal conservation activities. These include: cost-effectiveness studies for a range of conservation measures; cost-sharing of efficiency improvements; technical assistance in specific conservation technologies; educational materials, revised handbooks, and training to promote conservation values; and priorities in grant monies to encourage conservation plans and projects.

In the reform message, the President also directed the Water Resources Council to modify the Principles, Standards, and Procedures for water resource planning so that conservation would be fully integrated into the economic development and environmental quality objectives of planning. As a result, the revised Principles and Standards and supporting Procedures were published in the Federal Register as final rules in December 1979 and September 1980.

The revised Principles and Standards lists three elements of conservation: (1) reduced demand for water, (2) improved efficiency in use and/or reductions in losses and waste, and (3) improved land management practices to conserve water. The rule also states that conservation planning may consist of ". . . a range of measures that over time can balance water demands with water availability. . . ."

This revision shifts emphases and authorities in water resources planning, some of which directly affect water conservation planning. Conservation is now on par with supply augmentation; environmental quality is an objective equal with national economic development; nonstructural alternatives must be considered along with any structural approach; and plans that may be implemented by other Federal agencies, State and local government, and nongovernmental entities are to be included among the alternative plans.

These changes are to stimulate water conservation planning, provide a role for regional and local authorities to work with Federal authorities, and encourage Federal agencies to cooperate with other Federal agencies in the planning stages. The principle is cooperative planning that supports national and regional economic benefits and enhances environmental qualities.

In March 1981, the Water Resources Council published a Bibliography of Water Conservation giving references on water use, conservation planning, institutional/legal considerations, public education and participation, energy savings, wastewater reuse, emergency/contingency planning, and water conservation impacts.

In October 1980, the Council also published the State Water Conservation Planning Guide. The purpose of the guide is to help States develop water conservation programs and prepare applications for planning grants that include water conservation. It summarizes information on Federal, State, regional, and local policies, programs, and experiences and it describes procedures for integrating conservation planning into the State water management planning. It also provides sources of useful information for planning.

The introduction states:

> The procedures described in the guide should have broad applicability throughout the country. The value and usefulness will vary among the States. Some States have completed water supply and water conservation planning programs. Others have undertaken specific conservation measures. The Council recognizes that each State program will have a somewhat different orientation and is in a different stage of development or implementation. It is expected that the guide will be used selectively by each State to apply those elements which are appropriate to its specific conditions and needs. The one common emphasis is that almost all existing water use practices can be made more efficient, and that the maximum efficiency will result from a set of water conservation priorities that are developed as part of a statewide planning process.

The diversity of conservation measures proposed in State grant applications to the Council illustrates the soundness of a flexible approach to the support of water conservation planning.

A sampling of State responses shows the range of varying conservation needs or problems. One State (Arizona) is studying urban conservation methods, including effluent reuse. Another (Maryland) is investigating selective consumptive users to determine demand reduction criteria and procedures while simultaneously working to establish interstate and intrastate water conservation task forces. Another (Colorado) is identifying ways to increase yield and efficiency in existing facilities by improving allocation and distribution. One northeastern State (New Jersey) has a long list of conservation plans, including identification of systems for mandatory rationing during emergencies, daily tracking of water diversions, reservoir levels, precipitation, and demand reduction; distributing of shower and faucet flow restrictors in "rationing" areas; and field testing of retrofitted water closets.

A southwestern State (New Mexico) is passing on program funds to local and regional political subdivisions for water research, conservation, and demonstration projects. A midwestern State (Kentucky) plans to develop individual basin water budgets. A western State (Idaho) plans to technically assist local water users and groups in evaluating water systems design for more effective and efficient surface and groundwater use. Another (Georgia) is developing conservation criteria for surface and groundwater allocation permit programs.

A southeast State (Alabama) plans to test components of traveling irrigation systems and develop new simulations to decrease water and energy requirements. An eastern State (Virginia) is developing a mini-grant program and yearly progress and status reports of water conservation throughout the State.

Many States are developing educational materials on conservation for use by schools, media, or both. Another common element is a cost analysis of various conservation measures.

The Council handbook and State responses in grant requests illustrate two overall changes in water policy. The emphasis has shifted from centralized Federal planning to a broader involvement of non-Federal groups and from Federal control to Federal support of such planning. Non-Federal entities can work with the Federal agencies to tailor measures to meet local needs and economies. In turn, Federal agencies are also to include non-Federal plans among their alternative plans, as required by the Principles and Standards. But regardless of where the planning originates, conservation considerations are to be included in the planning process. By encouraging State and local conservation measures--or by withholding funds for programs that do not include conservation--the Federal Government is supporting the water conservation officials who often must compete with other State or local goals or special interest group pressures when program priorities are being established.

Conservation planning is not, however, an end in itself. It is a part, not the whole, of water planning and management. Theodore Roosevelt pushed for conservation to guarantee preservation of the resources for future generations. That long-range view of water conservation is particularly significant in light of the recent energy resource crisis. Oil supplies have dwindled faster than our appetite to use them. Similarly, water supplies in many parts of the country are also dwindling. If the Nation continues to treat water like an inexhaustible resource as it did with oil, the water will not be there for future generations.

The prospective drought has boosted water conservation into national consciousness, and some shortoterm emergency measures to mitigate drought effects are educating people to the importance of conservation. But once the emergency is over, people tend to forget the value placed on the resource during the crisis. Water planners--at Federal, State and local levels--must look at the long-term values and must reduce disincentives to conserve water. Federal water policy has been moving slowly in just that direction, and will, I trust, continue.

# PLUMBING CODES - ESSENTIAL IN WATER CONSERVATION PROGRAMS

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## ABSTRACT

The development and implementation of water conservation programs requires acceptance of low water usage plumbing fixtures and devices. The installation of innovative components or modifications to existing plumbing systems for reduced water consumption are controlled by local jurisdictions through the plumbing codes.

A review of the developments leading to current plumbing code requirements is presented. The basis for development of revisions to codes and supporting standards from current research projects is discussed. Requirements are indicated for (a) current data based upon real water demand loads to update water supply pipe sizing (Hunter's Curve) and (b) the necessity to consider the impact of deterioration of performance from reduced wastewater flows in the building drainage system with expanding water conservation practices. Examples of laboratory research and field demonstrations of water conservation programs are provided.

## INTRODUCTION

Recent efforts to investigate methods to conserve water available from municipal potable supply systems result from recognition of the limits for continuing expansion and development of water resources. The reasons for concern about excessive use of treated water are due to:

- limits on the availability of the water resources with continuing industrial/population growth and expanding real estate development;
- the high costs of plant construction, distribution and collection networks for both input and output phases;
- the extensive problems of pollution and the efforts required to return water to nature in approximately the same condition it was withdrawn;

- the regional experiences of severe water droughts or normally arid conditions with rapidly increasing populations (which can be alleviated by more judicious use of available supplies);

- increasing confrontations among competing segments of society with demands for more water allocations from available supply sources.

It is against this background that the federal cosponsors of this conference recognized the need to focus upon the wide range of issues specifically surrounding the topic of the processed potable water supply. Related issues of primary importance to the agricultural interests, industrial requirements, recreational purposes and power or fuels production have been extensively recognized at other forums; e.g., Needs and Implementing Strategies (1). The purpose of this meeting is to examine the interaction between local and state water management with federal programs that support or provide assistance and incentives for water conservation. This conference continues the efforts and themes which focus on water conservation initiated at the 1978 National Conference - Water Conservation and Municipal Wastewater Reduction (2).

Water has traditionally been viewed as an unlimited resource whose use was restricted only by legal or engineering constraints. Legal issues associated with environmental concerns complicate both water conservation and the related area of water pollution abatement. In recent years, state and federal statutes have taken preeminence in water resource questions and common law water use doctrines are still prevalent as issues in both water conservation and pollution control policy. Two main doctrines, riparian rights, which relate generally to Eastern states, and prior appropriation, which is applied in the West, have considerable influence on water resource decisions.

The Water Pollution Control Act amendments of 1972 and the Safe Drinking Water Act of 1974 have established requirements for potable and effluent processed water. Benefits of water conservation at the tap were recognized in the Clean Water Amendments of 1977; regulations now require the implementation of water conservation measures by all recipients of grants for the construction of wastewater facilities. Water conservation clearly has a direct impact on the volume of wastewater produced in a community. If each consumer uses less water, proportionately less wastewater will require treatment, and treatment plants can then serve more consumers with no increase in total capacity. The single issue of the relationship between water usage and wastewater treatment indicates that the benefits of conservation can extend beyond the question of water supply to issues of growth, development, and local public investment (2). The Environmental Protection Agency has identified the infiltration of groundwater into sewers as a major problem. As infiltration is reduced, the advantages of saving water in homes and industrial and commercial buildings will take on greater significance in lowering the volume of wastewater requiring treatment.

Increased demand for water has strained the existing capacity of public water systems making them more vulnerable to drought. The series of recent droughts have demonstrated that there are limits of storage, stream flows, surface water, groundwater and deep aquifers to provide and maintain delivery of quantities of safe, clean water in many communities. Local water systems have exploited fully the most accessible supplies, necessitating the development of more distant or difficult sources with increasing costs being passed on to consumers. Crisis response in recent droughts imposed significant changes in water use patterns (some voluntary and others mandatory) for residential and non-residential customers alike. However, the persistence of changes in consumption is unknown since water usage can be affected by a large number of factors; several studies on this subject are presented in other sessions of this conference. Water managers have introduced planning for normally reduced water supply (including rationing) due to drought situations and limits placed on watershed expansion. That represents a significant departure from the concept of supplying as much water as customers desired with declining block rates which encouraged increased water usage. However, a disincentive for water conservation has resulted from (the positive responses to the need for) reductions in water usage because increased rates were required in order for water utilities to meet the costs of bonded indebtedness and operating costs as total water revenues decreased as consumption declined.

The more efficient use of water is generally what is meant by water conservation; it includes the utilization of both devices and practices which reduce consumption of water supplies, limits waste and seeks to reuse, reclaim or recycle water. Conservation techniques of this sort are applied "at the tap," as persons, businesses and industry draw water. Also, in particularly arid areas conservation can mean landscaping for minimal water needs as well as large scale preservation of water in reservoirs, canals and lakes so that it will not be lost by evaporation or transported away. Broadening national concern for water conservation as a normal water management practice (as compared to drought crisis situations) has caused numbers of state and local jurisdictions to incorporate water-saving regulations in their local and state plumbing codes. Effective reductions in water usage requires implementation through the local building regulatory system to assure minimum requirements for health, safety and sanitary purposes. The requirements for satisfactory performance of innovative, new or retrofit devices are not necessarily the same as for conventional larger water consuming equipment. Therefore, research for test evaluation methods is essential for revisions to outdated standards. Automatic regulation with installed hydraulic control mechanisms in water devices to maintain efficient performance with low flows reduces the dependence and range of variability of other parameters in water savings programs which are normally assumed to be governed by strongly subjective influences, e.g., changes in load patterns by users. The issue of conserving water as well as energy in building water supply and distribution systems (plumbing) was a subject of the International Symposium (3) of September 1976 sponsored by the National Academy of Sciences. The theme developed in six national issue papers was to define the needs for wide ranging plumbing research and to place those needs in perspective with other building and utility research. There, R. Benazzi et al. reported (relative to peak demand flow rates):

> "In today's plumbing systems, one startling fact has become increasingly more evident; within the plumbing industry, very little is known about current water requirements and the procedure for estimating the demand for water. Methods used today in the design and sizing of water supply systems are based upon guidelines that were established many years ago with few subsequent changes. On the basis of experience, engineers have tried to modify existing sizing techniques, but they have met with only limited success even though recent studies indicate that most supply systems are oversized by a large margin, thereby providing excess capacity with waste of water as well as material, labor and time. A meaningful policy on water conservation and related energy requires current quantitative data for actual levels of usage as a basis of improved computational design procedures."

The process by which water supply distribution and wastewater effluent collection systems for buildings in the United States are planned, designed, constructed, and operated is highly regulated by prescriptive (as contrasted with performance) codes and standards. Those documents comprise the building regulatory system for the specification, assembly and installation of materials and equipment offered by a diversity of manufacturers. For the plumbing industry, the process revolves about products -- fixtures, fittings, or trim (often referred to as brass), specialty items, and piping. Product oriented technological advances are the result of proprietary research and development activities of manufacturers. Those proprietary activities benefit from plumbing systems research in the public sector performed in furtherance of the development of plumbing codes and standards. The broad and more basic research has traditionally been centered at the National Bureau of Standards and limited programs at universities; e.g., Stevens Institute of Technology, the University of Iowa, the University of Illinois, Pennsylvania State University, Massachusetts Institute of Technology, Johns Hopkins University, and Virginia Polytechnic Institute, supported by both public and private funds.

In this paper a limited historical perspective of plumbing code developments and supporting research for codes/standards is provided. A brief review of current water conservation programs at the National Bureau of Standards (NBS) and the Department of Housing and Urban Development (HUD) is then presented.

## PLUMBING

### What Is "Plumbing?"

The definition of "plumbing" is simple and essentially set forth as the water supply system and drainage system for buildings. However, the various model plumbing codes, the trades and construction industry and other special interests have constrained, specified or extended the definition to meet their own needs. The definition can include all requirements against contamination by use of cross-connection control and backflow prevention to the point of connection to the supply mains. Understanding the basis for requirements of installed water systems in buildings is required for successful water conservation programs and the need for changing plumbing codes has been recognized in most successful demonstrations.

The potable water supply and distribution systems are required to provide the essential health and sanitary services for building occupants and to provide for adjacent land improvements for lawns and gardens and/or recreational purposes. The evolution of plumbing regulations of current use began approximately 100 years ago as a result of water supply under pressure becoming available, initially for fire fighting and then for waterborne wastes removal. The burden of water quality and sanitary disposal enforcement originally was placed upon the local health officers by the local governing bodies. The early plumbing codes merely mentioned that water supply piping "must be there and adequate" - no provisions for sizing and occupant patterns of load demand; waste systems were the priority for protection against filth and disease. Through the first quarter of this century. plumbing codes were rewritten purely on the basis of demonstrated practical experiences with small impacts from manufacturers of plumbing products.

Plumbing Codes

Usage of potable water regularly occurs in buildings and is primarily governed by the design of plumbing fixtures and appliances and trim and by capability for the supply system to provide adequate design flow rates and pressures (which may require large pumping capacities for high-rise buildings). The costly infrastructure for the water processing plant connecting pipe network and the corresponding waste pipe collection network and waste treatment plant are all integral in the considerations for water conservation programs. The building plumbing extending to the connections to the above systems with protection by cross-connection control and backflow prevention are the usual limits of applicability of plumbing codes.

A review of texts, conferences, and meetings on water conservation or bibliographies shows a limited understanding of the relationship between reducing water consumption and plumbing systems research, the structures of the model plumbing codes and standards, and the local implementation process that depends on the cooperation of the trades and construction industry. Considerable emphasis has existed on improvisation with non-approved devices, as well as other disciplinary investigations for economic and sociological issues, conceptual and/or strategic approaches to saving water. Publicity has oftentimes been gained by inventors of low flow devices or by authors of guidelines on strategies and implementation of reduced flow practices although such devices or recommendations may violate the applicable plumbing codes. In many cases the requirements of the codes and other building regulations which are applied for review, inspection, and approval of plumbing systems installations are not followed. Because limited levels of research for plumbing are customary, very often rational methods for testing and evaluation of new or innovative devices and systems have not been established. Plumbing codes accept "standard" items; it is important, therefore, that standards be developed for new items. The application of the performance (functional) concept in developing such standards and gaining acceptance expeditiously as compared to traditional experience is based on the prescriptive approach.

Recognition of the need to incorporate requirements for water use reductions through the legislative process was shown, for example, by the states of California, New York, and Maryland; and the need to mandate plumbing code changes, as in the case study reported for Elmhurst, Illinois (2) and by the Washington Suburban Sanitary Commission (1). A detailed description of plumbing codes, their structure and standardization in the United States was presented by Snyder (5). Consensus standards are prepared under sponsoring organizations and the use of the standards is voluntary on the part of individual manufacturers other than Federal standards for use by the government in buildings for their own account. For assistance in seeking further information, a number of organizations in the plumbing codes and standards activities are listed in Appendix A.

- Minimum Requirements for Plumbing

The major change in plumbing guidelines and practices was initiated under the Secretary of Commerce, Herbert Hoover, in the early 1920's. The first exhaustive report "Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings" was issued in 1923 by the National Bureau of Standards (4). That was the first organized thrust at assembling the physical and hydraulic data applicable to plumbing, results of tests and other information related to standardization of materials culminating in a recommended plumbing code. The impact of that document persists since all currently derived codes remain as prescriptive specification types that reflect only detailed specifics; the author's intent, however, was that it was only a beginning and subsequent efforts to get performance type codes have failed. Since that effort, the National Bureau of Standards has pursued research in plumbing with major contributions and impacts upon codes and standards which have utilized the results reported over the past five decades.

The final report of the Subcommittee on Plumbing, "Recommended Minimum Requirements for Plumbing," revised 1931 (6), known as the "Hoover Code," was widely utilized by state and local regulatory bodies. That document was the forerunner of the later widely accepted American Standard National Plumbing Code, ASA A40.8-1955 (7). The recommended code was purely a specification-type code. The inclusion in the

Hoover Code of the research data and discussions concerning the physics of plumbing systems indicates the authors felt that this was only a beginning and that much additional work was needed. However, until almost the present time, plumbing codes in the United States reflect only detailed changes and little if any change in the concept for a plumbing code (i.e., no definitive performance parameters for function which could allow engineered solutions instead of the prescriptive specification and materials constraints). The details of the plumbing materials for use in installations were provided. Detailed references were made to the various piping materials then in common use for installed plumbing and a listing of the specifications of the American Society for Testing Materials (ASTM), included for the various pipes and fittings. The specifications or standards listed for the various pipe and fittings involved the details of the manufacture and testing, as well as the base materials used in the construction, with practically no listing or discussion of their use or adaptability in the installation of plumbing systems.

- Plumbing Manual

In 1940 the National Bureau of Standards published Report BMS 66 entitled "Plumbing Manual" (8), the result of the work of a government committee. Although this "Plumbing Manual" was intended primarily for federal plumbing work, it was anticipated that it would also be helpful in bringing about greater uniformity and reduction of costs in all plumbing work. The far-reaching forward look in sections on pressure and nonpressure drainage and specification of different capabilities for primary and secondary branches of the building drain were never picked up by model or local codes; that forward step is still not looked upon favorably. The BMS 66 also contained the famous "Hunter's Curve" for estimating water-supply demands and pipe sizing information which were also discussed in BMS 65 (9) and BMS 79 (10). The fact that these 35-year-old reports are still in widespread use (as indicated by continuing requests for the reports) indicates a lack of progress due to insufficient support for broadly based research required to provide new plumbing information for code writing.

- A40 Committee - National Plumbing Code

The American Standards Association (now known as the American National Standards Institute, ANSI) appointed a committee, known as the A40 Committee, to prepare "Minimum Requirements for Plumbing and Standardization of Plumbing Equipment" in 1928. The A40 Committee was reorganized with a broader-based membership in 1941 with approval obtained for their work as an American Standard in 1949. Very shortly after the acceptance of the 1949 report another A40 Committee with an extremely broad base of membership was formed to attempt to prepare a more modern updated plumbing code, "Minimum Requirements for Plumbing." This work produced the A40.8-1955 (7), published in 1955. For many years in most places (still in some places) this was known as the National Plumbing Code. Because of the continuing need for updated plumbing codes, and because of various political factions in the field of code writing which prevented the approval of a new version, A40.8-1955 became obsolete and was officially withdrawn as an American Standard on January 20, 1972. There is, at the present time, a current ANSI A40 Committee at work preparing a new version of this plumbing code.

Four organizations are in competition to have their model codes accepted as a national code after the withdrawal of ANSI A40.8-1955. These organizations are the National Association of Plumbing-Heating-Cooling Contractors (NAPHCC) jointly with the American Society of Plumbing Engineers (ASPE), the International Association of Plumbing and Mechanical Officials (IAPMO), the Building Officials and Code Administrators International, Inc. (BOCA), and the Southern Building Code Congress International (SBCCI). Their published code documents may be purchased; addresses are listed in Appendix A. The need for water conservation requirements in the codes has recently been recognized and some amendments have been introduced relating to reduction in water usage. At the level of local government it is possible to adopt one of the several model plumbing codes, although some local governments prepare their own codes. Mandatory plumbing codes at the national level exist in other countries but not in the United States.

## PERSPECTIVES ON PLUMBING SYSTEMS - WATER SUPPLY AND DRAINAGE IN BUILDINGS

Illustrative of the theme at this conference of federally derived information broadly applicable and useful at state and local levels of concern are the past plumbing research accomplishments. The broad range of research impacts resulting from the varied investigations have been cited extensively in six reports on continuing national issues for plumbing research (3). The subject matter in each issue paper identifies concerns appropriate to planners, developers and implementors of water conservation programs which require defining and retaining satisfactory performance for acceptable water supply and waste removal service. The papers address the following subjects:

- Water Requirements and Procedures for Estimating the Demand for Water in Buildings
- Protecting Water Quality in Buildings
- Water and Water Related Conservation in Buildings
- Hydraulics of Gravity Drainage Systems
- Performance Concepts for Water Supply and Drainage Systems in Buildings
- Alternative Concepts for Transporting and Treating Wastes Within Buildings

### Water Supply Demand - Pipe Sizing

The emergence of rational design for estimating peak hydraulic waste loads for pipe sizing involved the fixture-unit concept and the theory of probability appeared in the "Hoover Code." It was not until many years later (1940) that the full development of the fixture-unit concept to determine the demand on the water supply system was carried out by Dr. Roy B. Hunter (8,9,10). The most difficult task in determining the conditions of flow in a plumbing system is to predict the number of fixtures most likely to be operating simultaneously out of the total number of fixtures in the design. Knowing that the fixtures in a plumbing system are used intermittently, i.e., the operation of each fixture is a random event, it was theorized that the actual loading effect of a single fixture was dependent upon the frequency of use of the fixture, the length of time that the fixture was in use, and the peak flow rate of the fixture.

The mathematical modeling introduced a level of performance with the criterion that, for an adequate system, the demand should not exceed the design value more than one percent of the time. Because of the computation limits at the time Hunter developed his methodology, he did not generalize the model to encompass several fixture types. Alternatively, Hunter fully developed the fixture unit concept which provided an empirical computation procedure for estimating the demand of mixed systems. This concept utilizes the assumption that the design factor for different fixtures is independent of the demand. To determine the number of fixtures that could be in operation an expression was derived from the binomial probability theory for predicting the system requirements consisting of the same type of fixtures. The method was soon adapted to the prediction of peak loads for the sanitary drainage system, and was utilized to develop pipe-sizing tables for drainage and vent piping. This was reflected in design manuals and code recommendations of the late 1940's and the early 1950's and has been carried over into most of the present model codes.

The fixture unit approach has led to overdesign because of paucity of field measurements as input data to Hunter's technique. Currently, practicing engineers use design guides generally based upon adjusted usage parameters because of the lack of field data from comprehensive research on actual usage. Projections of refinements to the method indicate that smaller diameter pipes would result. With the need for energy conservation it should be recognized that significant benefits could be derived, since the sizing of hot water tanks and heating elements of hot water service systems are also affected (1). For the most part, building codes in the United States recommend Hunter's method for estimating the demand of water in buildings, but engineers may be allowed to vary from this method and substitute (with justification) their own methods. For drainage systems, although inflow is assumed equal to outflow, there are slight differences in the tables from one code to another. Comparisons with practices in other countries were shown in References 12, 13, and 14. Recently an evaluation of effects of peakload reductions, associated with water saving water closets, in the Hunter method was shown in Reference (11) showing the potential for reductions in pipe sizes.

## Drain-Waste-Vent Systems

The function of a plumbing drainage system is to collect and transport wastewater from the fixtures to the building sewer. The principal driving force in gravity drainage waste systems is the potential energy resulting from the water supply pressure, depth of water in fixtures and slope of the drainage piping. Kinetic energy contribution to waste transport is made in the immediate region following the change in pipe direction from vertical to horizontal. The waste system flow is non-uniform and unsteady, a complex combination of three components (water, solids and air) flow. Over the years, laboratory and field data have been obtained to provide design loading tables for use in limiting the flow through the drainage piping to levels which will not cause failure of the water seal in the traps. Water-sealed traps are used to protect the interior of the building from hazardous or noxious gases that may be produced in the drainage sytem or sewer. Traps are essentially water seals which permit the passage of water and waste solids into the drainage system while blocking gaseous return into the building. The wastewater does not generally fill the horizontal drains, with the occasional exception of the piping immediately adjacent to the trap and fixture. Main horizontal drainage lines are sized to run half full at the expected peak flow rate; this safety factor, applied to protect trap seals, accounts for uncertainties in design methodology with multiple fixture loads, and installation variables (e.g., pitch of pipes, smoothness of pipe surfaces, alignment of fittings). The full understanding and development of solutions to the governing equations of the fluid mechanics of partially filled pipe flow interactions with solids and trap seals at fixtures within the interconnecting network of pipes which comprise the vents and waste drainlines is still being developed.

Reductions in water usage may reduce the transport velocities in horizontal drains below the generally accepted velocities of 0.6 m/s (2 ft/s) minimum in drainage piping and impair the effectiveness of the system. A 25 percent reduction in the velocity of the wastewater in the piping immediately adjacent to the water closet was reported (15) as the result of changing from a customary water closet using 19 liters (5 gallons) per operation (this includes water used to restore the trap seal as well as the excess that may be wasted by overfill of the trap seal) to a water-saving water closet using 11 liters (3 gallons). The increasing use of very low-volume water closets, because they reduce the flow in sewers, might cause increased solids deposition and septicity in sewers under some circumstances (16).

Detailed investigations which have established the basis of generally accepted theory for current design criteria are reflected in present model plumbing codes; they treat the specific requirements for trap self-siphonage, stack venting, wet venting, and capacities of stacks and horizontal drains (17,18,19,20). Improved design and evaluation methods leading to reduced pipe sizes for water conservation would provide other benefits for energy savings to the extent that significant reductions in quantities of material required for construction provides corresponding savings for raw materials, manufacturer, transportation and handling. Resources conservation and associated cost reductions that might be realized by the proper sizing of piping to accommodate representative loads are significant. Estimates of the cost savings from innovative designs (single-stack or self-venting drainage) and reduced-size venting have been expressed (21) as "up to 40 percent of the DWV piping cost," "potential savings of the order of $60 per bathroom," and "up to $150 per living unit." Estimates of the annual national reduction in construction costs from an across-the-board 10 percent savings in the cost of water supply and drainage systems, that might be possible from research on loads alone, have approximated $500 million.

## RESIDENTIAL WATER CONSERVATION - LABORATORY AND DEMONSTRATION PROGRAMS

The Department of Housing and Urban Development (HUD) is currently sponsoring water conservation programs for laboratory research and national demonstrations. The development and implementation of that program was supported by the National Bureau of Standards (NBS) and the Stevens Institute of Technology (SIT). The projects are responsive to the national concerns for reduction in water usage and address many issues identified in the position papers on future requirements for plumbing and water conservation at the symposium of 1976 (3). The demonstration projects are being performed by Brown and Caldwell (22) and the laboratory-based research conducted at NBS and SIT.

The goals of the water conservation programs are to establish the basis for performance requirements and criteria to support acceptance of low water usage fixtures, devices and plumbing systems that provide acceptable levels of quality for health and safety and sanitary functions for water supply of quality for health and safety and sanitary functions for water supply and wastewater drainage in residential buildings. The plumbing investigations include the total building water system, i.e., demonstrations and laboratory research for the requirements of water supply distribution, devices, fixtures and appurtenances, waste drainage branches, soil stacks and connections to either sewers or on-site treatment facilities. Studies of incentives for use and acceptance of water savings practices and economic analyses for guidance in community decisions to implement water conservation are included in the program. A user's manual to assist in achieving lower water usage is being prepared. The objectives of the HUD program include:

a) Establish the essential technology measures (criteria) for water conservation performance and determine realistic levels of water consumption required for satisfactory operation of the installed system. These measures and performance levels must relate the functions and properties of the system and components to the essential characteristics of the services needed by the user.

b) Develop reproducible, reliable test procedures, model laws and mathematical models involving the key measures of performance.

c) Provide recommendations for consensus performance standards derived from laboratory test validations to gain acceptance by appropriate regulatory bodies.

d) The development of acceptance protocols for submission of supporting data to approval authorities, including guidelines for interpretation of results to determine conformance with requirements.

e) Establish methodologies for acceptance inspection procedures and installation standards for use by approval authorities.

f) Prepare rating system criteria for reducing water usage applicable to HUD Minimum Property Standards requirements for extending the existing available water supplies for dwellings.

g) Determine the effect on domestic water use of new reduced flow rate requirements which were legislatively established for low flow devices. Evaluate the economic and human factor impacts of reduction on water requirements in residential applications.

h) Provide guidelines and information resources based upon objective testing and derived results applicable to the legislative and regulatory officials promulgating water reduction regulations.

i) Establish incentives for acceptance and continuation of water reduction through use of education and feedback regarding potential costs and resource benefits.

j) Provide the economic evaluation methods for decisions on water reduction requirements through utility, community and consumer cost benefits.

Demonstration Projects

The three-year demonstration program is intended to develop field data in different sections of the country from installations involving water efficient devices and water system changes (such as reduction in supply pressure, metering, etc.) in single and multifamily residences. The demonstration in any category requires a sufficient number of dwelling units/residences and connections to provide a suitable data base for detailed evaluation as well as occupant behavior/satisfaction and safety. The test demonstrations are designed to provide results demonstrated locally with potentials for widespread application throughout the municipalities and local jurisdictions of the U.S.

The installed plumbing products include new fixtures and devices and/or retrofit components to existing buildings generally compatible with existing plumbing systems. They are:

(i) Conventional - typically acceptable (higher) levels of water usage fixtures and devices installed as components of the plumbing systems in dwellings as a baseline for comparisons.

(ii) Currently available low water usage fixtures and devices either currently marketed "accepted" water-saving components or recognized within plumbing codes or HUD-MPS.

(iii) Innovative (available) advanced development products and fixtures ready for introduction into the commercial market.

Appraisals are to be made for clarity and understanding of installation instructions, durability, maintainability, repair, cleanliness related to usage and appearance and requirements for skilled plumber repairs or handyman repairs.

Other variables in water conservation measured to be evaluated include:

At the building level -

- Installation of water meters
- Storage of rain water and special usage
- Dual piping for reuse of partially processed wastewater
- Landscaping with reduced water requirements
- Effluent flow quantities entering sewer connections

At the community level -

- Concepts, strategies for educational information and dissemination thereof
- Demonstrations within subdivisions of reduced size water supply distribution and waste sewer collection piping (without violating fire protection water pressure and supply requirements)
- Subsidized vs. nonsubsidized water savings incentives
- Evaluations of benefits on effluent load reductions with respect to on-site treatment and public wastewater sewer systems
- Water supply and wastewater rate structures with incentives for low water usage
- Economic benefit analyses of new practices
- The influence of regional and climatic condition representative of normally arid or normally adequate water areas

## Laboratory Research Projects

The plumbing laboratory research investigations provide data, test procedures and predictive modeling for design applications. The results are expected to provide the basis for recommendations for plumbing standards, codes and rating systems for performance of low water usage devices. Supporting investigations for acceptance or motivation for reduced water usage and economic studies are included to evaluate the impacts of water reductions. The establishment of a uniform basis of performance requirements provides an incentive for manufacturers in supplying plumbing products for low water usage in a national market across the United States.

The scope of the projects are as follows:

1. Water Efficient Fixtures Technology - The investigations include conventional and innovative fixture devices and components. The laboratory results are to be applied in development of recommended performance standards, test evaluation procedures (with specifications for accurate laboratory instrumentation) and draft guidelines for codes and practices.

2. Efficiency of Drainage Systems - Development of the detailed analysis and test validation of the dynamics of transient multi-component fluids/solids waste transport mechanisms (water, air and solids) for conveying wastes through low flow fixtures, branches and soil stacks. Prepare recommendations for new design procedures and tables for reduced pipe sizing to provide adequate wastewater sweeping velocities with reduced water flows. Establish the basis for engineering solutions for installations of pressurized drains, vacuum drainage and grey water sweep carrier transport.

3. Drainage, Waste, Vent Systems - Determine the impacts of reduced water usage and provide compatibility requirements for maintaining functional performance of existing plumbing/sewer connections with expanded water conservation practices. Develop hydraulic design relationships for horizontal and vertical stack interactions of low-flow gravity drainage systems.

4. Demand for Water - The investigation is intended to provide a limited update of the binomial probability design/demand procedures based upon the "Hunter" model established four decades ago (currently the accepted method as the basis of water supply pipe sizing with adjustment by empirical factors). The revisions are to demonstrate effects of updated data base information and load variability due to increased use of water consuming appliances in dwellings which reduce flow rates.

5. Usage and Acceptability Factors - Evaluate the user (human factor) requirements for acceptance of water conservation, implementation strategies and utilization of equipment with low water flows. Provide criteria for incentives and stimuli for maintaining lowered water usage. Develop methods for economic decisions with emphasis upon the cost parameters for potential benefits associated with owner and community incentives.

Presentations from results of several projects on low-flow water closets, solids waste transport mechanisms and decisions from economic evaluations were made at workshop sessions of this conference. A reduced flow water closet standard appears to be close to approval in the Vitreous China Plumbing Fixture Panel (ANSI A112.19.2) and a recommendation for standard requirements for two-step flush mechanisms was made to the Plastics Water Closet Committee (ANSI Z124.4) for their consideration.

## CONCLUSIONS

The need for development of plumbing codes and standards which advocate water conservation innovations requires continuing efforts. Almost no industrial research efforts are focused on the "plumbed system." The plumbing industry looks to government agencies to provide the resource basis for technical information related to the performance of systems. The diverse interests of the manufacturers involved in proprietary research related to product developments generally inhibits detailed data from becoming available to the voluntary standards committees.

Historically, most efforts in writing of plumbing codes have emphasized design and installation of drainage-waste-vent systems with reliance upon the occupant water supply requirements that have become obsolete for water savings equipment and user demand loads. The research developments from laboratory and demonstration projects are expected to have impacts on revisions to the existing standards and codes. Hydraulic performance levels gained by automatic control or hydraulic regulation of flow on devices and fixtures which can be incorporated in manufactured products and required by plumbing codes provides an effective means of implemeting community water conservation.

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APPENDIX A

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| NAPHCC | National Association of Plumbing-Heating-Cooling Contractors<br>1016 20th Street, N.W.<br>Washington, D.C. 20036 |
| NBS | National Bureau of Standards<br>Washington, D.C. 20234 |
| RMR | Required Minimum Requirements<br>BH 13 - July 1923<br>National Bureau of Standards<br>Washington, D.C. 20234 |
| ASTM | American Society for Testing and Materials<br>1916 Race Street<br>Philadelphia, PA 19103 |
| ANSI | American National Standards Institute<br>1430 Broadway<br>New York, New York 10018 |
| ASME | American Society of Mechanical Engineers<br>345 E. 47th Street<br>New York, New York 10017 |
| ASPE | American Society of Plumbing Engineers<br>16161 Ventura Boulevard - Suite 105<br>Encino, California 19316 |
| IAPMO | International Association of Plumbing and Mechnical Officials<br>5032 Alhambra Avenue<br>Los Angeles, CA 90032 |
| BOCA | Building Officials and Code Administrators Int., Inc.<br>1313 E. 60th Street<br>Chicago, IL 60637 |
| SBC | Southern Building Congress<br>1116 Brown Marx Building<br>Birmingham, AL 35203 |
| ASSE | American Society of Sanitary Engineering<br>228 Standard Building<br>Cleveland, OH 44113 |

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|---|---|
| AWWA | American Water Works Association<br>521 Fifth Avenue<br>New York, NY 10017 |
| CS | Commercial Standards, Commodity Standards Division<br>Office of Industry and Commerce<br>U.S. Department of Commerce<br>Washington, D.C. 20230 |
| FSS | Federal Supply Service<br>Standards Division- General Services Administration<br>Washington, D.C. 20405 |
| NSF | National Sanitation Foundation<br>Ann Arbor, MI 48106 |
| PDI | Plumbing and Drainage Institute<br>1018 N. Austin Boulevard<br>Oak Park, IL 60302 |
| UL | Underwriters' Laboratories, Inc.<br>207 E. Ohio Street<br>Chicago, IL 15420 |
| MSS | Manufacturers Standardization Society<br>420 Lexington Avenue<br>New York, N.Y. 10017 |
| SPR | Simplified Practical Recommendations<br>U.S. Department of Commerce<br>Washington, D.C. 20234 |

APPENDIX B

Commonly mentioned names of the model plumbing codes and standards bodies are:

ANSI - American National Standards Institute
ASPE - American Society of Plumbing Engineers
ASSE - American Society of Sanitary Engineers
ASTM - American Society for Testing and Materials
IAPMO - International Association of Plumbing and Mechanical Officials
AWWA - American Water Works Association
CS - Commercial Standards
FSS - Federal Supply Services
NSF - National Sanitation Foundation
PDI - Plumbing and Drainage Institute
UL - Underwriters' Laboratories, Inc.
ASME - American Society of Mechanical Engineers
MSS - Manufacturers Standardization Society
SPR - Simplified Practical Recommendations

Publicly Supplied Potable water conservation '81 A NATIONAL CONFERENCE

# Local Perspectives–Programs/Initiatives

# WATER CONSERVATION IN CALIFORNIA

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ABSTRACT

California's resource planning includes water conservation as a source of supply. By the year 2000, the State expects water savings of about 1.5 million cubic dekameters per year. Department of Water Resources (DWR) conservation activities are centralized in its Office of Water Conservation (OWC). Programs are in three major categories -- agricultural, urban, and in-school education. The largest urban program is distribution of residential water conservation devices. By the end of 1982 all those living in homes built before water conserving fixtures became mandatory will be given devices. The Department works with other state agencies to save water, develops water conserving landscape gardens, encourages water conserving pricing, has a grant program for water system leak detection and works to build water conservation into local planning. Elementary school programs train teachers and make curriculum materials available. Education activities include a newsletter, drought and water conservation related reports and brochures. The Department reports on comparative water conservation performances of selected communities in the State.

Water conservation has been made an integral and vital element of water resources planning by the State of California. We see it as our most economical source of additional supply, and one that almost invariably results in savings of energy.

When I became director of the Department in 1975, I issued a water management policy which included these points:

- Water resources already developed shall be used to the maximum extent before new sources are developed.

- To maximize beneficial use, optimum application techniques and processes for water conservation shall be used and waste shall be avoided.

- Water shall be reused to the maximum extent feasible.

This policy is buttressed by the State Constitution, which requires that "waste or unreasonable use... of water be prevented."

We have had an active conservation program since 1976, before the 1976-77 drought -- the most severe drought in the State's history. The program is steadily increasing in importance and visibility.

During the past three years, we've spent more than $5 million on conservation, and in broad terms we expect that by the year 2000 the State can have water savings that amount to about 1.5 to 1.8 million cubic dekameters (1.2 to 1.5 million acre-feet) of water per year. This reflects our conviction that water conservation must become part of our lives and must be practiced conscientiously in wet years as well as dry.

Because of our increasing levels of activity, about 16 months ago I created the Office of Water Conservation (OWC) in the Department to consolidate work in three major areas of conservation -- urban, agriculture, and education. The Office budget this fiscal year is about $6 million and we now have about 30 persons on the staff.

One important step we've taken is to create an advisory committee for our water conservation efforts made up of representatives of various constituencies in each area (water, industry, agriculture, education, and environmental interests).

We have found this committee very useful in keeping our thinking and programs closer to reality. It now has 24 members and functions both as a whole and in three subcommittees.

We have also created a local government advisory group to help us tailor programs that can help planners incorporate water conservation practices on the city, county, and regional levels.

This 10-member group, which includes representatives of cities and counties, regional water supply agencies, elected local government officials and others, is helping compile a guidebook to help build conservation goals and methods into the planning process.

While we have a number of programs to encourage the efficient use of agricultural water in California, my focus today is on our urban water conservation programs.

URBAN CONSERVATION

Our most heavily funded urban program is providing households with water-saving devices for toilets and showers. We have made these available to about a tenth of the State's 8 million households, and plan by the end of 1982 to make them available to every residence built before 1979. That was the year California laws and regulations requiring low-flush toilets and low-flow showerheads in new construction went into effect. The Chief of our Office of Water Conservation will discuss this particular program in depth this afternoon at the Case Studies panel.

Under a July, 1980 executive order of Governor Edmund G. Brown, Jr., each State agency must save water in its operations and help spread the word about conservation where appropriate. The OWC works with major water-using or water-use-influencing State agencies to cut down on excessive water use. We have focused on the Department of Parks and Recreation to reduce water use in park facilities, the Department of Transportation on freeway landscaping and irrigation, the Office of the State Architect on landscaping of new State buildings, and the Department of General Services which is responsible for leasing many State buildings and grounds. When major public agencies show their awareness of the need to use water wisely, it sets a good example for the public. Needless to say, when a State agency appears to be wasting water, it seriously damages our credibility.

LANDSCAPE SAVINGS

Nearly half of all residential water use in California is used outdoors, mostly for landscape watering. We have created, with community support, six model water conserving demonstration gardens in the State to help show the possibilities and techniques.

The gardens are designed by our staff, the land is donated, and the plants are provided free by nurseries. The gardens are built and planted by members of the California Conservation Corps, a dynamic group of young Californians whose accomplishments have ranged from firefighting to distributing water conservation kits.

We place the gardens in heavily traveled areas such as near the Rose Bowl in Pasadena, or at community centers. We have recently joined forces with a major builder to plant low water use landscaping at model homes to expand public education in this vital area.

In the next several months we will be commissioning field research into the labor, energy, and water savings of low water-using landscapes compared to conventional landscaping. We will also be supplementing our very popular Bulletin 209 on low water-using plants with four more publications -- a commercial source book on low water-use plants, a guidebook for landscape architects on low water-use landscape designs, curriculum material on drought-tolerant landscaping for California universities and colleges, and a brochure entitled "The Nonthirsty Book of Seeds," which will include seeds of drought-tolerant flowering plants.

One of our problems is convincing Californians that lush tropical or eastern-style landscapes are not appropriate in arid and semiarid climates such as ours. We are trying to show that low water-using landscapes can be beautiful.

Complementary programs have included a symposium on the use of rain storage cisterns as a supplementary water supply in high rainfall areas, as well as discussions and reports on possibilities of fog catchments and the use of gray water -- household water other than toilet water -- for landscape irrigation. While some of these measures may seem unusual, we have found great interest in some parts of the State that suffer chronic supply problems, and of course during drought and dry year periods. A report on the symposium is in the Department's Bulletin 213, "Small Scale Water Supply Systems," which will soon be off the press.

PRICING AND METERING

We are analyzing water pricing structures and encouraging the water supply industry to adopt policies that encourage conservation. Many California consumers pay for their water either on a flat rate (regardless of quantity used) or even on a declining block rate which reduces the price as quantities increase. Neither of these offers any incentive to reduce consumption and may, in fact, encourage waste.

While it is generally agreed that water meters encourage water conservation, some parts of California are still unmetered.

LOCAL GOVERNMENT COOPERATION

As I mentioned earlier, we are -- with the help of a steering committee -- writing a guidebook for local agencies that will include model codes and ordinances to help planners integrate conservation into city, county, and regional planning and enforcement processes.

Our conservation staff will take the guidebook -- and an accompanying slide show -- on the road in a series of workshops to acquaint planners and planning commissioners with the need and the methods.

In a sense, this is a continuation of a series of conferences we held throughout the State during the 1976-77 drought to gain the views of local agencies and local interests about conservation in both government and industry.

From a State viewpoint, this illustrates a point that cannot be stressed too strongly: Without the direct and continuing advice and information from the local level, no program can be successful.

LEAK DETECTION AND REPAIR

This year we are beginning a multi-year $2 million grant program for small and medium-sized publicly owned utilities for detecting leaks in water distribution systems. This program, funded by our State Water Resources Control Board (SWRCB) from $50 million in bonds approved by California voters in 1978, will be split into two phases. The first is research to determine the best method of leak detection, with two cooperating agencies serving as experimental models to test approaches. An advisory panel of water utility managers will help us with this phase.

Based on this effort we will set criteria for giving grants to utilities to carry out leak detection programs; the grants will be conditioned on agreement by participants to repair a certain percentage of the leaks found.

This can be a significant conservation program. In California, we estimate about 4 to 6 percent of water in urban systems is lost through leaks. That would be as much as about 370,000 cubic dekameters (300,000 acre-feet) of water per year.

IN-SCHOOL EDUCATION

Our in-school water conservation education program is another important and long-range part of an attempt to develop a water conserving ethic in the State. Targeted right now at the elementary grades, the program attempts to develop an awareness of water as a resource and to show the importance of conservation. We have already reached about 10 percent of the kindergarten through eighth grade population. By 2000 we expect to have fully integrated the information and philosophy of water conservation into the State's public education system and to be providing support for local agencies and schools on a broad scale.

PUBLIC EDUCATION

I believe it is important to have a ready supply of sound information materials available to the public. We get our materials out through fairs, exhibits, and cooperating water industries and associations. We have bumper stickers, brochures on a variety of subjects, and, of course, our "save water" (*ahorre agua, en espanol*) button. I wear mine through good and bad weather. In fact, in 1978 -- a wet year -- a TV commentator remarked that he saw "rust on it."

We also have a number of drought-related reports. Our mainstay is Bulletin 198, "Water Conservation in California," published in 1976 and which we hope to update in the next year or so. In addition, we have a comprehensive report on our 1977 pilot residential water conservation program, Bulletin 191; three reports on the 1976-77 drought, a basic review and two updates; Bulletin 206, "Impact of Severe Drought in Marin County, California," and reports of proceedings of a January 1976 conference on urban conservation, a June 1976 conference on agricultural water conservation, and a July 1977 conference on industrial water allocation and conservation.

We also produce a conservation newsletter about every two months for about 4,000 readers, and have specifically targeted pamphlets and leaflets and public service announcements for television and radio.

Over the next several months we will send a special mailing to all water purveyors in the State, supplying each of them with a package of sample materials which they can order from us at cost. We will also have a lending library of public service announcement tapes and examples of utility bill stuffers for use by the water industry.

We have recently reported on the results of conservation efforts of 17 California cities and communities in the immediate post-drought years to show the public which cities are doing well and which are not doing so well. Making comparisons is often tricky, because variables such as weather can strongly influence the amount of water used from year to year. We try to eliminate those variables in our analyses, and I think it is important to let the public know where they -- and their water agencies -- stand in relation to others.

GOVERNOR'S EXECUTIVE ORDER ON CONSERVATION AND RECLAMATION

In July of last year Governor Brown signed a bill authorizing construction of new water storage and conveyance facilities for the State Water Project. At the same time, he issued an executive order requiring our Department to develop a water management plan for the State Water Project that includes ways in which water can be conserved and reclaimed. The order also requires the State Water Resources Control Board (SWRCB) to impose water conservation measures on all water rights holders and agencies receiving grants for clean water treatment plants.

We teamed up with the SWRCB to jointly take major new conservation initiatives, including these:

-- The SWRCB will condition new wastewater facilities planning grants on the development, public disclosure, and implementation of a water conservation plan. DWR will provide technical assistance in preparing the plan.

-- DWR and SWRCB will investigate cases of "waste and unreasonable use of water," which is illegal under the State Constitution. Enforcement will be taken administratively, and judicially where appropriate.

-- The SWRCB will require water conservation plans of certain water rights holders and new applicants for water rights. DWR will provide technical assistance to those required to prepare such plans.

-- SWRCB and DWR will prepare guidelines for urban and agricultural water conservation plans and a water conservation reference manual documenting water conservation measures, examples of implementation, anticipated costs and benefits.

-- DWR is conditioning all grants and loans provided through our Safe Drinking Water Program on water conservation measures such as distribution of devices. Also, where cost effective, we are requiring installation of water meters.

CONCLUSION

Much of what we have been learning about water conservation in California is exportable, and, as the water shortages along the East Coast worsened this year, we have shared information and advised on problems where we have some knowledge.

Obviously, some of our programs and materials are geared to the semiarid climate characteristic of much of California, but many of them -- particularly those dealing with urban and industrial conservation -- can be applied broadly across the country.

We are eager to share our knowledge with others, and also eager to learn from you as we all increase our emphasis on conservation.

# THE NEED FOR A NEW FEDERAL WATER POLICY

Francis X. McArdle, Commissioner
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Federal water policy, such as it has been, has addressed the supply-demand nexus very narrowly, focusing almost exclusively on developing new supplies for agricultural and natural resource exploitation in the South and the far West. That policy must change focus to meet national needs as well as regional needs. And it must address the demand side of the equation as well as the supply side. Most cities haven't had the advantage of a near-by federal project to help them reduce their own new supply costs. And there has been no help with demand-side issues. Systematic replacement and rehabilitation can offset new supply needs. Conservation management is another tool that must be exploited along with reuse approaches. There has been little federal help here. There must be a new federal water policy. It must meet all urban needs as well as rural ones. But ultimately it must be a program that focuses program implementation and direction at the local level. Any other program focus will result in delays in implementation; will result in a failure to develop maximum local consensus; and will ignore the critical expertise at the local level.

There is a drought affecting most of this nation today. It spreads from the Northeast to the West. It affects Florida as well as Colorado. This drought presents us an opportunity to discuss and debate national water policy in the most appropriate context, the time when all of us must do with less. The drought presents us an opportunity that we cannot miss. So often in the past at the end of droughts we have relaxed. We have not gone forward to build upon those experiences. Today we must build rational policies and programs for all America to deal with our water problems.

The need for such a rational, national approach to water policy is most clearly evident at the federal level. We have had four years of debate and difference. We have had task force approaches, attempts at consensus building, and studies of specific issues with a narrow focus. Now we must build policies that contribute, through both planning and implementation, to what must be our common goal, a goal that must always be restated: national excellence in the use of our water. That is what we must strive for and our efforts must focus both in the Congress as well as in the executive. We cannot attempt to change water policy by administrative fiat.

The debate in the efforts of many agencies over the last four years must move forward. The issues that must be addressed are clear. First of all, there must be a national program. If we cannot build programs that satisfy all regions in the differing elements that affect their supply/demand equations for both quantity and quality, then there will be little progress made. There will be no movement towards our goal of national excellence in water use. There can no longer be sectional discrimination in our policies, no more emphasis on development in one part of the country, be it sunbelt or snowbelt, to the exclusion of others.

Secondly, there can no longer be sectoral discrimination in federal water supply programs in both the development and the pricing of new supply. There is no longer a rationale for treating agricultural water development differently than one treats the development of new supply for municipal and industrial uses. There should be full cost pricing so that real economic cost/benefit analyses can be undertaken. I was somewhat surprised to find the Department of Agriculture was not actively represented at this conference. They have a vital role in national water policy both through their focus on agricultural development and the very active programs that they operate through Farmers Home Administration for the smaller communities in this country.

Thirdly, the focus of any national water policy must be local and cooperative. The need for continuing effort to develop new technology and to further our national education about water policy was made very clear at this conference. It is in conferences like these that the exchange of information and ideas makes improvement in the efficient use of our water possible. But that can only happen when local political institutions and local elected officials believe enough to build a local consensus. They must be satisfied that it is worth their while to participate actively on these issues. And they will do so only if their interests are satisfied and their participation is real. Ultimately siting decisions, local financial participation,and the web of opposition and support must be resolved in local political institutions. It is impossible for any distant government, be they federal or state, to impose in this day and age choices upon localities that cannot be supported by that locality. By necessity that means the giving up of much control and authority and power to local government. That is not bad when it results in projects that really do have a broad local consensus.

And finally in any national water policy the supply and demand sides of our equation must be treated equally in both focus and financing. The tendency in the past has been to deal only with new supply, to see new supply as the only solution to our dilemma. That is, by the very existence of this conference, no longer satisfactory to everyone. The needs of older cities for help in rehabilitating systems, saving water to be used for additional supply, should be treated equally with a need for additional supply for new urbanizing areas throughout the country.

Saving water through a rehabilitation of the system can be just as powerful a solution to the problem as the development of a new dam or reservoir. There clearly should not be any financial bias in any national water policy towards new supply solutions alone.

Ultimately conservation of such a vital resource must be at the heart of any program. It is implicit in the need to rehabilitate systems as much as it would be in structuring new supply. It is very clear that conservation is more than just fixtures and education for demands side management. We have to look at and aggressively pursue: land use issues, end use management through technology and thematic education, and increasingly match end use needs with quality objectives. Conservation really means system and resource management and it has to be a cornerstone of any national policy. We can no longer afford to waste such a precious resource.

I would like to take a minute to speak specifically of one area that national policy has neglected too often in the past and that is urban water supply needs. I was proud to serve as a staff aide to the Mayor of the City of New York when he sat on President Carter's Urban Water Supply Subcommittee. The research efforts which were undertaken by that group have brought the needs of urban water supply much more in focus. It is very clear that over the next decade $80 billion must be invested in urban water supply systems to provide adequate replacement of existing systems, to meet new supply needs, and to provide for enhanced water quality. If one were to double the rates the people now pay for water over that period, it would still leave 20 percent of the water urban systems unable to meet their capital financing needs. As I have often said, when 20 percent of our housing stock was in trouble we saw the need to craft a federal housing program. I think if we fail to deal with this issue, most assuredly in a decade or two many Americans will have lost what is one of the most precious resources this country provides today--an adequate supply of potable, healthful water. If we fail to deal with the issues of urban water supply, particularly in those systems where local financing cannot make all of the difference at this time in raising capital needs, then all the end use conservation efforts that we have made in recent years, and hope to make through conferences such as this, will be lost.

There is one clear federal role that must be preserved. I am most disappointed to see the Reagan administration reducing one of the most important elements of any national water policy, the federal leadership role for research and development. Without aggressive leadership and financing of research and development, we will not be able to reach our goal of national excellence. It is difficult for individual water systems to finance the kinds of research in conservation system management in use matching with quality that is needed to maximize the use of our resource people. I am very happy with the efforts that have been made in the past by such organizations as the Office of Water Research and Technology (OWRT), even though I may have disagreed with the specific direction in which they went, because the very process of research and development raises questions that lead to answers that will benefit us all. This is one area I believe where the Reagan administration's policies have failed.

In the coming months there will be much ferment about national water policy. The forums for discussion will come. I urge everyone at this conference and throughout this country to participate actively in the development of a national water policy. We cannot let another four years go by without programmatic direction that can lead us into the next decades.

## LOCAL RESPONSE FOR OFFICIALS AND CONSUMERS

William H. Miller, Manager
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As chairman of the Water Utility Council of the American Water Works Association and by association with other water utility managers from around the country, I have learned that conservation is perceived differently in various parts of the nation. In the Rocky Mt. West, the goal is to catch runoff from the mountains in the Spring and "conserve" it by storing it in reservoirs for use the rest of the year. In some Coastal states, the goal is to conserve fresh ground water by preventing saltwater intrusion. In some older Eastern seaboard cities, a key conservation concern is renovation of antiquated, deteriorating underground piping systems. In major river basins and the Great Lakes area, where supply is no problem, demand for water conservation might well be countered with the question, "Why?" Therefore, it is difficult to mount a nationwide, federally endorsed conservation program. Perhaps the common denominator is an economic one: does it make dollars--as well as sense--to conserve?

MR. CHAIRMAN, LADIES AND GENTLEMEN: As Manager of the Denver Water Department and a native of this rapidly growing city, it is my privilege to add my welcome to this vibrant city to those of you who have come from around the nation to discuss the very vital question of water conservation. I am also fortunate in serving as chairman of the Water Utility Council of the American Water Works Association, a position that brings me into contact with other water utility managers across the country.

In this position, I have come to appreciate the problems and the differences in problems faced by the various water utilities. There are some very large differences in the nature and charge given to the 60,000 water utilities that supply the human needs of the nation. Of those 60,000 water utilities, 50,000 of them serve populations of 2,500 or less. Thirty-eight thousand of these water utilities are private, investor-owned entities serving some 20 to 25 percent of the nation's population. Seventy-five to 80 percent of the nation's population receives its water service from 8 percent of the nation's water utilities, the majority of them publicly owned.

From this wide divergence of sizes, varying conditions under which each of these systems operates, and the diverse nature of raw water supply systems, it is easy to understand the different meanings given to the term "water conservation" by these utilities. All of them, however, historically have urged wise or careful use of the water they supply to their customers.

Into this mix of differences we can also add the climatological variations from one region of the country to another. The 100th meridian, the traditional dividing line between the Eastern and Western United States, serves to illustrate these climatological differences. Sixty percent of the nation's land mass lies west of the 100th meridian, but it receives only 25 percent of the precipitation that falls on the nation. In many of the major cities of the Midwest and East, 40 to 50 inches of precipitation annually is not uncommon. Here in Denver precipitation is limited to less than 15 inches annually.

The very light precipitation we experience here, coupled with the seasonal nature of that precipitation, requires a specialized approach to water conservation. Because the water we use throughout the year is available only during the few, short weeks of runoff from melting snows in the mountains, we must capture and store that water in reservoirs with sufficient capacity to meet year-round demand with wide safety margins to compensate for wet and dry year cycles. It is often said here in the semi-arid West that the greatest conservation device known to man is a reservoir.

In Western cities such as Denver there is a unique characteristic of our life style that is manifested in the unusually great pride we take in the lawns, gardens, trees and parks that set most of our cities apart from the arid or semi-arid land that surrounds them. There are many reasons for this. Western cities were settled and developed by people who came from the lush and verdant East. They brought with them the amenities of greenery that are characteristic of cities in the East and elsewhere. Another reason is more practical in nature. Higher altitude and summertime afternoon relative humidities down in the 5 to 15 percent range require our cities to be "green oases" offering some escape from the relentless, searing sun. Recently, some horticulturists in Denver calculated significant increases in both daytime and nighttime temperatures plus increases in the amount of dust in the air, if our area were to adopt a total "dryscape" urban environmental plan.

The reasons for the inordinate pride taken by Westerners in their lawns and gardens may be as old as mankind itself. In Isaiah, 40, verses 18 and 19, reference is made to man's need of water in dry places. The verses read, "I will make rivers flow on barren heights, and springs within the valleys. I will turn the desert into pools of water, and the parched ground into springs. I will put in the desert the cedar, the acacia, the myrtle and the olive." This Biblical description may have been the origin of the Western Pioneer's passion for making the desert bloom and transforming it from a hostile environment to one that is hospitable, productive and livable.

Because nearly 40 percent of the average Denver household's annual water use is in outside irrigation, this is a primary area of conservation efforts. The challenge here is finding an acceptable balance between the legitimate needs of maintaining a pleasing and livable urban environment and the legitimate needs of conserving precious water resources. As a result, the Denver Water Department, in its Institutionalized Water Conservation Program, is recommending a compromise in future landscape design between traditional plantings and those requiring little or no water. We have been interested in recent research conducted on the question of how much water is required to sustain a bluegrass lawn in our semi-arid climate.

In other areas of the country, where precipitation is considerably heavier than here, other forms of conservation take on a greater significance. Shower and sink flow restrictors, toilet tank dams, and more water-efficient appliances take on a relatively greater importance in those places where the outside use of water for irrigation requires a far lesser share of typical annual household consumption than it does here. While these techniques are important in an overall conservation program, even in Western cities, the water savings from their use is relatively less than from those techniques addressed to Western outside irrigation.

In Coastal cities of the nation, "conservation" can take on entirely different meanings. With some of these urban areas depending on underground water supplies, conservation of groundwater may mean development of systems to prevent the intrusion of saltwater into the freshwater supply. In Orange County, California, for example, advanced treatment is given to wastewater before it is injected into the ground to form a barrier against the intrusion of saltwater from the Pacific.

On the Eastern seaboard, many great urban centers see the repair of aging water distribution systems, some of them a century or more old, as an important element in conservation. In some places it has been reported that as much as 40 to 50 percent of the water that passes through treatment plants is lost before reaching customers' taps. The tightening up of these systems would amount to a significant reduction in demand on raw water resources and treatment facilities.

The majority of America's great inland urban centers are located on or near large sources of water supply. The industrial cities of the Great Lakes Region and centers of commerce and trade along the Ohio and Mississippi River Systems are good examples. These cities owe their origins to the availability of an abundant supply of water. Conservation programs undertaken in these cities, in the name of conservation only, would probably be met with the legitimate question, "Why?"

There is a vast difference between developing a conservation ethic for energy supplies and water. Unlike oil, natural gas and coal, water is generally a renewable resource. It is being pointed out with increasing frequency that the world's supply of water is still the same as it was during the time of Christ. It's a matter of location. Where groundwater is "mined" from underground aquifers, there is a growing concern about the amount of water taken from these supplies and the inability of the aquifers to recharge through natural means. In these areas, the term water conservation takes on still another meaning and is accompanied by a sense of deep concern and urgency among those whose lives depend on this source of water.

All of these factors, the differences in sizes and missions of the 60,000 water utilities throughout the nation, the differing nature of precipitation patterns between East and West, the different ways individual communities use water, the abundance of water resources available to many large urban centers, require individual approaches to water conservation. A program designed to save water in Denver may be meaningless in Hackensack or Seattle because of the different ways people use water. A conservation program may not be needed at all in Milwaukee or Minneapolis. These differences add a great deal of complexity to attempts to declare a uniform, national water conservation policy. They will hobble attempts to implement a uniform nationwide program, and they run the risk of creating a credibility gap for those utilities serving areas with abundant water supplies.

An effective national water conservation program, it seems, must be based on a common denominator that is understood by all water users. In the face of the great diversity of situations, the common denominator of economics may be the one that offers a universal incentive for water conservation. In addressing the nation's water users with a call to conserve water, invoking conservation simply for conservation's sake or "because it's the thing to do" will produce meager results. Lately, it seems, even a crisis may not produce great enough voluntary water savings to overcome the crisis. The emergency regulations, heavy fines and strict enforcement needed in some areas to force conservation illustrates the nature of the problem.

Development of an effective, voluntary conservation program in those areas where such a program is indicated is basically a communications and marketing challenge. The consumer must first understand and agree with the need to conserve. The economic incentive of conservation must address the question, "What's in it for me?" If the answer is real dollar savings on the water bill, then an incentive for water conservation exists. In this regard some water utilities will have a difficult time demonstrating sufficient savings to make conservation efforts worthwhile. Despite the effects of rampant inflation over the past few years, water remains a relatively inexpensive commodity in most communities. Many major utilities are collecting, storing, treating and delivering water to their customers' taps for around 15 to 20 cents a ton. Under these circumstances, large water savings are needed to produce moderate dollar savings for the customer.

If inflationary pressures continue to mount and those water utilities which must support themselves through customer charges only are forced to raise rates, then the economic incentive becomes stronger. But the use of rates as a tool to force conservation, especially in areas with adequate water supplies, raises still many more questions about the fairness of that approach to a water utility's customers.

We are meeting at a time when national concern about water is high. Some national figures are likening the dry conditions we have been experiencing to the energy crisis. There are dire predictions of a major shift in our weather patterns from a relatively stable situation to one of radical changes from dry to wet cycles. We are viewing with alarm the rapid depletion of ground water supplies in several areas of the nation and the toxic waste contamination found in other areas. In these problem areas there is no question about the need of effective conservation practices and long-range planning and programs to overcome specific problems.

These, however, are localized or area problems requiring individual solutions and should be pursued by the people who are closest to the problem. In some of these areas, the failure to develop effective conservation practices and programs needed to assure adequate future water supplies could drastically affect the economies of these areas.

In these situations, it does make both dollars and sense to conserve rapidly depleting water supplies. It also makes sense and dollars to develop the water resources needed to strengthen, maintain and improve local economies. However, there is no universal program that can be all things to all people throughout the nation. The needs of water-short areas are not the same as those areas blessed with abundant supplies.

While conservation can be an important step in reducing demand on some municipal systems for specific periods of time, it cannot, in the long run, serve as a substitute for the development of adequate water supplies to meet the needs of the people served by these systems.

Possibly the best conservation practice would be better utilization of the water the nation receives in the form of precipitation. According to a recent Newsweek article, 92 percent of the precipitation that falls on the nation either evaporates immediately or runs off to the oceans unused. Putting some of this water to beneficial use may represent one of the great conservation challenges of the future.

Publicly Supplied Potable water conservation '81 A NATIONAL CONFERENCE

# Case Histories–Experiences with Solutions

# A FUTURE LOOK - WHAT ARE THE UNKNOWNS?

Jerome B. Gilbert, President, American Water Works Association
General Manager, East Bay Municipal Utility District
Oakland, California

## WHAT ARE THE UNKNOWNS?

As a born-again utility manager, I will try to reflect some of my renewed opinions and experiences as they relate to water conservation. Being a president of AWWA has given me a chance to see a wide variety of utility practices and to talk to many different people in the utility, consulting, and manufacturing sectors, as well as in government.

I was doing my duty for the AWWA on the Island of Kaui, where there was a meeting of the Hawaiian Water Works section. They were discussing safe yield and, as most of you probably know, the average annual rainfall on portions of that island, which is at the western extremity of the United States, is about 120 inches. Yet there are areas that have very significant water shortages either due to the lack of capital investment or to treatment and quality problems.

When I think about the national crisis that Frank McCardle and others are facing in the media and in reality during the last few months, I was reminded of a call I received from a major network TV program. They said, "Tell us what we are going to do about this national water crisis. For the first time we are experiencing a shortage throughout the country and it is obviously a problem of national proportion." I said, "What do you mean for the first time? We have been facing water crises that, although not perceived on a national scale, have been in existence since we developed this Nation." This is nothing new. If you look at the history of water development in all of the great cities, particularly in the arid Southwest, everything was done in crisis, and we approach all our water problems that way. However, this crisis mentality in the long run makes it hard to achieve water conservation and efficient use.

The character of, and attitudes toward, water use vary throughout the country. Each one of you tends to have a water-use concept or attitude, <u>the correct one</u>, which should be applied everywhere. There are, however, many factors that affect efficient use, including economic conditions, geographic conditions, lifestyles, desires, attitudes, environmental conditions, environmental preferences, and willingness to sacrifice. This wide range is reflected in the activities of the AWWA, particularly its preparation of a water conservation handbook.

All of us are trying to change attitudes toward water use, attitudes that have developed over a long period of time and ones that are essentially institutionalized. The great water resource development projects of the last century have been built into our laws and customs and have created a preference for water use or, rather, priority for water use, which is accompanied by a low-cost water system. This is particularly true in irrigated agriculture, but also exists in other areas where we built the great urban water systems with very dear dollars, and today are repaying that debt with very cheap dollars. The water rates, therefore, are low by definition. We now have this built-in "subsidy" that we are working against because we believe that resource use should be based on today's costs and today's attitudes. These water systems are very long lived, although we would have liked some of them to have more capacity and to have lasted longer than they have. Our objective has been to build nearly permanent water systems and yet we are demanding instantaneous response to changing the public's attitudes toward water conservation and the use of water.

As we moved into the environmental era of the 1960's, faced with this rather rigid system of water supply and development that affected our use patterns, we adopted new sets of rules. These grew out of the environmental impact process, which caused us to look at efficient use of water for its own sake and not because it really saved any money. Then the energy crisis hit and that launched us into what one might refer to as "the Great Water Conservation Crusade of the late 1970's," in which the Federal Government tried to apply some national standards through a variety of techniques such as permit conditions, treatment plant grants, and water supply development projects. This met with the disapproval by local government and industry because, unlike the national sewer program that was relatively new and could adjust to new rules, the water systems are all run by established entities with established revenue programs and methods of doing things. It was very hard for them to accept national standards, particularly when they perceived their local situations as being unique. They recognized the dramatic changes in cost and sometimes the need for prudent use, but were restricted by established rules, procedures, and cost allocation methods.

In 1977, 1978, and 1979, politicians and officials tried to solve the problem in the context of impending doom. We had many local water shortage problems, with the Federal Government desiring an immediate maximum regulatory effect. This led to the counterreaction that we are beginning to witness in the new administration. At the risk of speculation in this area, I would say that it is unfortunate that we go between these extremes when it applies to water conservation or any other resource matter. Conservative and liberal conservationists show a sensible and justified concern for efficient water use, and we all want to achieve our goals just as rapidly. But the crash program approach of the last decade, using maximum regulations and employing all the tools available, inevitably provoked the current counter-reaction. The philosophy that the role of Federal and State governments should be minimized, or eliminated, in these areas and that the local people should decide what to do is a reality that we must come to grips with. We want to move ahead in providing the tools and technology that local utilities can recommend to their users as viable water-saving devices. We want to achieve some progress in the efficient use of water, without necessarily requiring that progress by law.

This conference has been addressing the need for information. We need more information about effective pricing and its effect on water use, particularly for nonresidential uses such as agriculture and industry. They have tended to become more efficient in their water use because of the pollution control regulations, but we need to know a lot more about the cost and water quality factors that affect the quantity used. We need to share the information that is being developed on specific residential water uses. This is the most expensive form of use we have, even though its quantity is small. In fact, we spend more resources in trying to manage and deliver residential water effectively than we do for any other use. We have had some excellent studies done at Johns Hopkins, and there are studies underway now, such as the HUD demonstration program, which will hopefully, within the next 3 or 4 years, provide us with additional information on this subject.

The AWWA, through its Research Foundation, which is a semi independent arm of the Association, is trying to put together the first continuing scientific and technical information exchange among utilities. Initial sponsorship was given by the Washington Suburban Sanitary Commission. We have four or five other major utilities, hopefully including the East Bay Municipal District, that are also going to contribute. Even though we have not yet instituted the new Foundation dues structure that we are proposing, and we have not received any major Federal assistance, we are moving ahead with a major program designed to share technical information among utilities.

We have a lot of institutional problems that need to be overcome. The best way to do this is by encouraging local utilities to acquire the information on their system usage so that they can make their own decisions to improve efficiency. Any implicated threat of a requirement will reduce the chance of success, particularly with an investor-owned utility that has an established rate schedule subject to approval by a State utility commission. You can imagine the response they would receive if they were to approach that utility commission, saying that they anticipated a reduction in per capita use and wanted an increase in the unit cost of water in order to offset it. This fact should be considered when utilities are criticized for not doing their fair share in implementing water conservation: Adequate revenues must be assured first; then, partly as a result of increased rates, less water will be wasted.

I previously mentioned the AWWA handbook. It reflects the institutional problems that we have had in getting utilities comfortable with the idea of giving a priority to water conservation. In California we do not have that problem, and on the Eastern Seaboard the problem is certainly less than it was; but the problem still exists. The handbook is in final draft and is being evaluated by the review committee. We hope to have it available at the time of the Centennial Conference in St. Louis; if not, then shortly thereafter. AWWA publishes many items, and if everybody had to agree with everything we published, we probably would not publish anything. For example, there are people who object to a pipe standard for asbestos cement or PVC pipe and would never use it in their system, yet we have standards for those things. Despite our diverse membership, AWWA must put water conservation in the same category.

As we look at the effect of these educational efforts, we must evaluate how a utility arrives at a water management decision. It is essentially a part of water resources planning and not a separate issue. AWWA's policies emphasize this. The way to ensure the success of a program with the utility is to incorporate the conservation techniques into the water management program, rather than identifying them as a separate effort. In that way, new water supplies (including the risks involved in developing them, and their resultant yields) as well as new water conservation efforts are measured against the risks involved in taking a shortage and the resulting public's response. At East Bay we have had what we hope is a permanent savings of about 12 percent, resulting from our conservation measures during the drought. We are reasonably confident that we can increase that figure by 3 or 4 percent without any major effort, simply by emphasizing public education. We probably can get up to 25 percent with some additional effort, particularly in landscape irrigation. Beyond that point, particularly in a nondrought period, there will be difficulties; the key issue in our future planning is determining where the balance point is. The sooner this concept is recognized, the more likely that, on a nationwide basis, we can improve the efficiency of water use.

Let me just emphasize a few things in closing. The emphasis on the regulatory approach should be limited. I hope it will be limited in the future because I think we will make more progress that way. There need to be more meetings of this type and perhaps regional in character. An increased emphasis on the regional sharing of existing water supplies is vital, with less emphasis being placed on certain fixed or standard objectives for water conservation. We need to continue to expand water research. This is an initial effort, and others who have had occasion to be associated with the Reagan administration, while in office in California, know that in the early phases their emphasis was on a comprehensive type of economy without selective analysis. Within a relatively short period of time, however, that attitude gave way to a more practical and pragmatic approach; I hope this will happen in this case as well. The AWWA will be working on its expanded research program, as will others. There was a bill last year, introduced by a Congressman from New York, designed to set up an independent water research institute. AWWA hopes that it will be allowed to take on that task.

In regard to pricing and subsidies for water conservation, it is generally believed that the cost of water is the key factor in providing for efficient use. We can employ new technologies, educate the public, etc., but in the end, if the cost is high, as is currently the case with energy, the result will be a substantial reduction in consumption. I think we need to move toward a more realistic cost situation. I was reminded of the different philosophies when the East Bay board members were trying to get the new members of the community to carry a heavier burden for the cost of water system improvement. This is a struggle that takes place within all systems. The idea was to increase the charges to new developers and to reduce the water rates or to reduce the connection charges within the interior of the system. Which is more important though, to price for water conservation, or to make new development carry its own weight? If you have different sets of objectives, you have to decide what your ultimate goal is. I think that that becomes a local decision and not one that is absolute on a national scale. We need to sponsor more research in these areas but, more importantly, we must have an increase in the exchange of information. I am convinced that many of the utilities have the data available in their files that could be analyzed to acquire further understanding of such subjects as: pressure and water use, water use by different economic classes, and acceptable water use levels.

As I have mentioned previously, water savings in the utility context must be evaluated on a geographical basis. We have to develop long range plans and not accept short-cut solutions.

The balance between achieving efficient use through rates or policies is a critical factor. When we can promote policies that will reduce water use and, at the same time, price it realistically, we will have achieved more efficient use on a national basis. The outcome, however, should we continue the crisis mode of operation, will probably be to weaken the water conservation movement and perpetuate the inefficient use of resources. Rather, we should try to resolve these issues by working together.

In conclusion, I would urge the utilities and government officials to attempt to develop State and Federal programs that recognize the local needs and encourage localities to intelligently plan their own water conservation programs.

# APPRAISAL OF 1978 CONFERENCE CASE HISTORY: DO THE BENEFITS ENDURE?

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In 1978, Bob McGarry, General Manager of the Washington Suburban Sanitary Commission (WSSC), appeared at this conference and presented the story of the WSSC's water and sewer conservation-oriented rate structure. I am here today to update WSSC's experience and answer the question, "Do the benefits endure?" To set the response in proper perspective, I would like to give you some background on who we are, tell you what we have done, give you my answer to the question, and, equally as important, let you draw your own conclusion regarding our success.

The WSSC is an independent water and sewer authority set up by the State of Maryland. We provide service to the two Maryland Counties, Montgomery and Prince George's, immediately adjacent to the Nation's Capital. We serve a population of about 1.2 million, which represents 240,000 accounts. We are currently supplying an average of about 130 million gallons of water a day and operate and/or share seven sewage treatment plants.

In the early 1970's, there were three reasons why a water conservation program was essential for the WSSC: a pending water/sewer shortage, a developing "conservation ethic," and a planning stalemate over future water demands and resultant sewer capacities.

The first reason is obvious; the other two are more subtle but equally as important. These three reasons for our decision are interrelated and will be discussed in that order.

A series of local and Federal studies were initiated as a result of the droughts in the 1960's and revealed that in the Washington, D.C., metropolitan region, water consumption and population were increasing, but the dependable water supply was limited. There were many projections as to how serious the problem would be. Serious water shortages by the 1980's were predicted. The following chart shows a typical projection.

Washington, D.C., Metropolitan Region
Potomac River Supply Versus Demand

| Year | Projected Population (million) | Per Capita Consumption (gallons/day) | Potomac River Demand vs Flow (mgd) | |
|---|---|---|---|---|
| 1980 | 2.9 | 134 | 415 | 535 |
| 2000 | 3.7 | 141 | 635 | 535 |
| 2020 | 5.2 | 142 | 855 | 535 |

To make matters worse, WSSC was faced with a very serious shortage of sewage treatment and transmission capacity. A State-imposed moratorium on new hookups impacted the majority of our service area.

A successful water conservation program could alleviate both problems. Year-round conservation is essential to relieve sewage treatment limitations, while a reduction in seasonal peak demands would resolve the short-term water supply problem.

At the same time our water and sewer capacity problems were becoming serious, a very real conservation ethic was emerging. Up until the 1970's, the WSSC was like the auto manufacturers and petroleum suppliers -- proud of our record of providing service to meet the public's demand, regardless of how wasteful. Luxurious bath facilities, lawn irrigation systems, and car washes were the water utility equivalents of gas-guzzling cars and total electric homes. In the seventies, this wasteful use of resources was challenged (the energy crisis intensified the challenge, but it existed before the Arab oil embargo), and conservation of all natural resources, including water, became a vigorous theme that prevailed in our jurisdiction. WSSC responded to our public. We altered our entire thinking to encourage water conservation in every way. A serious major objective of the "Corporate WSSC" is to conserve water, because not to conserve is wasteful.

Once we adopted our conservation ethic, the third problem--the planning stalemate over future demand--began to resolve itself. The major reason that a potential water supply problem existed was inability of the region to agree upon a solution. A basic reason for disagreement was the conflict between the traditional water supply approach that would ensure plenty of water for the most unregulated use vs the financial, environmental, and social impacts of facilities to meet such large demands. We had developed feasibility plans to meet our water and sewer needs through reservoir expansions, pumping stations, and massive pipelines. With the expansion of water and wastewater treatment capacities, the traditional demands could be met. The costs and impacts of these plans were simply not acceptable. As time went on, it became apparent that WSSC's public insisted that water supply and sewage treatment planning be based on a far more "conservative" need than had been practiced. Accepting this directive, we have modified our planning to present a series of vastly reduced water/sewer needs, developed through a conservation and risk analysis. A consensus has been achieved on these sets of reduced needs and the planning stalemate has been resolved. A mid-range water supply (and sewage) plan is approved and under design. Had we not changed our philosophy from "abundant" to "conservative," we would still be studying and debating.

Having adopted conservation as our strategy, we developed a three-phase conservation program to make it work.

- Publicity and education
- Plumbing Code revisions requiring water saving fixtures
- A conservation-oriented rate structure.

A publicity and education program is essential to achieve two results: first, to encourage customers to save; and second, to continuously reinforce our image as a conservation-oriented agency. WSSC seldom misses an opportunity to discourage waste, to point out the savings our customers can achieve by using less water, and to explain how reduced demand benefits the region.

The Plumbing Code for the WSSC jurisdiction was changed in 1972. The revised code required 3.5-gallon toilets, 3.5-gpm showers, and pressure-reducing valves where the pressure is greater than 60 psi. In 1979, the Maryland General Assembly made WSSC's standards applicable Statewide. There have been absolutely no problems with these revisions and they do save water. It appears that there is no reason not to require these water-saving measures in all new construction.

The third major element in our conservation program was a rate structure that would encourage water conservation. Up until 1977, the WSSC had experimented with some pricing elements to reduce peak comsumption, such as a summer surcharge, but essentially the structure was a flat rate applicable to all water consumed. In making a major modification to support our water conservation efforts, two primary objectives were defined:

1. Customers making increased demand should be required to pay for the extra capacity required.

2. The price structure should encourage all customers to conserve.

In its final form, we recommended the elimination of all other elements of the billing structure, such as the summer surcharge and meter service charge, and adopted an increasing schedule applicable to water as well as sewage service. Implementation with respect to single-family residential users, which represent about 90% of WSSC customers, was relatively easy. One unique feature that was added to the structure was a separate billing system for multifamily residential units, which would place them on an equal footing with our single-family customers; that is, an additional factor was added into the billing formula that placed these multifamily units on a similar unit basis defined by average daily consumption.

The rate schedule had the desired effect; namely, accounts using 100 gpd had their bills cut in half. Customers using up to 350 gpd would remain essentially the same, and customers with high water consumption, which represented approximately 28% of all single-family accounts, would be billed at gradually increasing rates. Seasonal peak demand was also discouraged by the rate structure. A customer using 200 gpd would be billed $23.22 per quarter; however, if the average daily consumption doubled to 400 gpd during the summer, the unit charge would increase, resulting in a quarterly bill of $73.44 or about 3 times the charge for more conservative use. With the added element in the rate structure for multifamily unit accounts, a similar impact was produced; that is, well-managed residential units were rewarded for conservation.

At the 1978 conference, it was reported that the new rate structure as an element in our total water conservation program did begin to show dramatic results after one year. These results were in the quarterly accounts (single-family residential units) as opposed to our commercial and governmental accounts. The initial report between distribution from June 1977 to June 1978 reflected an almost 13% reduction in residential water consumption. This method of comparing distribution of the average daily consumption groupings was continued through the fall and winter quarters. During the peak demand periods, the same results were experienced; however, in the winter quarter, it showed some easing back to prerate structure patterns. In the first year, we labeled the program a success.

However, the question is, "Have the benefits endured?" The following is information relative to 3 full years after adoption of the increasing rate structure. At this juncture, it appears that the effect of an increasing rate structure has been not only to shave peak demands, which, as I said earlier, alleviates short-term water supply problems, but to reduce consumption year-round as well. This latter element favorably impacts on sewage treatment limitations. The following chart compares the average daily consumption (ADC) patterns of over 200,000 WSSC residential customers for the spring and summer quarters combined and the fall and winter quarters combined.

| Single-Family Residential: | ADC | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|
| Spring & Summer (April-Sept) | 101 | 10.9 | 12.5 | 13.1 | 13.1 |
| | 101-200 | 38.6 | 43.9 | 45.3 | 46.3 |
| | 201-300 | 64.7 | 70.5 | 71.9 | 74.0 |
| | 301-400 | 80.4 | 84.7 | 85.4 | 87.8 |
| | 401-500 | 88.6 | 91.3 | 91.5 | 93.5 |
| | 501-1000 | 98.1 | 98.5 | 98.5 | 98.8 |
| | 1000 | 100% | 100% | 100% | 100% |
| Fall & Winter (Oct-March) | 101 | 11.6 | 13.6 | 13.0 | 14.7 |
| | 101-200 | 43.5 | 47.9 | 47.0 | 52.3 |
| | 201-300 | 72.0 | 75.6 | 75.2 | 79.6 |
| | 301-400 | 87.0 | 88.9 | 88.6 | 91.4 |
| | 401-500 | 93.3 | 94.3 | 94.0 | 95.8 |
| | 501-1000 | 98.8 | 98.9 | 98.7 | 99.2 |
| | 1000 | 100% | 100% | 100% | 100% |

The statistics shown in the chart above represent the cumulative percentage of customers falling within the various average daily consumption (ADC) categories who are consuming at that ADC rate or less. For example, during the spring and summer period of 1977, 38.6% of our residential customers used 200 gpd or less, and 80.4% used 400 gpd or less. Similarly, in 1980, 46.3% used 200 gpd or less, while 87.8% used 400 gpd or less. Clearly, a very marked shift to lower ADC patterns is discernible not only during the spring and summer period in which discretionary water (lawn care, car washing, etc.) is used, but also during the fall and winter months. This is exactly the effect anticipated from an increasing rate structure. These results were also achieved at the full range of a very wet and a very dry year.

The following chart, reinforcing the shift in downward consumption usage, shows actual usage in 1977 consumption vs. 1980.

| ADC | Actual 1977 | | Increased (Deferred) | Actual 1980 | |
|---|---|---|---|---|---|
| 101 | 10.9% | | 2.2% | 13.1% | |
| 101-200 | 27.7 | | 5.5 | 33.2 | |
| 201-300 | 26.1 | 64.7% | 1.6 | 27.7 | 74.0% |
| | | | 9.3% | | |
| 301-400 | 15.7% | | (1.9)% | 13.8% | |
| 401-500 | 8.2 | | (2.5) | 5.7 | |
| 500-1000 | 9.5 | | (4.2) | 5.3 | |
| 1000 | 1.9 | 35.3 | (.7) | 1.2 | 26.0 |
| | | 100% | (9.3%) | | 100% |

As can be seen in the chart, below 300 gallons per unit there was an increase of 9.3% in the various categories, while a corresponding decrease occurred in the higher consumption groupings.

As in our 1978 results, the commercial accounts surveyed showed virtually little measurable reduction. This has generally been the pattern over the full 4-year period also.

In summary, and to answer the question, do the benefits originally experienced under the WSSC's water conservation program endure, the answer is emphatically and resoundingly yes. Water utility managers have had to change their thinking to realize that managing a natural resource means shifting from an "all you want" to an "all you need" philosophy. A successful publicity and education program supported by changes in the plumbing fixtures and innovative pricing techniques can change customer consumption patterns and produce lasting benefits.

# CONSERVATION IN A NONCRISIS ENVIRONMENT - TOWNSHIP OF EAST BRUNSWICK, NEW JERSEY

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## THE TOWN AND SYSTEM

East Brunswick Township is a suburban community of 38,000 located midway between New York City and Philadelphia. East Brunswick's socioeconomic standing is the highest in the county and ranks No. 4 in the United States based on the standard metropolitan statistical area as reported in the 1980 Sales & Marketing Management Magazine. Its government is professional and progressive.

The municipality's water system consists of many parts incorporated into one major system. The facility consists of one ground treatment plant, a pumping lift station for purchased supply, and three elevated and one ground storage tank connected through 200 miles of pipe ranging from 4 inches to 30 inches. Currently, the system treats and delivers an average of 4.5 million gallons per day (Mgal/d). The distribution system is relatively new, and the majority of the piping has been installed within the last 40 years. Some piping installed over 80 or 90 years ago is still being used. The Township is 21 square miles and 60 percent developed. The present system service base consists of 9,608 residential and 807 industrial accounts, for a total of 10,415. Most are residential accounts and account for 92 percent of use. Water conservation directed at the industrial/commercial enterprises would be shortsighted. Our Conservation Program was developed for residential use. The system is 100 percent metered, and the unaccounted-for water is incurred by theft (unauthorized hydrant use by road contractors) and water main breaks. All nonrevenue usage such as main flushing, street sweeping, and normal everyday activities by the municipality (hydrant repair, sewer main cleaning, storm sewer cleaning, and street sweeping) are metered or calculated. The unaccountable loss of water within the distribution system is 8 percent. A system is considered tight if loss is in the range of 10 to 15 percent.

Why would a community such as East Brunswick want to formulate a water conservation program? During the early 1970's, East Brunswick's daily usage and peak demand started outstripping its supply and unaccountable water ranged from 12 to 17 percent. At that time, 80 percent of the accounts were metered. Relief was being sought through the State, which controls ground water diversions and negotiations with surrounding communities for additional surface water supply. The Township was in a sharp growth pattern, and it was determined that additional water supply would be needed by the year 1990.

## THE PROGRAM

To change the habits of individuals, institutions, and government in a noncrisis environment is considered difficult, if not impossible. In 1976, a water conservation ethic was not strongly held by the people in the State of New Jersey. The last major drought of any significance that impacted upon the State and region was in 1960. Adequate water for industrial and residential use had been available. The cost of water was inexpensive and the quality high. Per capita usage increased yearly in the suburban community of East Brunswick. The net indebtedness of the Township was approximately 1.3 percent of its assessed valuation. The municipal budget was less than 20 percent of the local property tax dollar, and the water utility operated with a positive fund balance.

Against this backdrop, the mayor, the Governing Body, and the professional staff of East Brunswick held a 2-day retreat/planning session during the spring of 1976. The purpose was to address the issues of water supply--past, present, and future--and water quality. It is good to report that heightened awareness by the Governing Body to the principles of conservation resulted in the conservation commitment. In 1976, the Township was 40 percent undeveloped. The mayor and council realized that conservation was morally correct, economically sound, and politically wise. The concept of conservation and the implementation of such a program would impact new construction that did not immediately require a change on the part of the existing population. The Staff Retreat gave impetus to the development of a Water Master Plan, adopted in November 1977.

The Water Master Plan provided for a planned approach to capital investment in both the distribution system and the treatment facilities. Contained within that Master Plan was a commitment to water conservation. That planned capital program held a major assumption of 15 percent reduction in per capita water consumption through construction regulation and educational programming to the existing population. In 1978, the mayor appointed "The Water Conservation Committee" consisting of two Rutgers University staff and three municipal staff. The five were charged with the responsibility of obtaining the 15 percent reduction.

A Heath Sonic Leak Detector was purchased to locate leaks and the system was fully metered. Substantial water savings resulted. Leak detection is a fairly new science within the water field. The sonic detector is an excellent piece of equipment. The only drawback it may have, if it is a drawback, is that the individual using it must do so on a continuous basis. If the instrument is to be used haphazardly or by different individuals, there is no clear-cut way an individual can become familiar with the "expertise" that is needed to fine-tune the instrument and pinpoint leaks. A meter survey was the next major area of concern. Schools, other public buildings, and charitable organizations were unmetered. Many reasons were given for this nonmetering and nonbilling. The current standard operating procedure is that all accounts must be metered, billed or not.

There are two general ways to reduce water consumption: One is through public education, causing the public to become conservation minded. This would result in a conscious reduction of water and the installation of water-saving devices that have become readily available. A second method is to price the product sufficiently high enough to encourage conservation. Both of these approaches were taken by the Township of East Brunswick.

WATER RATES

Prior to 1976, East Brunswick had a declining water rate that encouraged water consumption. The initial rate was 72¢ per thousand gallons declining to 50¢ per thousand gallons. After the Staff Retreat, the water charges were amended to provide a flat rate, regardless of use. This was our first step towards conservation. In 1977, the rate was raised from 72¢ to 94¢ per thousand gallons, and the concept of a flat rate was continued. This step (a 30 percent increase), we believed, would result in a decrease in water consumption, but the elasticity of demand was small. Elasticity of demand is defined as "that percentage of change in the rate of consumption when divided by the percentage of change in the price of water." If a 30 percent increase in price gives rise to a 5 percent decrease in consumption, then the elasticity is 0.16. The greater the elasticity value, the more responsive consumption is to price change.

The 30 percent rate increase in East Brunswick did not result in conservation. The normal upward consumption patterns continued. In fact, outdoor water demand increased significantly. People began new landscaping, and the number of outdoor swimming pools installed increased dramatically. During 1977, the average daily demand for water was approximately 3.4 Mgal/d. But the peak demand, if continued on a 24-hour basis, reached points of 25 Mgal/d. The high peaks reflected outdoor water use and caused real problems to our pumping stations and our ability to deliver water and maintain adequate pressure.

A third step to deal with peaking was to restrict most outside water usage between the hours of 11:00 a.m. and 6:00 p.m. Swimming pool filling, carwashing in driveways, and lawn sprinkling could not occur during restricted hours. A fourth measure was an ascending water rate. The base rate of 94¢ per thousand gallons was maintained, and added on top of the base rate was a surcharge that increased from 14¢ to 44¢ per thousand gallons. The new rate was called a surcharge and was earmarked for capital items only.

TABLE 1. Surcharge Rates

| Annual Use | Base Rate Per 1000 Gallons | Conservation Surcharge | Total Charge Per 1000 Gallons |
|---|---|---|---|
| And Up | .94 | .44 | $1.38 |
| 375,000 | .94 | .42 | $1.36 |
| 350,000 | .94 | .40 | $1.34 |
| 325,000 | .94 | .38 | $1.32 |
| 300,000 | .94 | .36 | $1.30 |
| 275,000 | .94 | .34 | $1.28 |
| 250,000 | .94 | .32 | $1.26 |
| 225,000 | .94 | .30 | $1.24 |
| 200,000 | .94 | .28 | $1.22 |
| 175,000 | .94 | .26 | $1.20 |
| 150,000 | .94 | .24 | $1.18 |
| 125,000 | .94 | .22 | $1.16 |
| 100,000 | .94 | .20 | $1.14 |
| 75,000 | .94 | .18 | $1.12 |
| 50,000 | .94 | .16 | $1.10 |
| 25,000 | .94 | .14 | $1.08 |

There is a 214 percent increase from the lower rate to the highest rate. The surcharge applies to every gallon of water used depending upon annual consumption. This means that rates are not gradual stepping increases but are pronounced. If annual consumption is 225,000 gallons, then the 30¢ surcharge on top of the base rate is applied to all gallons. This represents a surcharge of 32 percent. If the annual use is 325,000 gallons, then the surcharge is 38¢, which reflects 40 percent.

We experienced approximately an 8 percent decrease in water consumption during 1978 and the reduction has held. The 8 percent decline in water demand has not been taken up, as the service base increased by 550 homes. It is safe to say that outside water use will respond to increased rates. We have not calculated the elasticity of demand by surcharge interval but this could be done.

The conservation-oriented rate structure also had a very positive effect on the local industry. Premium Plastics is a manufacturing industry whose average annual consumption was 34 million gallons. After the revised rate, they installed water recycling, which reduced their annual consumption to 3 million gallons. Continental Bakery implemented water conservation into their manufacturing process and reduced their water demand by 35 percent. DAK Foods, Inc., imports Danish hams, which they cut, process, and distribute from their plant. The escalating rates encouraged them to completely repipe their systems and install thermostatically controlled shutoff valves on all water-cooled equipment. Their average monthly consumption dropped from 330,000 gallons to 98,000 gallons, or a decrease of 70 percent. These are three of the dramatic examples. Their cooperation was motivated by the conservation-oriented rates, and their participation in conservation was encouraged by the Town.

During the time East Brunswick was moving forward with its water conservation program, the State of New Jersey changed its Uniform Construction Code. On January 1, 1978, a new State Energy Code became effective. Part of the State Energy Code was a revision of the Plumbing Code, and the Plumbing Inspector rigorously enforces the revised code.

The final part of our Water Conservation Program may be considered educational. Rutgers University cooperated by providing staff to work with the Water Conservation Committee on a three-phase approach to reach the residents of the community. The educational process also was supported by the local media and the U.S. Environmental Protection Agency (EPA), and videotapes were shown on closed-circuit television. Approximately 50 percent of the households in East Brunswick subscribe to closed-circuit television. In addition, local programming was developed, and the water utility budget was aired over closed-circuit television. On each water bill, customers received conservation tips. Also, conservation devices to refit home plumbing were offered for sale at cost over the revenue counter.

## THE RESULTS OF THE RESIDENTIAL CONSERVATION PROGRAM

The goals of the water-saving devices program were to (a) measure the extent to which households cooperated and installed the water-saving devices that were distributed; (b) measure the resulting reduction in water consumption (increase in water supply); and (c) evaluate the cost-effectiveness of the program. The overall goal was to cut demand by 15 percent and thereby demonstrate the feasibility of installation of water-saving devices during noncrisis situations.

A pilot study scheduled for the first months of the year was conducted with a small group of households. A variety of problems delayed the start of the program and distribution of the conservation packets until June. Savings of indoor water consumption could not be determined because of outdoor use masking the effects. The packets contained toilet dams, faucet aerators, and, in some packets, a showerhead. Separate instructions for installing each of the devices, a booklet of water-saving tips, and a lengthy article explaining in detail the social and private benefits of conservation were also included. In retrospect, there were too many separate pieces of paper and the article required too much time to read. The message had to be nonambiguous and concise.

In the fall of 1979, a broader conservation program was to be conducted in phases to extend the program. The benefits could be achieved progressively while water revenues would be maintained through the growth of population. An advantage of the phase program was avoidance of a large initial budgetary commitment. If at any point in the program the Council felt that the Township was not getting its money's worth, it could terminate the program and cut its losses to a figure that would be less than the cost of a full Townshipwide program.

The phased program consisted of the free distribution of water conservation packets to water customers along two meter-reading routes. Each packet contained the following:

- Three toilet dams (capable of saving 0.5 gallon each)
- A low-flow faucet aerator
- A flow-reducing aerator button (2 gallons/minute)
- A plastic shower flow control device for insertion into the shower water line (3 gallons/minute)
- An instructional brochure on how to install the devices
- A booklet of water-saving tips to be used inside and outside the home: "Water Conservation at Home."

The selections were purchased by the Township. Teenagers were hired to assemble the packets, which were distributed to selected routes by the meter readers.

The professionally prepared instructional brochure on how to install the devices strongly emphasized both the potential available water savings by installing the devices and the dollar savings on water and energy bills. It succinctly stated the reasons for the program, the expected water savings from using each device, and provided diagrams and instructions for installing each of the devices. A telephone number was provided so that people could call for installation assistance if desired.

The brochure informed water customers about two kinds of specially designed water-saving showerheads (an inexpensive version and a moderately priced version) available at cost from the Township. This brochure thus had the distinct advantage of presenting all the needed information on one handy piece of paper.

In late November, a letter signed by the Township's mayor was sent to 564 households on two selected water routes, informing them of the forthcoming distribution of water conservation packets and urging them to make use of the devices. The packets were distributed during the first week in January 1980. A followup letter was sent by the water utility to these households in February, again urging them to install the water-saving devices.

In addition to the two meter-reading routes chosen for the water conservation experiment, two other routes were selected as statistical control routes. Each of the control routes was matched with one of the conservation routes. Both groups had approximately the same mean annual water consumption per household and the same variance. There were 392 accounts on the control routes, giving a total of 956 residential accounts.

A letter was sent to all 956 households at the beginning of January 1980, explaining the nature and purpose of the water conservation research program and requesting their assistance. Each household was asked to provide a water meter reading in January and again at the end of March. Residents were also asked to complete a questionnaire on their use of the water-saving devices and on the water-using characteristics of their families. A preprinted card was enclosed with this letter, showing the dial face of a water meter; customers were asked to fill in the card with the numbers on their water meter and the date of the reading, and to return the card. There were 256 cards returned, a response rate of 26.7 percent.

These same households were asked to fill out a mailed questionnaire on their use of devices, the number of people in the house, household income, and other information about home water-using characteristics. Statistical analysis on these data was performed to estimate the effectiveness of the water conservation program on the average daily rate of water use per household after allowing for the effects of other variables.

Because those households cooperating in the statistical analysis program were much more likely to have used the water-saving devices, a telephone survey (Table 2) was conducted on an unbiased sample of the households receiving the packets to estimate the percentages of households that installed each of the devices. About 19 percent of the households were surveyed.

From the telephone survey:

Table 2. Installation Rates for Water-Saving Devices (Statistical Projection)

| | |
|---|---|
| Toilet Dam (1 or more installed) | 58% |
| Faucet Aerator (low-flow) | 45% |
| Faucet Volume Reducer (plastic button) | 21% |
| Shower Flow Control (plastic) | 24% |
| Showerhead Sales (3-month record) | 2.5% |

These figures do not include removals after initial installations because no followup survey was performed. One-third of the homes surveyed did not install any of the devices.

Table 3, based on statistical analysis, gives the daily water savings to be expected by installing each device.

Table 3. Water Savings Per Household as a Function of Water-Saving Device Installed (Statistical Projection)

| | |
|---|---|
| Toilet Dam (2 installed) | 8.6 gal/day |
| Faucet Aerator | 4.9 gal/day |
| Shower Flow Control | 19.5 gal/day |
| All Devices | 33 gal/day |
| All Devices | 12,000 gal/year |

An average household that installed two dams, an aerator, and the shower flow control would reduce its daily water use by 33 gallons per day or by 12,000 gallons per year. The annual water savings per household, averaged over all the homes that received the conservation packets, was 5,010 gallons per year.

Table 4 presents an analysis of the cost-effectiveness of the program. The current East Brunswick rate is $1.16/1,000 gallons, or 94¢ base and 22¢ average surcharge.

Table 4. Analysis of Cost-Effectiveness of the East Brunswick Township Water Conservation Program

| | |
|---|---|
| Total Cost of Program (excluding $2,650 for student help and computer services in monitoring the program) | $5,606 |
| Total Projected 1-Year Water Saved | 2,825,640 gal |
| Yearly Conservation Program Costs | $1.98/1000 gal |
| Water Cost (amortizing over 5 years) | 39.6¢/1000 gal |
| Water Cost (amortizing over 10 years) | 19.8¢/1000 gal |

The conservation program cost the Township $5,606, giving a cost per 1,000 gallons saved per year of $1.98. This should more reasonably be amortized over the lifetime of the water-saving devices, about 10 years, giving a cost per 1,000 gallons saved of 19.8¢.

If these results remain valid when the program is extended to the entire Township, the aggregate annual savings in water consumption would be about 42.5 million gallons per year or 116,600 gallons per day. This is 3.4 percent of the average daily water production during the first 3 months of 1979. The average home in East Brunswick consumes about 105,000 gallons of water per year, including both winter and summer usage. The annual projected savings of water from a Townshipwide conservation program could then support more than 400 new homes without an increase in water production.

As a postscript to this study, severe drought conditions began just as this research was completed. East Brunwick went from a non-crisis to a crisis situation with mandatory conservation measures imposed by New Jersey's Governor by Executive Order in February 1981. As part of many banned activities, the Executive Order prohibited the watering of all plant growth except commercially grown crops, the use of water for all outdoor recreational purposes, and restricted indoor usage to 50 gallons per person per day. It is of interest to note the response of the citizens of the Township to the Executive Order. The sale of water conservation devices skyrocketed: low-flow aerators went from a rate of 10 per week to over 180, shower flow control devices from 20 to a projected 340, toilet dams from 5 to 180, and showerheads from 3 to 75 per week. Because the Township and citizens were familiar with water conservation techniques, they were able to respond almost immediately with a 19 percent drop in consumption noted after the Governor's Executive Order.

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CASE STUDY - IN-SCHOOL WATER CONSERVATION EDUCATION PROGRAM

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ABSTRACT

California's in-school water awareness and conservation program for kindergarten through eighth grade students offers special curriculum materials and teacher training. Children are the greatest resource of the future and must learn to be wise consumers and citizens in order to make informed decisions when adults. The program teaches water's vital role in life, and that this resource is limited. A secondary benefit occurs when children carry water conservation messages home. Materials are available for the entire kindergarten through eighth grade spectrum, and as a result of evaluations, 4-6 grade materials are now emphasized. The program is continuous, not just a one-time informational campaign. With a small budget and staff, 10 percent of the total elementary grade population has been reached in the last three years.

One of our most successful water conservation programs and the one that has been around the longest is our in-school education program. It is a water awareness and conservation program for kindergarten through eighth grade students throughout the State that offers curriculum materials and teacher training.

## Why The "In-school Program"?

With a small budget and staff, this program has managed to reach 300,000 kindergarten through eighth grade students in the last three years, or 10 percent of the total K-8 grade population. We have about $450,000 budgeted, a permanent staff of five and two student positions.

Why should we spend this money on water conservation education? California has always been a leader in education because we believe children are our greatest resource of the future. We sometimes forget that sixth graders will be voting in seven years. We believe that students must start learning to be wise consumers and citizens when they are young in order to make informed decisions when adults.

Our program teaches students about water's vital role in human, animal, and plant life, and that we have just so much of this precious resource. After all, California's population is increasing by 400,000 a year, and we must make our water supply stretch.

You'd be surprised at the enthusiasm these children have when it comes to learning about water conservation. And there's a secondary benefit: they tend to carry the water conservation message home to the rest of their families.

## In The Beginning

Actual operations of the program began in September 1977, but preliminary work began even before our severe drought of 1976-77.

Materials were chosen and developed, and the endorsements of the State Secretary for Resources and the State Superintendent of Public Instruction were obtained.

The program was originally designed for fourth through sixth graders because they were judged to be the most effective in spreading the word about water conservation.

In early fall 1977, promotional work began with news releases and mass mailings of promotional material. The Department sent letters to water agencies asking them to join with their schools to finance the materials and to develop local supplements. The response was a tremendous showing of interest from schools and water agencies throughout the State.

The Department, realizing the teachers' need for local information, developed seven Regional Teacher's Guide Supplements. These supplements provide regionalized educational resource data for K-8, plus regional and State water supply information. The water supply information was developed along the lines of the Department's hydrologic study areas to help teachers relate the materials to the major water supply features of their areas. In addition, the supplements contain teaching strategies and customized projects and problems for the various workbooks used in the program.

Kindergarten through third grade materials were added in 1978, and seventh and eighth grade materials were added in 1979. The cost for the whole package of curriculum materials in the average classroom is about 40 cents per pupil, including tax and shipping charges.

Teacher training is vital to the program. Our limited staff would find it impossible to train the almost 120,000 California public school teachers individually. Therefore, free workshops throughout the State are given to train "masters" how best to use the materials. These "masters" are sometimes environmental teachers or school principals. They go back to their schools and show the classroom teachers how best to use the materials. This has been an efficient way to reach a large number of teachers.

## The Present

We now have written curriculum materials, including workbooks, teachers' guides and supplements, and films and slides for the entire K-8 spectrum.

Our education program works hand in hand with our urban device distribution program. The areas chosen to receive free water saving kits also receive free curriculum materials. The education program complements the device program by going into an area first. Teachers are asked to mention the device distribution program in their classrooms before the parents actually receive the water saving kits in the mail. Thus, the education program and the device distribution program reinforce each other.

## The Future

With hard work, adequate funding, and a little luck, we plan to reach every 4-6 grade student in the State by December 1983. In addition, we are now beginning to develop materials for high school students because we strongly believe that the need for water conservation should be reinforced before the students are cut from the umbilical cord of home. In high school they become "real" consumers and can begin to appreciate the adage "a penny saved is a penny earned." They can more closely relate to the fact that saving water, particularly hot water, saves energy and this means extra dollars in their pockets. These "cold, hard" economic facts as well as environmental considerations begin to jell in their minds.

## Evaluations

Each year we hire an outside contractor to do an independent evaluation of the program and materials. Results have indicated that children who participate in the program are more fully aware of water and the need to conserve it than children who have not, and that the greatest effect on students seems to be at the 4-6 grade level. In addition, as mentioned earlier, children carry the conservation message home to their parents and siblings.

Evaluations also show that teachers think the materials and programs are useful, and teachers involved in the more intensive teacher training presentations tend to use the materials longer and in better ways.

The evaluations also tell us that coordination of the program with the county schools offices has been a great strength of the program. In other words, our program does not just go into a county and say, "Here we are." We must have the cooperation of the county superintendent of schools, the school district offices, the principals, and the teachers for an effective program.

Improvement For The Future

As a result of evaluations, we are now emphasizing 4-6 grade materials. By the time children reach this grade level, they have the skill to handle the fairly difficult water concepts contained in our curriculum materials.

Teachers are finding their own time more and more limited, with little time left for training. This has placed us in a real dilemma, since our materials work best with trained teachers. We hope part of the problem will be solved by a teacher self-training module now being developed. This module will enable the teacher to learn about our program in free time either at school, at home or even in the park, by using a branched learning program. This program consists of film strips, printed materials, and tape cassettes. Preliminary testing has been favorable.

Southern District Office

The Department has four district offices around the State, but the one with the largest in-school education program is our Southern District office in Los Angeles. This is not surprising when one realizes that most school children live in Southern California.

The Southern District has recently finished in-service training of school staff in Ventura County and our curriculum material has reached 25,000 4-6 graders in that county. This accompanied a device distribution program. The staff is now working in Orange County, which has a very large population. It is a real challenge to reach the almost 80,000 4-6 graders in the area, but the Southern District staff has already given in-service training to almost all the staff for 4-6 grades, and soon materials will be in the classrooms.

Our Southern District staff has also been very innovative in developing and carrying out new and creative educational projects. They have been working with the Los Angeles Parks and Recreation Department to develop an Inner City Student Summer Program. Children from the Los Angeles area will be bused to Castaic Lake, a Department-owned reservoir 48 miles from downtown Los Angeles in the Tehachapi Mountains, where they will learn about water conservation and ecology. It will be a learning experience sprinkled with fun, including fishing and hiking. We are very excited about this program, since many of these inner city students have never experienced nature first hand. And what better place to learn about the natural environment, including the water cycle and water conservation, than at a lake. We expect 2,000 students can be reached through this program every summer.

We have found that a successful education program can best be carried out through cooperation with area environmental groups. Therefore, the Southern District staff has tried to put together environmental education coalitions to share ideas and carry out programs in area schools. For instance, following the in-school program in Ventura County, we are now working with county school representatives to set up a permanent environmental education coalition for that area.

One final note about our Southern California efforts. School children there are finding out that education is not <u>all</u> work and <u>no</u> play. We are coordinating water awareness contests in Ventura and Orange Counties, sponsored by local water agencies. Each class must conduct a water project of its choosing, such as building a weather station, tracing the source of water to a school, or planting low-water-using plants. In Ventura County, the winning class is spending one day at an outdoor environmental education facility. In Orange County, the winning class is going to Knott's Berry Farm.

## Conclusion

We believe education should continue through a lifetime. Therefore, our water awareness program is continuous, not just a one-time informational campaign. We do not merely fly over a school yard with some booklets, dump them out, and leave. We go into the area, get to know the administrators and teachers, train them on the best use of the curriculum materials, and then distribute the materials. We also try to get permanent environmental education programs set up in these areas. And then, of course, we are always available to help.

# CASE STUDY - DISTRIBUTION OF RESIDENTIAL WATER SAVING DEVICES

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ABSTRACT

A state-wide program of distributing water conservation devices to residents of the State is to be completed by 1983, and to result in annual savings of about 58,000 acre-feet of water and the energy equivalent of 1.3 million barrels of oil. Savings pay for program costs in about three months. Distribution programs began in 1977 with pilot studies resulting in the present program configuration that is based on mass mailing of kits containing displacement bags and shower flow restrictors. All programs are cooperative with local agencies and tailored to local situations, and are accompanied by an advertising campaign and in-school education programs. Detailed reports on past programs are available.

California has about eight million households. We began our program in 1977 and by June of this year we will have made water-saving toilet and shower devices available to about 30 percent of those households.

By 1983, we hope to have offered free devices for every California residence built before 1979, when laws requiring low-flush toilets and low-flow showers went into effect.

Based on the voluntary installation rates so far, we expect this will save about 58,000 acre-feet of water a year and energy equivalent to 1.3 million barrels of oil. Costs are remarkably low. We find that these retrofit programs pay for themselves in about three months. Since the devices last at least five years -- and probably more -- they are a great bargain as water and energy supplies go.

We began device installation programs in 1977 with seven pilot projects funded by a special $750,000 appropriation. The largest project was in San Diego, and six others were conducted in smaller communities. We were trying to determine not only which devices worked best and were most likely to be installed by householders, but which delivery methods were most efficient and cost-effective. (DWR Bulletin 191, "A Pilot Water Conservation Program," October 1978.)

We tried -- and evaluated -- a variety of devices and methods, and finally concluded that the most effective combination was direct delivery of the simplest devices: plastic displacement bags for toilets, plastic inserts for showers, and dye tablets to test toilets for leaks.

Our pilot programs covered about 455,000 households. Last year we began an extension of the program, this time financed by $2.2 million from California's new Renewable Resources Investment Fund.

It is important to note that this funding was provided during above-normal water conditions in California, and represents the State's commitment to water conservation as a regular part of doing business. It was not a response to drought, or even to the expectation of one.

With the new funding, we have extended the program to Santa Barbara and Ventura Counties on the south coast, and to Humboldt Bay on the north coast. By June we will have conducted similar programs in Santa Clara and Orange Counties, the City of Los Angeles, and the City of Fresno.

These are all cooperative programs, and in some cases cost-sharing. We are, for example, paying for 50 percent of the cost in Los Angeles, and in Santa Clara we are sharing the costs with local agencies to add a second displacement bag to the conservation kits. Santa Clara County is particularly important because existing sewage treatment plants are overloaded and the device distribution program is being counted on to reduce sewage flows.

In addition to these large areas, we are beginning a parallel program targeted at low-income families. One reason for this -- as it is for so many things these days -- is the cost to individuals for energy. We estimate that an average family can save upwards of $60 per year in water heating bills through the use of shower flow restrictors and, through adoption of other water conservation measures, can do even better. In the low-income program, we work through community action agencies to get the devices not just delivered to low-income homes, but actually installed. This is possible because these agencies contract with the federal government to "weatherize" low-income homes through the federal low-income energy assistance program.

As I mentioned, in the pilot programs we experimented with several approaches. In delivery, for example, we tried hanging kits on people's doorknobs, delivering them door-to-door, and setting up depots where householders could pick them up.

Our evaluations showed that, considering costs and installation rates, the best way was to get them to each household, and the most effective way to do that was through direct mail.

The kits themselves are simple -- an envelope containing a plastic displacement bag and a two-piece plastic clip along with a hook to hang it inside the toilet tank. The envelope also contains a pair of flow restrictors for two shower sizes, leak-detecting dye tablets, and a brochure explaining water conservation measures and how to use the kits.

For several weeks before the mailing, we conduct an advertising campaign using newspapers, radio, and television, to announce and explain the program. After distribution, the campaign is shifted to urge installation of the devices.

A parallel water awareness program is conducted in the schools. Basically we try to increase the level of interest in water and water conservation through an in-school education program aimed primarily at fourth, fifth, and sixth graders. This often begins well in advance of the actual device distribution program.

What happens after we've got the kits to the households?

We're finding -- based on post-project interviews by independent evaluators -- that about 35 percent of the householders install the displacement bags in the toilets and around 17 percent put the restrictors in the showers.

We think we can increase that installation rate with more emphasis on local public relations campaigns, and by involving local groups interested in conservation. We are working in that direction with our spring campaigns, and that will probably become part of our regular program design.

Some other things we have learned during these program operations:

-- There are benefits beyond the actual savings in toilets and showers. The existence of the program, the public awareness that is generated, and the other intangibles related to it, appear to affect water-using habits and create a sort of induced conservation.

-- If a householder is going to install a kit, it will most likely be done within two weeks of delivery. While newer homes (in California, at least) will already have water-saving toilets and showers, it is more efficient to mail kits to them than to try to exclude them from mass mailings. We use the "simplified mailing address system" -- that is, we don't use addresses; we simply mail to "Residential Customer." In this way, postage only costs us 6.7¢ per kit. This brings the total cost per kit to 59¢. The kit manufacturer assembles the kits and delivers them directly to the U. S. Postal Service, which takes care of delivering to each residential customer in each zip code area. If there is an argument for longer zip codes, by the way, this may be one -- we should in theory be able to define smaller units and thus at least eliminate new subdivisions from mailing.

-- Local support for a water-saving program may come from several areas, and advertising campaigns should take advantage of all of them. For example, in our Santa Clara County campaign we will emphasize water saving to reduce the load on a sewer system that is stressed to capacity.

-- Local funding is important, at least from our viewpoint. It tends to get local officials more deeply involved in the program and, of course, it allows a more extensive program, perhaps with second bags in the kits or a broader public information campaign.

-- Second bags and a second set of restrictors can be offered on request as an alternative to including two in the kit. Another option is to set up a depot where those who don't want -- or can't use -- the kits can return them, and those wanting another can pick one up.

-- Quality control is important in selecting a kit manufacturer. We had one bitter experience where at least 12 percent of the kits contained defective components and where we are offering replacements. We are now writing the quality control segments of our bid proposals more tightly and hope that such defects won't recur.

-- Timing is important in the advertising, education, and kit delivery systems. Since it all hinges on the actual delivery, in mail-out programs it is well to work closely with postal authorities to make the delivery period as short and precise as possible. In at least one case, we had kits arriving before the advertising campaign, a circumstance we suspect may have puzzled some residents.

The Department's Office of Water Conservation staff in Sacramento will be happy to discuss details with anyone planning a program. We don't pretend to have all the answers, and each of our programs teaches us a bit more. But we will be glad to share what we do know with anyone.

You can write to us at P. O. Box 388, Sacramento, CA 95802 or phone (916) 322-4327.

# RESULTS OF A PEAK MANAGEMENT PLAN FOR TUCSON, ARIZONA

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## INTRODUCTION

Prior to the summer of 1974, the prevailing water service philosophy of the Tucson Water Utility had been to anticipate, and meet, the unmanaged peak demand requirements of the system by increased capital expenditures for expansion of the water system. The peak demand period of the summer of 1974, however, proved to be one of the driest and hottest periods on record in Tucson. The City well system proved to be incapable of consistently meeting the prolonged peak periods. This resulted in localized disruptions in service and chronic low pressures throughout the system. The experience of that summer convinced the staff of Tucson Water and their engineering consultants of the need to evaluate and reassess the original service philosophy regarding meeting future unmanaged peak demand requirements.

In the summer of 1976, the City Council adopted a new water rate structure designed to reduce peak period use through an inverted rate structure. They also adopted a controversial "System Development Charge," intended to recover the capital costs created by new connectees to the system. The new rates and charges proved to be very controversial and unacceptable to a large segment of the Utility's customers. These problems as well as other factors involved with community growth led to the recall of four members of the Council and repeal of controversial lift and system development charges.

An analysis of the increased groundwater level decline, potential land surface subsidence, increased energy costs, and lower quality were initial concerns. However, the large capital demands, reflected in rate increases, created by the high peak demands were unacceptable. It was determined that the capital improvement program could be reduced from $150 million to under $100 million if the peak demands could be reduced. This potential capital cost savings was the primary reason for the formulation of the "Beat the Peak" program in the summer of 1977. "Beat the Peak" has proven to be a major success. It has become one of the primary factors in the substantial reductions in peak summer water use as well as reduced per capita water use by the single family residential user class supplied by Tucson Water.

## COMMUNITY GROWTH FACTORS

The City of Tucson is located in south central Arizona in what is geographically termed the northern Sonoran Desert. As a result Tucson enjoys a relatively mild climate with cool, mild winters and generally hot summers. Mean minimum temperatures during the winter range from 30°F while during the summer temperatures often exceed 100°F. It is the water use associated with these summertime temperature extremes which create our peak demand water requirements.

Precipitation plays a minor role in terms of climate relief from the semi-arid environment surrounding Tucson. In fact, precipitation is so minimal throughout the northern Sonoran Desert that it is not a factor in providing a water source for Tucson Water's service population. The Tucson area receives about 11 inches of rainfall per year with approximately one half of this amount occurring during the winter months. When one recognizes that the average annual evaporation rate in the area is 72 to 84 inches per year, it is apparent that rainfall does not and cannot provide any appreciable part of the area's water supply. As a result, Tucson Water develops its entire supply from local, stored groundwater sources. Tucson is one of the largest communities in the country obtaining its entire supply from underground sources.

Collectively, the positive factors of climate, recreational opportunities, and local scenic beauty have combined to foster a phenomenal growth rate for the area. Tucson remains to be one of the fastest growing communities in the United States.

Table 1 has been prepared to show recent historic population figures as well as population projections for the Tucson Water service area to the year 2000, assuming an average annual growth rate of three percent.

## WATER USE PATTERNS

The patterns of water use for several of the various user classes supplied by Tucson Water are seasonal in nature. Water Utility records indicate that water use during the winter months tends to be generally low and relatively constant while the summer months experience larger demands which usually peak in direct response to air temperatures and local precipitation patterns.

To analyze the overall impact which these fluctuating demands have on the operation of Tucson's water system, it is necessary to establish and verify the peaking factors appropriate to our system. Table 2 shows the tabulation of the ratio of peak day pumpage to average daily pumpage for the most recent 10 years of record for the Tucson Water Utility.

Data presented (Table 2) indicates the ratio of peak day pumpage to average day pumpage is around two. Historically, the ratio of peak day pumpage to the average daily winter pumpage has been between three and five. It is anticipated that the peaking factor of two for the ratio of peak day pumpage to average day pumpage will decline somewhat as the demand management program "Beat the Peak" receives a wider acceptance and understanding by the service population.

Similarly, a review of past ratios for the average day of the peak month to the average day of the year indicates a relatively constant relationship. Figure 1 illustrates this by a comparison of the peaking characteristics of the Water Utility for the years 1928 and 1978, a 50-year time span.

Although the actual quantity of groundwater pumped during 1928 was significantly less than that produced during 1978, the peaking factor for each year is remarkably consistent. Also note in each year the peak monthly water usage occurred during the month of June with a secondary peak period in September. This fact is interesting in that lifestyles are now quite different than they were in 1928, and there has been a tremendous growth in both Water Utility service area and the population served. The relationship between the average day of the peak month to the average day of the year, however, remains very close to the value of the 1.5 as presently used by the Tucson Water Planning staff.

## SEASONAL WATER USE

The data plotted on Figure 1 illustrates the seasonal variability in water use for the Tucson Water Utility as a whole. During the months of December, January and February, water use is at its lowest point of the year. With the coming of summer, however, water usage climbs to the peak demand period which is usually experienced during the month of June with the peak day of the year generally occurring between June 20 and July 20. However, not all water users demonstrate the extreme seasonal fluctuation in usage as shown by the system-wide averages plotted in Figure 1.

The water use characteristics for each of the five principal customer classes served by Tucson Water is shown in Figure 2. Analysis of average daily water use indicates that each user class has a varying impact on any given peak demand period.

## PEAK DEMAND WATER USE

That the greatest proportion of water required during peak demand periods occurs outside the home is shown in Figure 3. The estimated monthly volume of sewage flow relates principally to that quantity of water which supplies inside household uses such as bathing, laundry, dishwashing, etc. Historically, metered sewer flows tributary to the treatment facilities have shown little increase through the summer months (May through September) indicating that it is outdoor water use which is the primary contributing factor to our peak demand periods.

For the single family residential user group, this corresponds to the watering of lawns and decorative plantings, and it is this segment of water use which has been significantly changed by the implementation of the "Beat the Peak" demand management program.

"BEAT THE PEAK"

Early in 1977, the consultant firm of Black and Veatch, together with the Water Utility staff, initiated a study of the potential effects peak management programs might have on various capital improvement programs required to meet anticipated peak demand requirements. Developing two demand projections, Black and Veatch (1) demonstrated that a properly coordinated demand management program could significantly lessen the need for immediate system expansion. Results could be realized in reducing projected increases to rates then in existence as well as forestalling the need for additional capital construction to meet larger use conditions. Rate payers would be the direct beneficiaries of such a program.

With no peak management program it was projected that the required well system capacity would be 200 million gallons (757,576 $m^3$) per day by 1983. If a reduction of 25 percent in the outdoor water use could be effected on the peak day, well capacity requirements could be reduced to 166 million gallons (628,434 $m^3$) per day. Further, projections assuming no reduction in peak demands indicated the need for a substantial increase in system well capacity prior to 1979.

Providing for the additional well system capacity as required in these projections would have involved a massive capital spending program. Additional supplies were best obtained from Avra Valley some 12 miles (19.35 km) west of Tucson and separated from the City by the Tucson Mountains. Black and Veatch (1) estimated a six-year capital improvement program at a cost of $140 million for projected needs based on the status quo. By effecting a 25 percent reduction in peak outdoor watering demands, the required capital program was estimated to cost only $100 million. Under these circumstances, the City of Tucson initiated a public information and education program entitled "Beat the Peak."

The program was initiated with public appearances by the Mayor and City Council Members on June 1, 1977, prior to the anticipated peak demand period of the summer season. The essential elements of this voluntary program are simple. We request outdoor watering be limited to alternate days between 4:00 p.m. and 8:00 p.m. Excellent media coverage of the program was afforded by daily news reporting of reservoir levels, total pumpage, and per capita consumption during June, July, and August compared with similar system parameters experienced during the same time periods for the previous year.

That the "Beat the Peak" program continues to be a success is evidenced in Figure 4 which provides a comparison between 1974 and 1980 metered water usage for all customer classes in the aggregate and the single family residential class, individually. In 1974 the total single family residential usage amounted to about 66 percent of the total system water use. For the total system, average daily water use during the peak month fell from 100 million gallons in 1974 to 83 million gallons in 1980, while the average daily water use during the peak summer months for the single family residential class continues to show a 23 percent reduction over the same time period.

PROGRAM RESULTS

The success of the "Beat the Peak" program has far exceeded the expectations of either the consultant or Tucson Water staff. As a result of changed water usage patterns, total pumpage of groundwater for urban water users has been significantly reduced. However, since urban use represents only 12 percent of the total use in the Tucson metropolitan area, the reduction has not provided a solution to the area's overall water resource problem.

Table 3 indicates system-wide pumpage for the utility during the past several years. The figures presented indicate that system-wide pumpage for the Utility during fiscal year 1978-79 was comparable to that experienced in fiscal year 1972-73 in spite of the sustained growth rate of about three percent during that time frame. Although the "Beat the Peak" program was not originally devised as a conservation program, our service customers have significantly reduced their overall per capita consumption. This reduction may be explained in part by increased awareness of the local water resource problems on the part of the consumer and by newly adopted rate-making philosophies incorporating an inverted rate feature.

Table 4 shows the degree to which our various customer classes as a whole have altered their usage habits to effect the marked reduction in per capita pumpage figures observed since fiscal year 1974-75. From the figures shown in Table 4 it can be seen that the per capita pumpage for the system has been reduced from a high of about 205 gpcpd during fiscal year 1974-75 to about 146 gpcpd during fiscal year 1979-80. This reduction would be significant on its own merits considering a static service population but with the realization that the service area population has shown an increase of 84,767 people during that interval the impact becomes even more significant.

Analysis of the data contained in Tables 3 and 4 also reveals that Tucson Water through the success of the "Beat the Peak" demand management program has been able to initiate the management of its presently available water resources in answer to major concerns for land surface subsidence, cost of water production, and water quality. Tucson Water is beginning a major source shift to more effectively manage its available supplies and to prepare the system for major imported water supplies. The "Beat the Peak" program has allowed pumpage of the interior wellfield to be reduced while pumpage from Avra Valley has been increased. Such an option would not have been possible without a developed alternative supply if per capita demands had continued to increase as anticipated prior to initiation of "Beat the Peak."

## CONCLUSION

Collectively, individual user classes have modified their usage patterns principally in their outdoor watering habits. Substantial numbers of multifamily living units and single family residences have removed lawns and plantings and replaced them with low water use desert landscaping. These are permanent changes in lifestyle and indicate a permanent reduction in peak usage and in daily per capita use. Living units with these low maintenance, low water consumption features have become prime selling points to the local real estate market which further encourages individual users to cooperate with the program. The City of Tucson has done much to promote the program by serving as an example. Street medians, formerly planted in grasses and other high water use plantings, have been replaced with attractive and low water-consuming desert vegetation. Also, the local building industry has made greater use of low-flow water fixtures in many new developments as well as making these fixtures available for voluntary retrofitting at the individual homeowners option.

The success of the "Beat the Peak" program cannot be completely ascribed to a one-time public education effort on the part of the City. The awareness of the individual user has been enhanced by increased media understanding of the problem and increased involvement by interested community groups. These efforts, coupled with changes in water rate philosophies incorporating increased unit rates for water, have done much to perpetuate customer support for the program. Deferral of capital projects has allowed the Water Utility time to resolve numerous technical and institutional problems associated with the establishment of a long-term water supply plan for Tucson. The complex variables involved with such a plan are difficult to resolve. It is believed that continuing the "Beat the Peak" management program will allow rational, planned solutions to these problems.

## ACKNOWLEDGEMENT

The assistance rendered by Tucson Water staff: R. Bruce Johnson, Stephen E. Davis, and Frank Brooks, during the preparation of this paper is gratefully acknowledged.

## REFERENCES

(1) Black and Veatch Consulting Engineers, 1977. Report on Capital Improvement Program, Revenue Requirements, and Water Rates, City of Tucson Water Utility.

Table 1. Tucson Water Service Area Projections

| End of Year | (1) Pima County Population | (2) Retail Service Population | (3) Active Services |
|---|---|---|---|
| 1978 | 502,700 | 427,295 | 115,485 |
| 1979 | 521,300 | 443,105 | 119,758 |
| 1980 | 539,800 | 458,830 | 124,008 |
| 1985 | 606,300 | 515,355 | 139,285 |
| 1990 | 655,500 | 557,175 | 150,588 |
| 1995 | 727,100 | 618,035 | 167,036 |
| 2000 | 818,600 | 695,810 | 188,057 |

(1) From Arizona Department of Economic Security, May 1979. Adopted by PAG, September 27, 1979, through the year 2000.

(2) Assumed to be 85 percent of County population.

(3) Assumed to be 3.7 persons per active retail service.

Table 2. Historical Average and Peak Day Pumpage

| Fiscal Year | Average Day Pumpage (MG) | Peak Day Pumpage (MG) | Peak/ Average |
|---|---|---|---|
| 70-71 | 54.1 | 110.2 | 2.04 |
| 71-72 | 57.8 | 112.3 | 1.94 |
| 72-73 | 60.1 | 118.8 | 1.98 |
| 73-74 | 75.4 | 130.4 | 1.73 |
| 74-75 | 67.6 | 115.2 | 1.70 |
| 75-76 | 70.0 | 117.6 | 1.68 |
| 76-77 | 60.5 | 131.1 | 2.17 |
| 77-78 | 59.4 | 112.1 | 1.89 |
| 78-79 | 60.8 | 113.2 | 1.87 |
| 79-80 | 66.2 | 110.0 | 1.66 |

Table 3. Annual Pumpage by Wellfield (Acre-Feet)

| Fiscal Year | Santa Cruz Wellfield | Southside Wellfield | Avra Valley Wellfield | Interior Wellfield | System Total |
|---|---|---|---|---|---|
| 71-72 | 15,178 | 5,030 | 1,449 | 43,282 | 64,939 |
| 72-73 | 15,634 | 5,535 | 3,248 | 42,828 | 67,244 |
| 73-74 | 16,574 | 7,018 | 5,361 | 55,498 | 84,452 |
| 74-75 | 16,614 | 4,846 | 7,245 | 47,041 | 75,745 |
| 75-76 | 15,031 | 4,919 | 8,715 | 49,916 | 78,580 |
| 76-77 | 14,397 | 2,737 | 9,623 | 41,043 | 67,800 |
| 77-78 | 14,593 | 2,868 | 9,703 | 39,293 | 66,457 |
| 78-79 | 15,209 | 2,192 | 15,382 | 35,305 | 68,088 |
| 79-80 | 14,198 | 1,738 | 15,236 | 43,149 | 74,321 |

Table 4. Service Area Per Capita Pumpage Per Day

| Fiscal Year | Average Daily Pumpage (MG) | Active Services | Service Population | Pumpage Per Capita/Day |
|---|---|---|---|---|
| 69-70 | 51.2 | 71,241 | 263,592 | 194.2 |
| 70-71 | 54.1 | 78,177 | 289,255 | 187.0 |
| 71-72 | 57.8 | 84,816 | 313,819 | 184.2 |
| 72-73 | 60.1 | 95,105 | 351,889 | 170.8 |
| 73-74 | 75.4 | 99,604 | 368,535 | 204.6 |
| 74-75 | 67.6 | 102,813 | 380,408 | 177.7 |
| 75-76 | 70.0 | 105,595 | 390,702 | 179.2 |
| 76-77 | 60.5 | 109,480 | 405,076 | 149.4 |
| 77-78 | 59.4 | 113,105 | 418,489 | 141.9 |
| 78-79 | 60.8 | 117,777 | 435,775 | 139.5 |
| 79-80 | 66.2 | 122,514 | 453,302 | 146.0 |

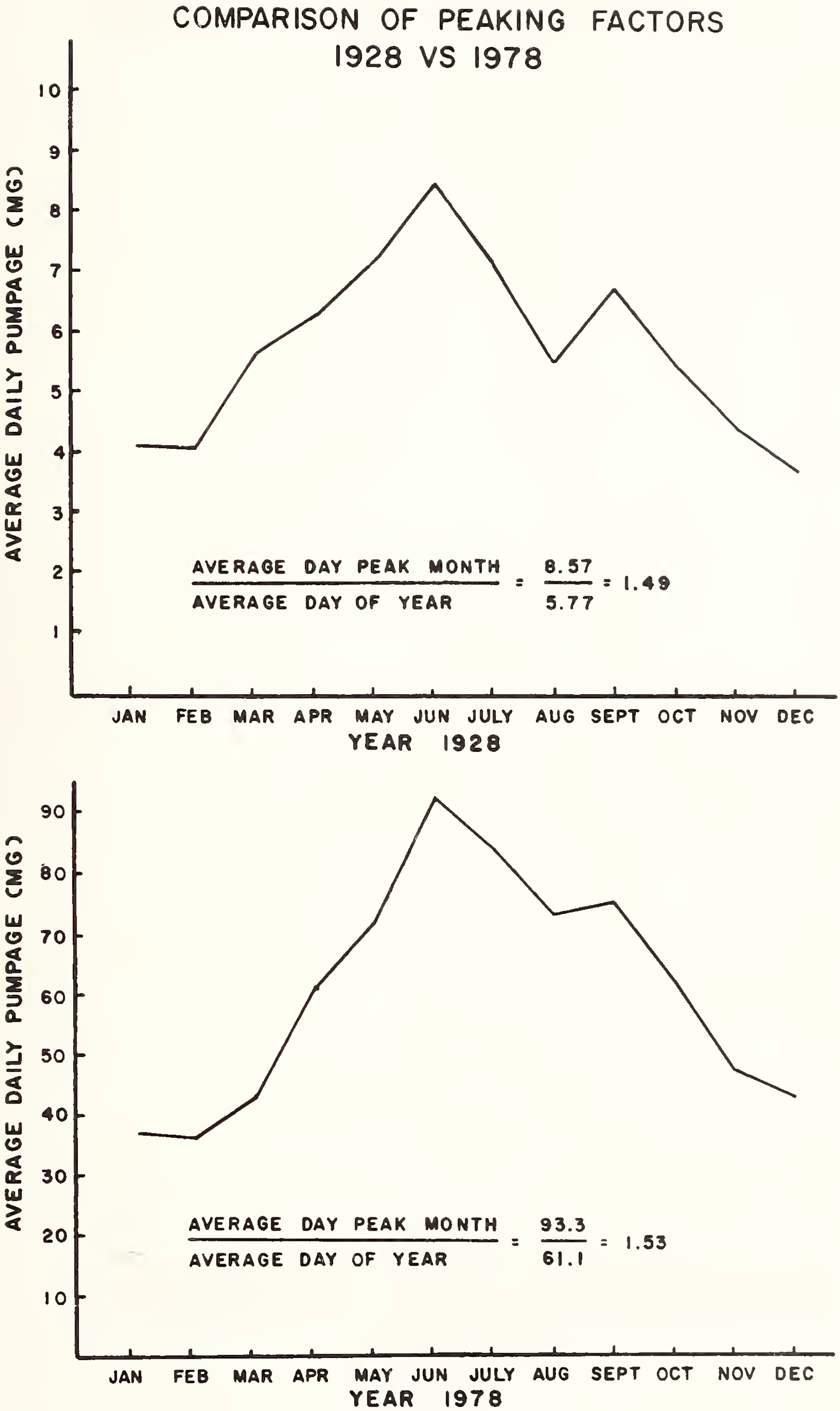
COMPARISON OF PEAKING FACTORS
1928 VS 1978
AVERAGE DAILY PUMPAGE (MG)
10
9
8
7
6
5
4
3
2
1
AVERAGE DAY PEAK MONTH / AVERAGE DAY OF YEAR = 8.57 / 5.77 = 1.49
JAN FEB MAR APR MAY JUN JULY AUG SEPT OCT NOV DEC
YEAR 1928
AVERAGE DAILY PUMPAGE (MG)
90
80
70
60
50
40
30
20
10
AVERAGE DAY PEAK MONTH / AVERAGE DAY OF YEAR = 93.3 / 61.1 = 1.53
JAN FEB MAR APR MAY JUN JULY AUG SEPT OCT NOV DEC
YEAR 1978

FIGURE 1

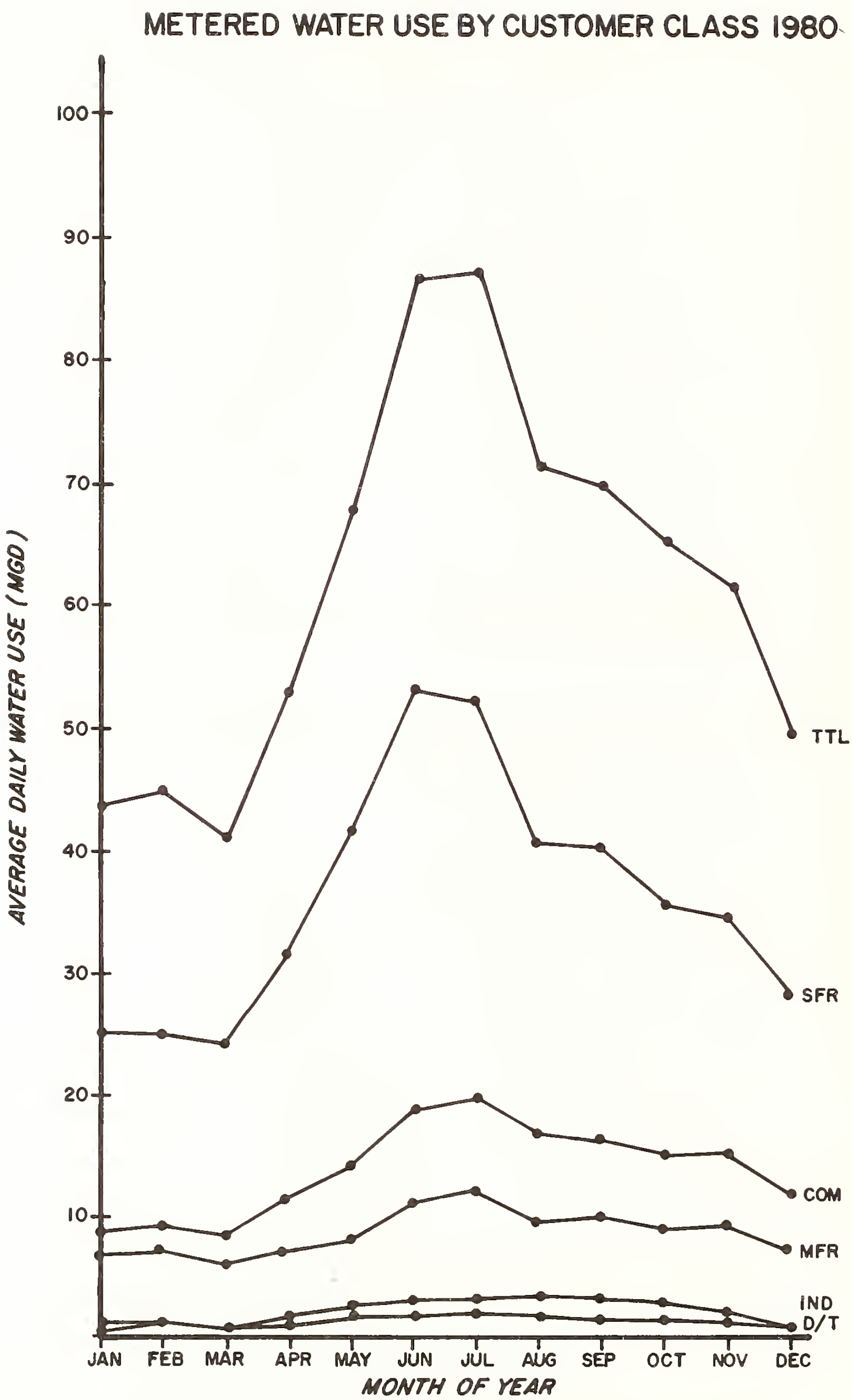
METERED WATER USE BY CUSTOMER CLASS 1980
AVERAGE DAILY WATER USE (MGD)
100
90
80
70
60
50
40
30
20
10
TTL
SFR
COM
MFR
IND
D/T
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH OF YEAR

FIGURE 2

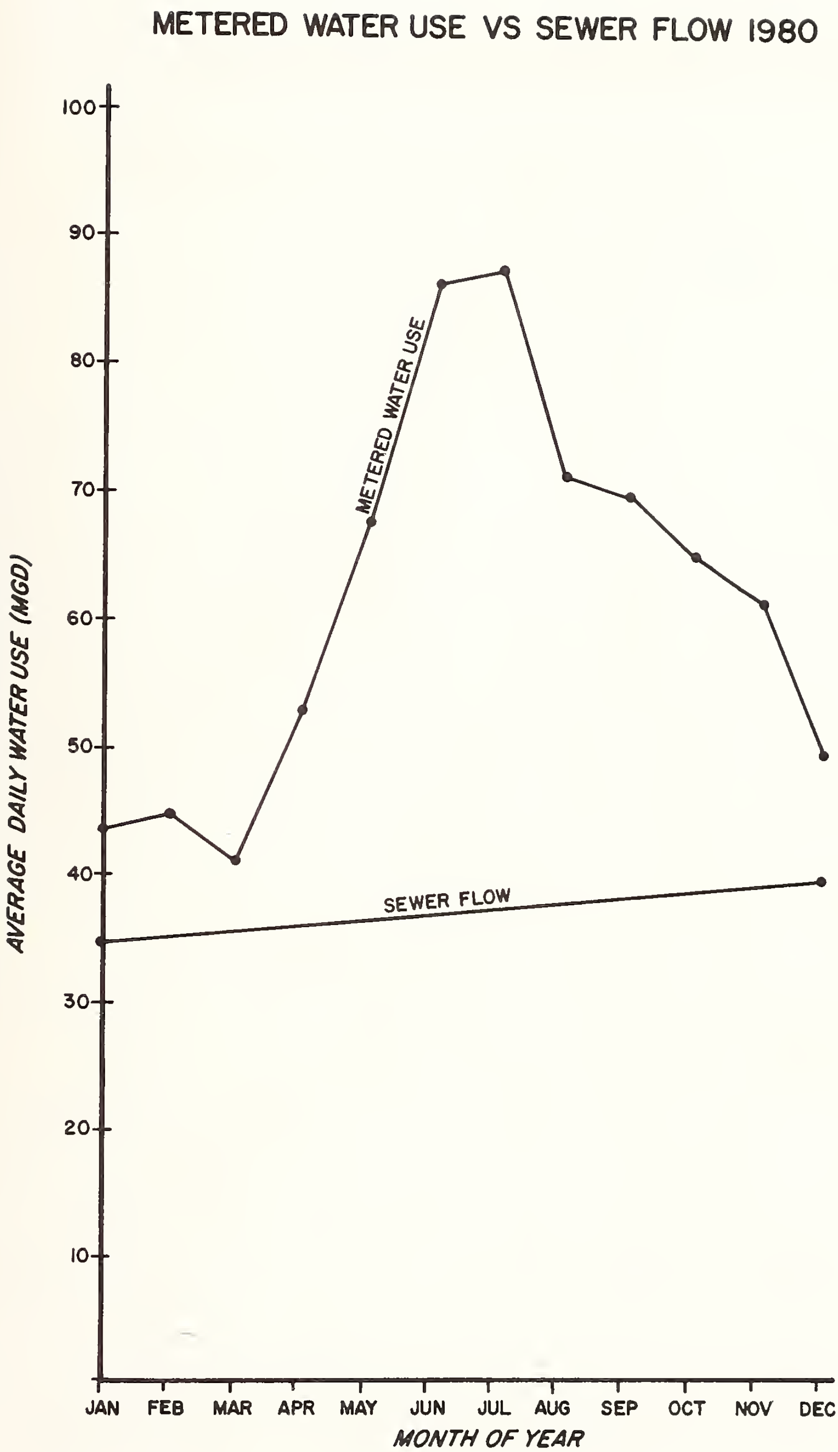
METERED WATER USE VS SEWER FLOW 1980
AVERAGE DAILY WATER USE (MGD)
100
90
80
70
60
50
40
30
20
10
METERED WATER USE
SEWER FLOW
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH OF YEAR

FIGURE 3

COMPARISON OF METERED WATER USE 1974 & 1980

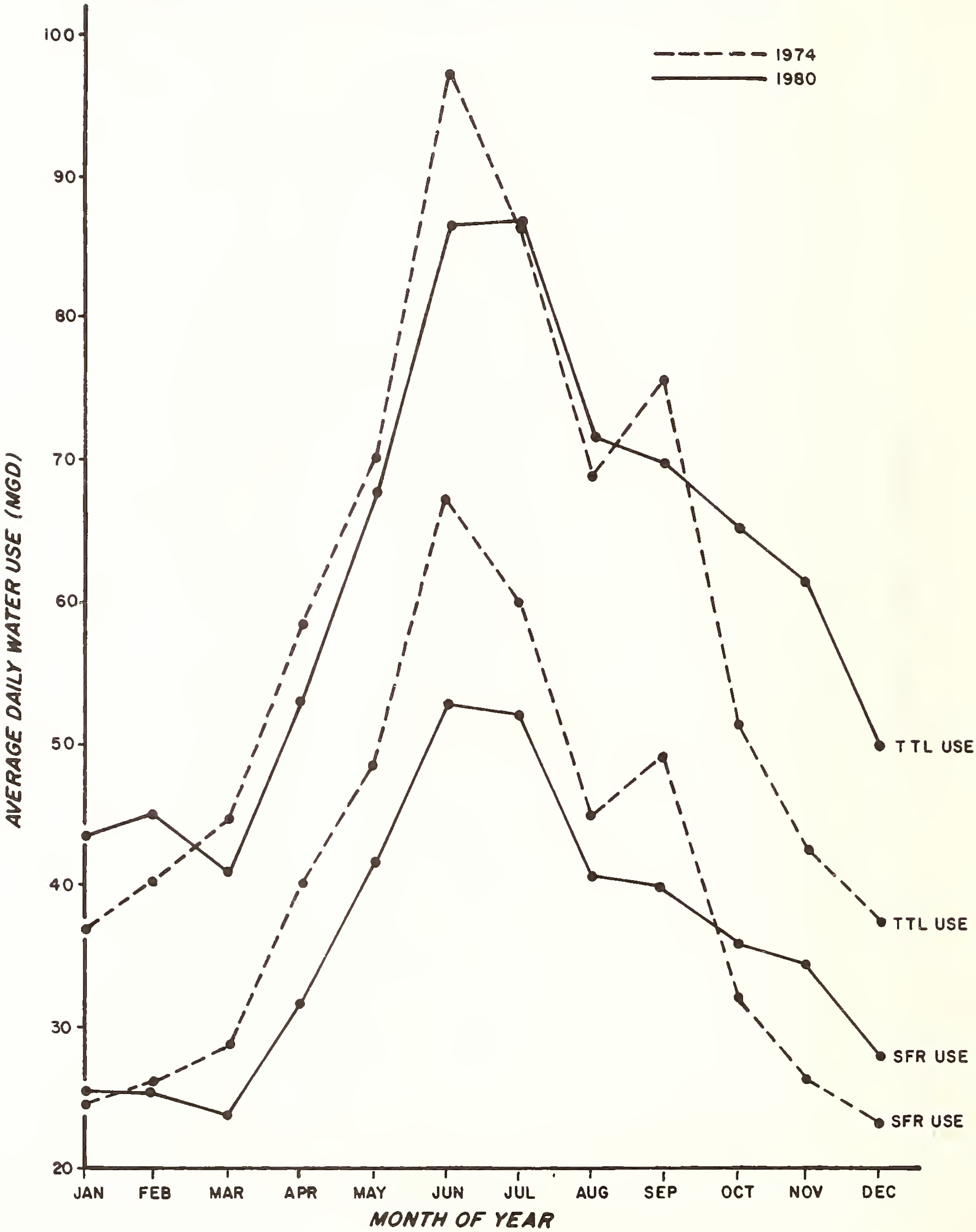


FIGURE 4

# WATER CONSERVATION EFFORTS IN RURAL AREAS

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North Carolina is predominantly a rural State. Recent census figures indicate that the rural counties in the eastern and western parts are growing at a more rapid rate than are the more urbanized counties in the central part of the State. Nonetheless, major population centers do lie along the interstate highway routes that link Charlotte in the west with the Raleigh-Durham area in the east. Almost half of the State's population reside in this area known as the Piedmont Crescent. Historically, the water resources base that supports these areas has been adequate; however, with increasing population pressures, rapid industrial development, concomitant industrial development pressures, agricultural water uses, and commercial uses of water, the future availability of these once plentiful water resources is now being questioned. Many of the large urban areas are engaged in some form of water conservation program that has two primary aims: raising the level of consciousness and awareness of the local residents regarding potential drought emergency plans, and focusing on a series of educational programs, mailings, slide tapes, public meetings, exhibits, etc., on routine residential, commercial, industrial, and institutional demand reduction.

The problems in the rural areas of the State are somewhat different from those encountered in the urban areas. Often, rural counties do not have the engineering or planning staffs necessary to examine potential water supply problems, and water conservation plans are more akin to "putting out the fire" rather than to preventive fire protection programs. The need was emerging throughout the State to provide both leadership and semitechnical support to those rural communities experiencing water supply problems. The Agricultural Extension Service at North Carolina State University saw this emerging need to provide both safe sanitary water and safe sanitary wastewater treatment disposal systems for these rural areas. Working cooperatively with the Water Resources Research Institute of the University of North Carolina, the Agricultural Extension Service sought a Title V grant from the Rural Development Panel to establish a pilot water conservation, water supply, and wastewater management program, general water resource educational program, and to incorporate such a program into the administrative and operational structure of the North Carolina Cooperative Extension Service.

The major goals of this program were to facilitate the development, implementation, and evaluation of cost-effective water supply and wastewater management systems for both individuals and small rural communities. The reasons for creation of this position are manifold. Paramount among them, however, were concerns for the escalating capital costs associated with developing water supply and wastewater systems, increased operations and maintenance costs for keeping the systems operating, and the general lack of assistance available to these small communities in solving their water resource problems. A two-part work plan emerged. One major program area was water supply and water conservation, and the second major area of concern was wastewater treatment and disposal. Gradually, there emerged a program that could satisfy the water-related needs of the rural population. The first phase of the program was to establish a framework upon which to focus efforts and to establish goals.

Three areas of concern emerged in the area of water conservation: technical, institutional, and behavioral concerns. A demonstration water conservation effort then began in the State with which both the urban and the rural residents could identify. This program focused on the technical (hardware) and the behavioral aspects of a water conservation program. This initial effort was directed at determining the hardware and determining individual water-using behaviors and habits. This was done by (1) gathering information regarding other water conservation programs operating elsewhere and selecting those conservation practices that appeared to yield the most significant results; (2) canvassing hardware and plumbing supply companies; and (3) questioning homeowners and renters. Once this was accomplished, several areas of the State were identified and pilot efforts were attempted. Demonstrations were undertaken in both rural and urban settings, and the results of these demonstrations were widely publicized through Extension communications channels such as news bulletins, workshops, television and radio programs, and the Statewide series of Extension training programs. Significant results were obtained in these pilot efforts, and average residential water savings amounted to over 1,500 gallons per month for a family of four.

Greater conservation figures were achieved in the larger residential multifamily housing units. As a result, we did achieve one of our major institutional objectives: to get the Building Code modified to encourage or actually to require low-volume plumbing fixtures in all future construction in the State. A second benefit was retrofit of some State-owned buildings. This is currently proceeding on many of the university campuses.

Demonstration projects and pilot programs, such as those we undertook, are critical to the establishment of any such program. It is imperative that residents of a State or other geographic area feel that the results of a demonstration are applicable to them. Something that was done in Washington, D.C., may not be applicable to somebody living in a rural community in North Carolina. Something that was done in Fresno, California, may not be applicable to someone who is living in Polk County, North Carolina. There is nothing, however, like a real, felt need to bring a program to some fruition. Such was the case in a rural western North Carolina county.

Polk County in North Carolina is a predominantly agricultural county. It is located in the extreme southwestern corner of the State and borders on South Carolina. Major population centers are located in the southwestern corner of the county. About 75 percent of the county lies in what is called the Piedmont Plateau, while the northwestern portion of the county is considered a part of the Blue Ridge physiogeographic province. Topography in the Piedmont portion of the county is gently undulating, while the Blue Ridge portion is decidedly hilly, with two peaks reaching over 3,200 feet above sea level. Ground water supplies are limited, while rainfall and surface supply in the county are usually abundant. Recently, however, the area has been plagued by drought. Water supply for the small municipalities is surface water. The intake structure is located near one of the small towns on the South Carolina border. The existing system was just adequate to support the existing development on the small county system and was inadequate to support any significant increase in residential development, and industrial development was considered out of the question. The dilemma then arose: "How do we attract industry to our area and improve our low standard of living with an inadequate water supply system?" One possible answer was to simply allow for no growth. That option was quickly discarded because of the relatively low standard of living of many of the long-time county residents. Another option was to build another intake structure on the river and to improve the existing distribution system. This option proved to be quite costly, and the county decided that the cost for such a system would be prohibitive given the current revenue-producing activities in the county. It was imperative that additional revenue-producing activities be present in the county before the system could be improved.

The County Agricultural Extension Chairman was a member of the local rural development committee. He was cognizant of these local problems and had recently attended the Statewide extension agent training program and was made aware of the recently created program concerning water supply and wastewater treatment for individuals and small rural communities. The county chairman contacted the extension water supply and wastewater specialist and arranged for exhibit space in an upcoming county fair for the demonstration of water-conserving devices. Soon after the county extension chairman contacted the Agricultural Extension Service water and wastewater management specialist, the fair was conducted and was well attended. Local officials, both elected and appointed, were impressed by the benefits a water conservation program could produce. County officials discussed some of the potentially immediate benefits of such a program. Following the energy fair, the county officials concluded that a community-based water conservation program could extend the available supply of water and might provide some of the necessary reserve for expansion of their system. This would serve to help attract a small, relatively dry industry to the county, which would improve the financial position of the county. County Commissioners moved to install water-conserving devices in all county buildings. Once the County Commissioners were convinced of the efficacy of such a program, business and commercial establishments were then involved. A local Chamber of Commerce was contacted and agreed to participate and to encourage the sale of water-conserving devices to interested businesses, homeowners, and the one industry that was planning to locate in the county. Sale of the devices has been a successful money-making venture for the local Chambers of Commerce, and according to several information sources in the county, the local response has been that the sale of water-conserving showerheads "sure has beat the heck out of candy bars." The industry that did locate in the county was a very small, very dry industry. Extreme water conservation measures were required in the building, such as the very low-volume water closets, spring-loaded faucets, and low-volume faucet aerators. The slight increase in county revenue that resulted from the siting of the industry in the county has provided the county with some incentive to begin planning for expansion of its water resource base. This is now considered a viable option because of the increase in revenues and the interest in industrial development that has been fostered. Water conservation is by no means a complete solution to the county's dilemma. It did, however, provide a means to attract a small industry and thereby increase the county's revenue, tax base, and standard of living.

Water conservation programs do have a place in the rural county, just as they do in the large urban areas throughout the country. In North Carolina, the Agricultural Extension Service was involved in the delivery of such a program. The Agricultural Extension Service is a nationwide organization composed of specialists, researchers, and technicians at major land-grant universities nationwide, and local county extension staffs. There is an extensive outreach program in each county, and the potential for information exchange, technology transfer, and behavior change is real. Programs in water conservation can help extend available resources in a community and provide a channel for a plethora of community development activities that might follow. Resource-centered community development programs are an effective means of mobilizing a community. Recently, units of local governments throughout the State have expressed interest in working cooperatively with the Extension Service to promote a water-conservation program. Initial concerns for reduced revenues resulting from decreased sales have been replaced by enthusiastic support. Support for the conservation effort in North Carolina has been strong. On February 2, 1981, approval was given for retrofitting the Governor's Mansion with water-conserving plumbing, and with time other State buildings will be retrofitted. We are a rural State. Communication between Murphy in the extreme west and Manteo in the extreme east is difficult. The Extension Service has implemented a series of programs to facilitate this communication. Water conservation messages have received thousands of requests over the "Teletip" toll-free number, and Extension publications on water conservation are again exhausted after their second printing. There is interest and there have been changes in water-use patterns. A number of benefits have resulted from the water conservation effort in the rural areas of the State of North Carolina.

# WATER CONSERVATION/FLOW REDUCTION IN FACILITIES PLANNING FOR SALT LAKE COUNTY

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## INTRODUCTION

Salt Lake County is an urban county in Utah with a 1980 population of 620,000. Twelve municipalities are incorporated within Salt Lake County including over 40 public water systems (as defined under the Safe Drinking Water Act standards). Fourteen wastewater collection entities, ranging from municipal systems to dual-purpose improvement districts, to single-purpose "county service area" entities, collect wastewater for disposal at nine treatment facilities and one dual-purpose lagoon.

An areawide plan was completed in 1978 that provided for consolidation of seven treatment facilities into two larger "regional" facilities. The remaining treatment facilities were projected for further planning. The 1977 amendments to the Federal Water Pollution Control Act introduced a new requirement into the facilities planning process required by Title II of the Federal Water Pollution Control Act (hereafter cited with the 1977 amendments as the Clean Water Act). The new requirement was an amendment to Section 204(a)(5) and provided that reserve capacity designed into treatment works would be approved after the assessment of possible flow reductions resulting from water conservation efforts approved under regulations to be developed by the administrator of the U.S. Environmental Protection Agency (EPA).

Local officials from one of the treatment entities in Salt Lake County, the South Valley Water Reclamation Facility Board, had contracted for engineering services prior to receiving the policy of EPA on the water conservation/flow reduction issue, and a water conservation/flow reduction plan was not part of the contract. EPA, through the Region VIII office, adopted the policy that a Step I facilities plan could not be approved for grant funding until regulations were developed and in place providing detailed law guiding engineering and grant approval. The problem was complicated further by the fact that flows for treatment plant design were approved as part of the 208 planning process and no historical data were available to predict the flow reduction that could be achieved by a water conservation program.

Faced with a potential delay in grants for construction planning, overloaded treatment plants, a rapidly growing population, and record-high construction costs, local officials were disappointed and angry. This article describes how the Regional EPA staff, Utah State officials, and local officials worked together to plan a water pollution improvement project in compliance with the water conservation mandate of the 1977 amendments to the Clean Water Act. The selected program is also described together with the process for planning the selected program.

## BEFORE STEP I

The water conservation/flow reduction problem was presented to local officials representing the South Valley Reclamation Facility Board (SVB) and the Salt Lake County Department of Water Quality and Water Pollution Control (SLCo) during a pregrant application conference in the summer of 1978. The SVB and SLCo are two separate entities; SVB is the management agency designated for wastewater treatment in the Upper Jordan Planning Area of Salt Lake County, and SLCo is the designated areawide planning agency for the Salt Lake County Geographic Area. The water conservation problem was one of a series of issues that was to be addressed in the facility planning process for the regional treatment works. EPA Region VIII personnel advised the SVB and SLCo that resolution of the issue was a prerequisite to a construction grant and that regulations were under development in EPA for guidance on the issue. Personnel of the SLCo office were aware of the potential time involved in the development of regulations and of the limited legal authority of some of the SVB member entities; three of the entities are single-purpose Improvement Districts with very limited or no authority to influence the political entities, water companies, etc., that are certainly necessary participants in a successful water conservation/flow reduction program. In addition, the scope of work for engineering consultants had been defined and a contract was in force.

Time and regulatory uncertainty threatened to delay the project, escalate costs, and create a water pollution crisis in view of the rapid growth of the member entities and the overloaded condition of existing facilities.

After consultation between SVB and SLCo, the county agency agreed to assume the responsibility for the development of the water conservation/flow reduction program and to amend the Management Agency Agreement between the parties to reflect the shared responsibility in the planning process. Other environmental issues that were required to be addressed because of Clean Water Act amendments or regional EPA policy were also included.

A proposal was made to the State of Utah and to the EPA Regional Office articulating the work that could be done by SLCo and the steps SLCo would follow to ensure that the flow reduction program would fit within the regulations under development. SLCo personnel recognized the risk and assumed the responsibility after evaluating alternatives ranging from lawsuits and formal administrative actions to simply delaying the project. Since delay would result from any challenge to the EPA policy, a strategy was developed to propose a planning process. The issue was critical not only to SVB but also to a second regional facility board entering the planning and construction process.

The planning process proposal that developed involved using a countywide public participation-technical resource group formed under the County Water Quality office enabling ordinance. Under the county enabling ordinance, a Water Supply Policy Committee was formed--consisting of representatives of all entities, public and private, involved in the wholesale and retail distribution of potable water.

The planning of a countywide water conservation/flow reduction program was technically outside the scope of responsibility defined for the group, but the Water Supply Policy Committee working with the staff of the Water Quality office coordinating with the regional Wastewater Treatment Boards proved to be the only institutional planning vehicle available.

The State of Utah quickly approved the proposal and encouraged the EPA Regional Office to do so. EPA then approved the proposal, demonstrating a willingness to assume some risk and to trust the local officials. Reserve capacity in the regional treatment plants would be reduced in the first phase of construction, and a second phase, which would include flow reduction program experience, would be considered after 1990. Planning the actual flow reduction program started in earnest after everyone involved understood the proposal and became committed to the completion of the work. The overall program development would be conducted within the conceptual framework of the Step I-II-III process used in the preparation, analysis, and approval of engineering plans and the actual construction of the physical plant. A countywide program would be planned and the Water Conservation Program details would be acceptable to wastewater treatment entities entering the 201 process and to major public and private entities responsible for distribution of potable water in Salt Lake County. Institutional and technical planning, and physical mapping of entities and geographic service areas would confirm that the water conservation/flow reduction concept plan (Step I), implementation plan (Step II), and execution of the implementation plan (Step III) would be successful.

Advising each potential local participant of the need for the water conservation/flow reduction program and gaining a commitment to participate in terms broader than meeting a "federal mandate" required a careful approach with continued reassurance of opportunities to participate, criticize freely, and make additional studies if initial results were unsatisfactory. Consulting with local entities in the earliest stages of plan development and listening to each perspective on the issue of water conservation, generally, and flow reduction to sewage treatment plants, specifically, proved later to be the most valuable part of the planning process--not only from a political standpoint but from a technical feasibility perspective. Everyone familiar with the political conflict in planning knows that a tour of meetings with each affected entity is necessary, but very few consultants and planners take the time to question tactfully and listen carefully to the answers and then use the information gained in the interview in a positive way. As we moved into the actual process of evaluating water conservation programs and techniques to develop a Step I, or conceptual plan, the interviews with water supply entity managers, water wholesalers, plumbing code inspectors, and wastewater collection and treatment entity managers proved to be a valuable source of the possible and rational elements of the selected program.

## THE STEP I CONCEPTUAL PLAN

In the EPA grant-funded construction of a wastewater treatment plant, three definite, separate steps are followed that permit review and approval by State and EPA construction grant managers. The first step is the conceptual plan, which includes determining the initial and subsequent capacity or size of the plant, the treatment process to be used, and the site for construction of the plant. Step II is the preparation of detailed design, including all drawings and specifications for construction; and Step III is the actual construction of the physical facility. The Salt Lake County water conservation/flow reduction program plan was developed in a parallel sequence.

All water conservation programs developed in the last 5 years that were directed at indoor water uses, as distinguished from outdoor or irrigation uses, were collected and reviewed. Based on the results of earlier efforts in other areas, as well as in Salt Lake County, we concluded that economic incentives or increased water and sewer rates provided the only meaningful results. Increased sewer rates, creating a demand for easily installed and more efficient water-conserving devices, provided a conceptual dynamic process inherent in our planning. The 1977 experiences in Utah and in California were particularly helpful. Although articles on treatment works problems did not begin to appear until our work was substantially complete, we were able to collect some of the basic data verbally through telephone conversations. Draft copies of evaluations were also made available to us by some authors. Typical indoor-use data for cooking, clothes washing, bathing, and general sanitation were available in published material. We were also able to estimate reductions in average uses that could be achieved with flow reducers, low-flush toilets of various designs, and recycling options. In reviewing the technical materials, it became obvious that technical innovation is limited only by the inventiveness of the human mind and by economic demand factors. The design of collection systems and treatment plants presented what appeared to be significant barriers, but management options such as line flushing and pump station retrofits are possible to overcome the in-place system obstacles.

After rapidly surveying the theoretical limits, the staff recommended to the Water Supply Policy Committee that a processoriented program be considered with a low per capita day use target of 60 gallons. The effect of the 60-gallon/person/day target would be to construct in place a permanent water conservation/flow reduction program.

Actually, a far lower target of 40 gallons per capita per day was initially considered and rejected because it had a demoralizing effect on everyone who heard the proposal.

After consultation with the Regional Wastewater Treatment Boards and the Water Supply Policy Committee of SLCo, a Step I proposal was circulated for comments. The proposal articulated a policy of establishing a permanent water conservation/flow reduction effort targeted to a 40 percent reduction from a 1976 base of 100 gallons/person/day.

The proposal recommended an initial public education program effort that would focus on the avoidance of future tax expenditures for developing new water supplies, controlling treatment costs, and preventing the need for sewer treatment plant expansion after 1985 when the first phases of the regional plants would be complete.

If the public education effort failed to reach the target (as we suspected), a new phase would be added to the program relying totally on economic incentives. Lower sewer-use fees would be offered to individuals with pressure regulators installed and set at 45 psi, the lowest pressure that will operate most outdoor sprinklers.

An additional economic incentive would be created under the third and most complex phase of the program, requiring that sewer-use fees be implemented based on metered water deliveries during November, December, January, and February when no outdoor use occurs in Salt Lake County. The winter months' readings would be extrapolated for 12 months, and sewer-use fees would be based on per gallon estimates of flow. The Third Phase program would require detailed information transfers with virtually no errors between many different entities with varying capabilities. After the proposal was circulated, we received several well-reasoned comments generally approving the concept plan, but reserving final approval until specific costs were developed, roles defined, and dates for the length of each program proposed.

Since the specific details were Step II tasks, our Step I work was essentially complete. In fact, the largest water supply entity in the county, Salt Lake City, went directly to the Phase III program within 18 months of the proposal. Salt Lake City was motivated to do so by economic considerations related to a need to accumulate a reserve for system repairs and upgrades. But the rapid implementation of the Phase III program by Salt Lake City provided an opportunity to evaluate public acceptance, technical issues related to meter accuracy and computation problems, as well as beginning a period of record to see how consumers would react over time. In the case of Salt Lake City, a computer analysis of sewer fees based on previous years' use of water showed that the fee structure actually saved 52 percent of the consumers money, while 48 percent, mostly large, commercial users such as hotels, restaurants, and office buildings, would pay higher charges. Apparently, the lack of a rational fee structure with conservation incentives had produced a relatively wild, unmanaged system in the commercial sector. When the first bills began to go out, plumbers were in demand to reduce flush-valve settings and install various conserving devices that reduce consumption and flows to treatment plants but have no effect on the quality of service. It is still too early to fully evaluate the Salt Lake City experience, but the early results are encouraging.

Step I was approved and forwarded to the State of Utah and EPA for review and approval. With the completion of Step I, we experienced an unpredicted and unpleasant problem. We could not start Step II.

## STEP II AND BEYOND

Toward the end of Step I, an enormous amount of momentum was created to move forward with the program. Each participant was interested in resolving the remaining questions; in fact, we wanted to modify Step I almost as quickly as we completed it. But in the step-by-step process, local officials cannot go on to Step II until Step I has been reviewed and approved by the State of Utah and EPA. State officials who were close to the local momentum quickly reviewed the materials, made rational comments, and approved Step I with the condition that some further work and slightly new directions be considered. EPA's Region VIII simply was not organized and staffed to respond rapidly. Everything stopped. Almost 5 months passed before we began to receive comments verbally. We did not receive written approval or comments until grant applications for Step II were approved, and then our approval with conditions appeared as conditions of a Step II grant to the South Valley Board.

Recovering lost momentum is a time-consuming process that requires the participants to return to materials and plans laid aside months before. A subcommittee of the Water Supply Policy Committee was formed to evaluate costs, respond to comments, propose changes, assign roles, and set timetables. After several meetings, the Water Supply Policy Committee and the subcommittee finished their work. The pressure regulator program would be substituted for a broader program of incentives for retrofits of water-conserving devices in plumbing and new devices tied to the plumbing code provisions of the Uniform Building Code. The 1979 version of the Code had been written in a way that could require water-conserving devices as they became available at the discretion of the building official. Economic incentives would provide the basis for demand for better devices, management agency agreements between Salt Lake County, and each political entity with a building inspection system--and each water supplier would provide the institutional vehicle to tie the process together. Early in 1979, funds were identified and made available to Salt Lake County in 1981 for a public education project; the public education portion of the water conservation program would be conducted using those funds.

The final Step II submittal retained the policy of Step I: to make water conservation a permanent component of water supply and wastewater management. The target figure of 60 gallons/person/day remained, and the program would start with public education. Daily and weekly newspapers would be provided with advertising identifying devices and encouraging retrofits. Saving future tax dollars and future user fee increases would be emphasized. Public education is a permanent feature of the selected program, along with plumbing code enforcement requiring the use of the latest approved water-conserving devices. The plumbing wholesalers in the State would be consulted and advised of the strong policy shift toward water-conserving devices, since we were all sensitive to the problems of suppliers who may be caught unaware with stocks of unsalable items. If public education and plumbing code enforcement failed after a 4-year period, economic incentives would be implemented in the form of sewer-use fees tied to metered water delivery in winter months. Economic incentives, public education, plumbing code enforcement, and continuous program evaluation by 1990 should provide enough use and flow-reduction experience to evaluate when or if future reserve capacity will be exhausted.

Detailed cost studies and effectiveness evaluation will be necessary if Step II is approved by EPA Region VIII and if the program is deemed appropriate for implementation in view of current administration statements downgrading conservation as a resource management tool. Developing the program in a very fragmented local government framework was a product of hundreds of person-hours contributed by water supply entities, city officials, wastewater management entities, and private citizens.

Today our local officials are confronted with reductions in the budget for construction grants and with a philosophical shift in the administration away from conservation as a resource management tool. At this point in time, abandonment of plans for treatment works and the resulting water pollution problems seem possible.

Separate and apart from our efforts to develop a water conservation/flow reduction program, I believe that the need to develop new supplies and replace systems that have been in place for many years will inevitably confront our local government officials with the need for rate increases in the future. If we are forced to pay the real cost for systems and supplies, a water conservation program will become a reality simply because of our needs to reduce personal expenditures as consumers.

# Summary

## PROGRAM QUALITY AND PARTICIPANT INVOLVEMENT IN NATIONAL WATER CONSERVATION CONFERENCE - PUBLICLY SUPPLIED POTABLE WATER

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### INTRODUCTION

From its inception, the Planning Committee for the National Water Conservation Conference held in Denver, Colorado, was concerned about program quality and participant involvement. These concerns prompted the incorporation of two data-gathering mechanisms designed to assist conference planners in progressing toward these objectives.

The purpose of this paper is to summarize results of data gathering and provide some feedback to participants at the National Water Conservation Conference on three aspects of the conference: who attended the conference; what issues were participants most concerned about; and how well did the conference meet the expectations of the attendees.

### WHO ATTENDED THE CONFERENCE?

A total of 359 persons attended the conference; 294 had preregistered and the remaining 64 registered onsite. Table 1 and Figure 1 present a summary of each conference attendee's affiliation and place of residence, respectively:

Over half (52 percent) of the conference attendees indicated that they worked for some level of government (Federal, State, or local). Private industry representatives accounted for the largest single cohort--25 percent of the total attendance.

Most of the regions of the country were rather evenly represented at the conference (between 8 and 14 percent) with the exception of the Rocky Mountain region (37.5 percent). People from Colorado comprised the majority of attendees from this region of the country. The Pacific Northwest had relatively few representatives. Most of the people from the Pacific Coast were from California.

TABLE 1. Affiliations of Conference Attendees

| Affiliation | No. of Persons | Percentage |
|---|---|---|
| Private industry | 90 | 25% |
| Federal Government | 80 | 22% |
| Local Government | 56 | 16% |
| State Government | 51 | 14% |
| Academia | 23 | 6% |
| Utility | 18 | 5% |
| Association | 16 | 4% |
| Public advisory | 13 | 4% |
| Other | 6 | 2% |
| Unknown | 6 | 2% |
| TOTAL | 359 | 100% |

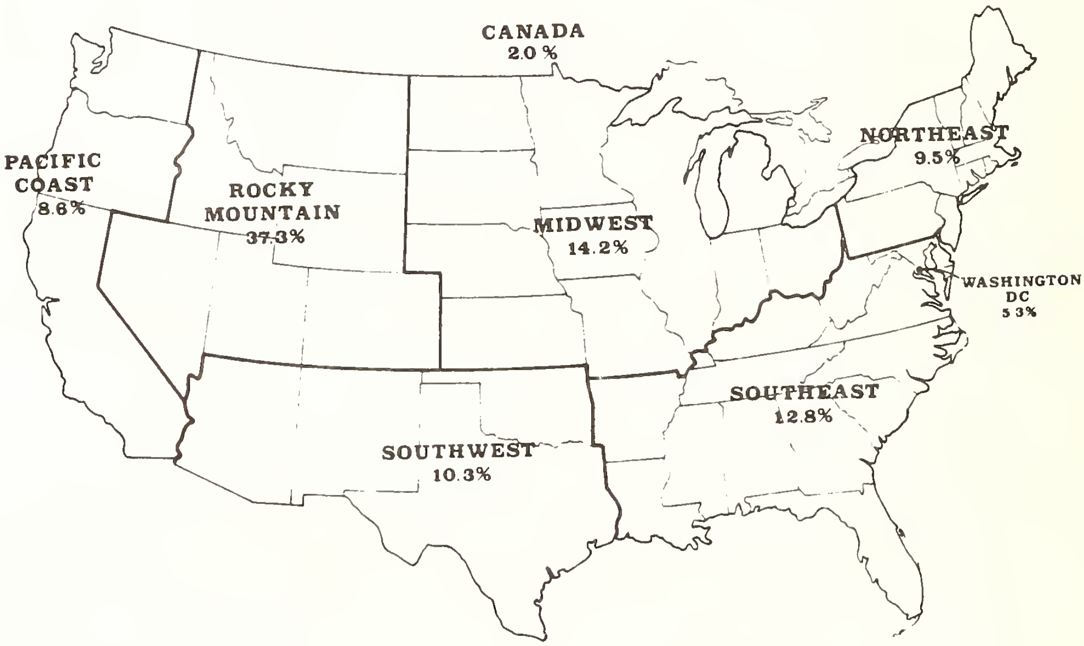


FIGURE 1. Residences of Conference Attendees

TABLE 2

QUESTIONS FROM REGISTRATION QUESTIONNAIRE TO BE DIRECTED TO FEDERAL AND STATE/LOCAL PANELISTS DURING THE INITIAL PORTION OF THE DISCUSSION PERIOD

Generic Questions Recurring Between State and Local Interests

1. How can assistance be obtained?

   -- What kind of technical assistance is needed?
   -- What kind of financial assistance and incentives are needed?
   -- To what level of government should such assistance be directed?

2. What is the effect of conservation on rate structures and outstanding committed financial responsibilities, bonds, construction projects, engineering studies, etc.?

3. How does conservation relate to the need for retrofitting existing, old, and deteriorating water supply and distribution systems?

4. How can Federal programs be adapted to meet local needs?

Generic Questions Recurring Between Federal and State Interests

1. What kind of new legislation and codes might be required?

2. Is a new definition of Federal, State, and local roles required to implement conservation?

3. How can existing water resource projects and water supply facilities be used more effectively?

Generic Questions Recurring Across the Group

1. How do you deal with the need to conserve in conflicting and competing uses such as agriculture, self-supplied industrial, recreation, etc.?

   -- How can and should priorities be set?
   -- What are the effects on waste loads and treatment?

2. Is more centralized authority and direction needed to manage droughts when conservation is a part of supply management?

   -- Where and what is needed?
   -- What functions should be included?

3. What impact will the change of administrations have on water conservation?

## WHAT ISSUES WERE PARTICIPANTS MOST CONCERNED ABOUT?

Participants were asked to fill out a brief questionnaire as they registered for the conference. Forty-two percent (151 of 359) of the attendees completed the form.

A preliminary analysis was conducted prior to the Plenary Session Wednesday morning. The results of the analysis are presented in Table 2 as a generic list. This list asked questions most frequently raised by State and local interests, Federal and State interests, and across all groups attending. These recurring generic questions were used by the moderators for the Plenary Sessions to stimulate initial discussion after the brief presentations by the panelists.

Subsequent to the conference, the questionnaires were analyzed in depth. The discussion that follows includes the most pivotal issues gleaned from the handwritten responses.

The conference attendees perceived a lack of clearly defined roles and/or policies regarding water conservation among all levels of government. In the eyes of some respondents, the Federal role in water conservation seemed nonexistent. They expressed the need for stronger Federal roles--incentives for water conservation relative to demand as well as supply. Two respondents specifically mentioned the need for Federal technical assistance--and there may be a larger latent demand for such assistance based on the nature of some of the narrative responses. The respondents also were concerned about shifts in National Water Policy that might occur under the Reagan Administration. Respondents complained about the lack of Federal commitment to water conservation.

Moving to local level concerns, the respondents wanted to know what policy options were available at the local level that address water conservation problems (e.g., rate structures, plumbing devices, and tax incentives). Particularly, respondents wanted to discuss the rationale and mechanics of various pricing structures that would induce water conservation and what impacts the various options would have on local water supply economy and how to evaluate their effectiveness.

Respondents complained about the need for coordination and the problem of water-use conflicts arising from the interface of municipal/residential with other water uses such as agriculture, industrial, etc. Many of the respondents acknowledged that water conservation was a political problem as well as a technical one that required overcoming entrenched interests and rights in water allocation.

Finally, there were several respondents that were primarily concerned with older city infrastructure decay and the need for Federal assistance for reconstruction.

As part of the preconference questionnaire, attendees were asked to identify what major issues other than publicly supplied potable water they wanted to have addressed at the conference. The responses produced a litany of issues. Agriculture, self-supplied industrial, and instream uses were at the top of the list. These three topics comprised 67 percent of the total response. The tally of responses is shown in Table 3.

## HOW WELL DID THE CONFERENCE MEET THE EXPECTATIONS OF THE ATTENDEES?

On several occasions during the proceedings, attendees were asked to participate in an evaluation of the conference. Approximately 10 percent of those who registered completed the forms. The questionnaire was divided into two parts. The first part broke the conference program into three sections (panel discussion, workshops, case studies). Respondents were asked to indicate whether each particular session "exceeded expectation," was "acceptable," or "did not meet expectations." The focus was on program content and not personalities. The second part of the questionnaire asked five questions that probed the attendees, feelings about issues not covered, adequacy of the program, opportunities of participation, suggestions for future conferences, and overall impression of the conference.

TABLE 3. Issues Attendees Wanted Addressed

| Category | No. of Responses | Percentage |
|---|---|---|
| Agriculture | 17 | 30.9% |
| Self-supplied industrial | 12 | 21.8% |
| Instream uses | 8 | 14.5% |
| Multiple uses | 5 | 9.1% |
| Energy conservation | 3 | 5.4% |
| Methods of analysis | 3 | 5.4% |
| National policy | 2 | 3.6% |
| Reuse | 2 | 3.6% |
| Sewage treatment | 1 | 1.8% |
| Miscellaneous | 2 | 3.6% |
| TOTAL | 55 | 99.7% |

### Evaluation of Panel Discussions and Workshops

The respondents indicated that approximately 75 percent of the panel discussions and workshops met or exceeded their expectations. Of those respondents indicating that the program content did not meet their expectations, dissatisfaction with the content and tenor of Federal positions were most frequently mentioned. The remainder of comments covered a variety of concerns including quality of audiovisual equipment, degree of audience participation, and selection of topics covered in the sessions.

There appeared to be four major issues that were not adequately addressed at the conference:

Implementation--how to do it. Respondents who fell into this category were concerned about the problems of implementing water conservation. What political obstacles might they encounter? People appeared to have a real need to hear about the "war stories" of others who had tried and succeeded or learned from their experiences.

Rehabilitation of infrastructure. There were two positions on this issue. There were those who wanted to know how to eliminate water losses, and there were those who wanted to know how to avoid the problems that have arisen in many older urban water systems.

Economics of water conservation. Not enough attention was paid to this aspect of the problem. However, this may be indicative of the fact that economists, in general, have not paid much attention to water conservation. One person compared the economics of water conservation to the position the economics of energy conservation was in 10 years ago. People also expressed a need for evaluation techniques to measure the efficiency of conservation methods already in place.

Agriculture. It is generally recognized that agriculture is one of the heaviest consumers of water. Respondents were interested in agricultural advances and what "hi-tech" solutions might contribute to solving water supply problems. Also, respondents wanted to know how urban and agricultural sectors could work more cooperatively in the future.

## Program Evaluation

Sixty-eight percent (24 of 35) of the respondents indicated that the conference met or exceeded their expectations. Of those who thought the conference exceeded their expectations (7 of 35), they felt this conference was an improvement over the 1978 conference. They were impressed with the speakers and the substance of the conference (mix of practical applications and theory). Of those who thought the conference did not meet their expectations (6 of 35), they expressed criticism over the lack of audience participation and the fact that there were too many speakers from Washington. Those who indicated a lack of ample opportunity for participant involvement complained about the lack of time for questions and answers. It should be noted, however, that 57 percent (20 of 35) of the respondents indicated that the conference provided ample opportunity for participant involvement.

Sixty-five percent (23 of 35) of the respondents indicated that the conference provided a sufficient cross-section of regional issues and personages. Those who responded in the negative suggested that Washington was overrepresented and that the Southwestern States were underrepresented.

## Suggestions for the Next Water Conservation Conference

Suggestions for the next conference (e.g., new panel discussions, workshops, and case studies) were clustered into three categories:

The integrated view of water conservation problems. The interrelationships of potable water conservation and agriculture industry, mining wildlife, etc., should be more fully considered. Respondents appeared to be concerned about shifts in the interface among the various sectors of water use that would occur as various water conservation techniques were put into place.

More opportunities for interaction on specific problems. The concern over lack of opportunity to interact with speakers and panelists appeared widespread. Although audience participation was considered satisfactory for the format of program chosen for this conference, several respondents asked for a change in the structure of the conference to permit more interaction (e.g., roundtable discussions, poster sessions, and smaller audiences).

Expand discussion of new technological solution. Respondents were interested in "technological breakthroughs" that might have an influence on future water supply management. People were also interested in grand schemes that may help eleviate water supply problems (e.g., recycling, desalination, and interbasin transfers).

## CONCLUSION

The Conference Planning Committee appreciated the time and effort taken by attendees to voice their opinions on various water conservation issues. The results of these data-gathering activities will provide valuable input for future endeavors of a similar nature.

Publicly Supplied Potable
water conservation '81
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This "Proceedings" is a complete compilation of the papers presented April 14 and 15, 1981, at the National Water Conservation Conference - Publicly Supplied Potable Water in Denver, CO. The Conference was primarily directed toward elected and administrative officials of local governments, the individuals who are responsible in some part for the quantity and quality of water available to their communities.

Techniques for, and analysis of, potable water conservation and wastewater flow reduction were presented. The topics addressed included:

- Water-Saving Technology: Plumbing fixtures, testing and performance of low-flow devices, leak detection and repair, potential problems in wastewater flow reduction, and landscaping with native vegetation
- Public Education and Motivation
- Economics: Water pricing systems, analysis of cost/benefits, and development and management of data
- Planning: State and local urban planning efforts for conservation, and Federal programs and incentives
- Case Studies: From California, Washington, Utah, Arizona, North Carolina, Maryland, New Jersey, and Massachusetts


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