# Contents

List of Figures, v  
List of Tables, vii  
Preface, ix  
Acknowledgments, xi  

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Definitions</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>History</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Potential Drivers for Dual Distribution Systems</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Potential Uses for Reclaimed Water</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Nonpotable-Water Reuse Legislation</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>About This Manual</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>9</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Water Reuse Regulations and Guidelines</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Existing State Regulations</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Treatment, Quality, and Monitoring Equipment</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>35</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Planning</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>General Planning Concepts</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Reclaimed-Water Supply</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Reclaimed-Water System Types</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Development of Distribution System Options</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Existing Utility Coordination</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Conclusions</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>56</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Engineering Design—Treatment</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Source Water</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Supply Type and Treatment</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Availability</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Supply Variations</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Treatment Requirements for Reclaimed Water</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Monitoring Needs and Requirements</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Types of Reclamation Plants</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>68</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Engineering Design—Distribution</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Demand Management</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>System Hydraulic Modeling</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Design Components</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Safeguards</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>85</td>
</tr>
</tbody>
</table>
Chapter 6  Management. ................................................................. 87
   Introduction, 87
   Management Philosophy, 88
   Protecting Public Health, 89
   System Policies and Procedures, 91
   Developing the Nonpotable Infrastructure, 95
   Understanding Customer Needs and Requirements, 98
   Establishing a Viable Customer Base, 101
   Service Connections, 102
   Permits/Service Agreement, 103
   System Operations and Maintenance, 103
   References, 105

Chapter 7  Financial/Economic Issues. ........................................ 107
   Overview, 107
   Making the Business Case, 108
   Institutional Issues, 115
   References, 116

Appendix A  2012 Guidelines for Water Reuse ............................. 117

Index ................................................................. 139

List of AWWA Manuals .............................................................. 145
Figures

1-1  Crop irrigation with reclaimed water, 3
1-2  Irrigation with reclaimed water at a North Carolina golf course, 6
1-3  Firefighter using reclaimed water, 6

3-1  Typical survey form to ascertain interest in water reuse, 39
3-2  Centralized reclamation facility, 41
3-3  Decentralized (satellite) reclamation facility, 41
3-4  Indirect potable reuse, 42
3-5  Direct potable reuse, 43
3-6  Dual distribution system for a new community, 52

4-1  Potable- and nonpotable-water use—monthly historic demand variation, St. Petersburg, Fla., 62
4-2  Key elements of the technical components of a potable reuse program, 65
4-3  Three typical advanced water treatment trains for the production of advanced treated water: (a) treatment train employing MF, RO, and advanced oxidation, and an engineered storage buffer with free chlorine; (b) treatment train employing ozone with BAF, MF, RO, and advanced oxidation; and (c) treatment train employing ozone with BAF, UF, advanced oxidation, and an engineered storage buffer with free chlorine., 66

5-1  Purple pipes for reclaimed-water distribution system, 72
5-2  Line tap into reclaimed-water line, 72
5-3  Reclaimed-water meter box, 73
5-4  Reclaimed-water valve box, 73
5-5  St. Petersburg, Fla., reclamation facility with onsite storage, 77
5-6  Backflow-prevention device between reclaimed water and alternative source of nonpotable water, 80
5-7  Neighborhood sign noting use of reclaimed water, 80
5-8  Notice of use of reclaimed water, 81
5-9  Typical urban utility pipe separations, 82

6-1  Cemetery watered with reclaimed water, 99
6-2  Baseball field maintained with reclaimed water, 100
6-3  Xeriscape watered with reclaimed water, 100

7-1  Reclaimed-water marketing mix, 110
7-2  Creating a reclaimed-water market, 111
Tables

2-1 Uses of reclaimed water, 13
2-2 Summary of state reuse regulations and guidelines for reuse applications, 14
2-3 Number of states with regulations or guidelines for each type of nonpotable-water reuse, 17
2-4 USEPA suggested guidelines for nonpotable reuse of municipal wastewater, 27
3-1 Urban water demand categories, 46
3-2 Expected per capita indoor water use with conservation efforts, 47
3-3 Expected California indoor water use with 25% supply reduction, 47
4-1 Advanced water treatment processes commonly used in potable reuse, 65
5-1 Utility separation regulations and standards from various states, 83
6-1 Attributes and management requirements for typical reclaimed-water applications, 88
6-2 Guidelines for workers’ safety, 104
This publication is the third revision of the original AWWA Manual M24, *Dual Water Systems*, published in 1983. In the second revision, the title was changed to *Planning for the Distribution of Reclaimed Water* to better represent the content of the manual. This fourth edition builds upon that wholesale change in the manual and provides updates and additional information on the planning and design of dual distribution systems for appropriately treated reclaimed water (nonpotable water) for applications that do not require potable-quality water.

The distribution of reclaimed water using dual water distribution systems—one for potable water and the other for nonpotable water—is now a widely accepted practice. The drivers for the increasing use of reclaimed water are diminishing supplies of high-quality water resources, escalating costs for developing new sources or for treating poor-quality water to potable-water standards, and the increasing costs associated with discharging wastewater to the environment.

When faced with the task of developing additional water sources, utility managers and design engineers are increasingly evaluating the potential for distributing reclaimed water to serve their community’s needs. Properly treated and distributed nonpotable water, as defined herein, can safely be used for irrigation, industrial applications, and a wide range of other nonpotable urban purposes, including toilet flushing in high-rise commercial and residential buildings. Developing a reclaimed-water distribution system may be less costly and less wasteful than existing practices that use potable water for purposes that do not require such high-quality water. In recent years, there has been a growing interest in smaller dual distribution systems using reclaimed water from distributed water-reclamation facilities within a utility’s service area. This concept is introduced in this manual.

National standards for the distribution and use of nonpotable water have not been established; however, the US Environmental Protection Agency (USEPA) updated its Guidelines for Water Reuse in 2012. As of 2018, 22 states have regulated standards for the distribution and use of nonpotable water, and 25 other states have some form of regulation (9) or guidelines (16) related to the production of reclaimed water. The AWWA Water Reuse Committee, which prepared this manual, provides the information in this manual for water systems wishing to distribute reclaimed water. Water utilities should consult state and local regulatory agencies before designing a nonpotable-water distribution system, as state and local regulations may impose requirements that differ from the recommendations in this manual.
Acknowledgments

This fourth edition of the AWWA Manual M24, *Planning for the Distribution of Reclaimed Water*, was prepared by members of the Water Reuse Committee of the AWWA Water Resources Sustainability Division. Alan Rimer of EnviroTechNovations LLC (retired from Black & Veatch) served as Chair. There were many contributors to this manual. Some wrote full sections, while others contributed extensively by providing materials for the manual and/or through their thorough review of the document. The Chair and AWWA Staff are very grateful for all of the effort that went into the creation of this fourth edition.

Specifically, the following were primarily responsible for various chapters of the manual:

- **Chapter 1 Introduction** – Dr. Alan Rimer, EnviroTechNovations LLC (Black & Veatch Retired), Chapel Hill, N.C.
- **Chapter 2 Water Reuse Regulations and Guidelines** – Craig Riley, Washington State Gov. (retired), Spokane Valley, Wash.
- **Chapter 3 Planning** – Don Vandertulip, Vandertulip WateReusEngineers, San Antonio, Tex.
- **Chapter 4 Engineering Design—Treatment** – Dr. Erin Mackey, Brown & Caldwell, Walnut Creek, Calif.
- **Chapter 5 Engineering Design—Distribution** – Sumon Ghosh, Canada, & Dr. Alan Rimer
- **Chapter 6 Management** – Ane Deister, Shingle Springs, Calif.
- **Chapter 7 Financial/Economic Issues** – Jerry Brown, Contra Costa Water District, Concord, Calif.

David Ammerman, Thomas Bell-Games, Jim Crook, Venkatraman Radhakrishnan, and Peter Rogers provided information and/or editorial guidance on the final document. Many members of the AWWA Water Reuse Committee provided input to the manual along the way.

AWWA staff were most helpful. Sue Weikel took up the project midway through the effort and was instrumental in moving this publication along. Alex Gerling provided technical editorial guidance.
Introduction

Since 1983, when the first edition of this American Water Works Association (AWWA) manual was published, many water and wastewater utilities, communities, authorities, states, and countries have implemented dual water distribution systems, particularly in light of the increased emphasis on higher degrees of wastewater treatment. These water-reclamation facilities can significantly increase the availability of reclaimed water for use as described in this manual. They provide reclaimed wastewater to a variety of customers, making the most of all their available water resources. The International Water Association in London lists, in addition to the United States, Australia, and the United Kingdom, 13 other countries that have strong programs in dual water distribution and water reclamation. Assessing the growth of water reclamation and the adoption of dual water distribution systems for communities large and small has been a difficult task as their growth seems to be almost exponential. What is appreciated worldwide is that wastewater reclamation and dual water distribution systems are an important consideration for communities as they search to expand their water supply resource(s).

This manual discusses the planning, design, construction, operation, regulatory framework, and management of community dual water distribution systems, which consist of separate systems for distributing potable water and nonpotable water principally drawn from reclaimed wastewater specifically for use in such dual distribution systems. Increasingly, there is the potential for potable reuse, which is discussed in various locations throughout this manual. Reclaimed water treated to potable-water standards is not distributed in a dual distribution system.

DEFINITIONS

- **Advanced water purification facility (AWPF):** A water purification facility that through a series of unit operations produces a purified potable-water source suitable for use as a potable-water supply from the supply water from a water resource recovery facility (WRRF), a raw water supply, or a combination of both.
• **Dual distribution systems:** Two separate water distribution systems conveying water to customers, one carrying potable water and the other conveying lesser-quality water (e.g., nonpotable reclaimed water) for reuse purposes.

• **Direct potable reuse:** The supply of advanced purified reclaimed water directly into potable-water supply lines, potable-water treatment plants, and/or drinking water transmission or distribution systems.

• **Indirect potable reuse:** Includes augmenting raw potable-water supplies with advanced purified water indirectly through storage and transmission through an environmental buffer.

• **Nonpotable water:** Water that is considered unsafe, unpalatable, or both for drinking. Other sources of nonpotable water may include brackish or mineralized surface waters and groundwaters, including seawater, certain industrial wastewaters, fracking wastewaters, stormwater runoff, polluted natural waters, and irrigation return flows.

• **Potable water:** Water that is safe and satisfactory for drinking and cooking.

• **Reclaimed water:** Treated domestic wastewater (among other sources) that is used for a variety of purposes before it passes back into the water cycle. Reclaimed water may also be referred to as recycled water.

• **Water resource recovery facility (WRRF):** A wastewater treatment facility employing primary, secondary, and tertiary treatment for the production of reclaimed water or as a supply water for an AWPF (see below).

**HISTORY**

The concept of dual systems is not new, having been adopted by Augustus about 2,000 years ago. Water from one of the hills near Rome was found to be highly poisonous, but it was still used to feed the many fountains of Rome and for many other nonpotable uses. In 1911, W.T. Sedgwick of the Massachusetts Institute of Technology read a paper to the New England Water Works Association titled “Has the Time Come for Double Municipal Water Supplies, One—Naturally Pure—for Drinking and Cooking, the Other—Denatured or Sterilized—for All Other Purposes?” (Sedgwick and Letton 1911). This was the advent of the period when dual distribution was at least recognized in the United States.

The basis of the adoption of water reclamation and dual distribution systems stands on a firm foundation dating back to the late 1950s. The policy affirming this approach was enunciated by the United Nations Economic and Social Council, which stated, “No higher quality water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade” (United Nations Economic and Social Council 1958). For public drinking supplies, it is AWWA’s policy that the highest quality sources be used (Drinking Water Quality Policy Statement adopted by the AWWA Board of Directors Jan. 24, 1988, and revised Jan. 29, 1989; Jan. 23, 2000; June 15, 2003; Jan. 21, 2007; June 9, 2013; and Jan. 14, 2017).

With population growth and urban and industrial development throughout the world and with most high-quality sources of substantial yield already developed, surpluses of high-quality water for the future are being exhausted. Using wastewater treatment plant effluent for industrial, urban, or agricultural irrigation purposes is one way a nonpotable supply can lessen the demand on potable water. An example is the introduction of wastewater treatment plant effluent for use in the steel industry in Baltimore, Md., over a century ago (Okun 1973). Another example is the distribution of reclaimed wastewater to several industries in Colorado Springs, Colo., in 1960 to relieve the demand on limited freshwater resources.
Substitution of lower-quality water for nonpotable purposes to preserve limited resources of high-quality water remains one of the primary purposes of dual distribution systems. For example, seawater has been used extensively for decades for toilet flushing in commercial and multifamily residential buildings in Hong Kong to preserve limited freshwater resources.

The first dual distribution system illustrating the potential for the future was built in 1926 for the Grand Canyon Village in Arizona, which is on the south rim of the Grand Canyon and had become a fast-growing community with the El Tovar Hotel at its center. The village had virtually no rainfall, and water had to be carried by train and other vehicles as other sources such as groundwater were not available. In 1926, a source of fresh water was found north of the Colorado River, which was pumped to the village to serve the hotel and other facilities. When it was recognized that the resulting treated wastewater produced in the village might be applied usefully, these treated wastewaters were circulated in a dual distribution system, thus originating the first purposeful water-reclamation system and dual distribution system in the United States.

In the 1950s, at meetings of the National Research Council’s committee on sanitary engineering and the environment, Gordon M. Fair of Harvard suggested dual water supplies. In 1965, Paul Haney enhanced the idea in the first published article on dual systems. These were the two most widely circulated publications encouraging the construction of dual systems at the time.

Two factors have accelerated the development of dual distribution systems. First is the need for water supplies that do not necessarily need to be of potable quality for urban and industrial use. Second are new requirements for costly, advanced wastewater treatment, including nutrient and organics removal, to protect receiving waters. Using reclaimed water for nonpotable purposes may reduce treatment costs when nutrient removal is not only unnecessary but wasteful. This is the case for urban and agricultural irrigation because nutrients already in the wastewater can replace those that would ordinarily need to be added (Figure 1-1). An extensive distribution system for urban irrigation, including the watering of parks, campuses, median strips, and residential lawns, is an important element of a reclaimed-water system used for other nonpotable purposes.

![Figure 1-1 Crop irrigation with reclaimed water](image)
POTENTIAL DRIVERS FOR DUAL DISTRIBUTION SYSTEMS

With numerous successful dual water distribution systems now in operation, ranging from systems that serve only one or two major customers to systems that serve almost all properties in a community, water supply professionals are now considering dual distribution systems for addressing water supply needs, water pollution-control problems, or both. Reclaimed water is the “new” water resource. There are many drivers that a community will consider when developing a plan for assessing the feasibility of dual distribution. Such drivers range from conservation to limited water resources.

Conservation

Before any concerted effort is made to find additional water resources for a community or to build costly dual distribution systems, water conservation is the utility’s first approach to reduce water consumption. Wasteful water practices, such as the use of older high-volume flush toilets, inefficient local landscaping practices, and water rates that encourage high water consumption, must be carefully examined by the utility and its customers. As might be expected, communities have had varying degrees of success in reducing water consumption through conservation practices. AWWA has a manual on conservation strategies entitled M52, Water Conservation Programs – A Planning Manual, the second edition of which was published in 2017.

Limited Water Resources

Competition for existing water resources or limitations on these resources often make acquisition or expansion of additional water resources politically and financially difficult. For example, obtaining additional water resources might require interbasin (raw water) transfer, which is currently less politically acceptable than it was in the earlier years of water resources development. The specter of climate change and its potential implications for urban water utilities has added to this mix of uncertainty. Consideration must also be given to downstream users impacted by water rights issues and stream flows where applicable. Greater knowledge of groundwater hydrology has illuminated the concerns associated with excessive withdrawals from aquifers, which result in increasing costs of pumping, impaired water quality, and land subsidence. Limited new water resources create a situation in which water reclamation and a dual distribution system may become attractive.

Limited Water Supplies

When demand is expected to exceed the yield from existing water supply facilities and additional facilities need to be constructed, the gradual introduction of a nonpotable system might be appropriate. Water users, whether industrial, commercial, or municipal, may well be served with reclaimed wastewater in place of potable water at a cost that is generally lower than the cost of developing new high-quality sources of supply for potable purposes.

Polluted Sources

The 1962 US Public Health Service Drinking Water Standards recommended that “water supply should be obtained from the most desirable source which is feasible” (USPHS 1962). US Environmental Protection Agency (USEPA) National Interim Primary Drinking Water Regulations adopted in 1974 state that “priority should be given to the selection of the purest source.” Many communities have selected the highest-quality source...
available, and additional development may require use of a lesser-quality source. In the past, engineers believed that they could render most polluted water safe for potable supply through adequate treatment, generally consisting of coagulation, filtration, and disinfection. However, the chemical revolution following World War II resulted in the creation of thousands of synthetic organic chemicals that are not readily degraded in the environment or easily treated. The number of contaminants regulated in potable water has grown from four in 1925 to 103 primary and secondary contaminants in 2009 (the latest listing), with more regulations anticipated (USEPA 2009, Calabrese 1989). The treatment of water that will meet drinking water standards in the future may cost considerably more than it currently does. Degraded sources may therefore be less suitable for potable-water supplies but well-suited for one or more nonpotable purposes.

Rigorous Wastewater Treatment

To restore and preserve the quality of North American waters, treatment requirements for municipal and industrial wastewaters have become increasingly stringent and costlier. Treatment processes also have become increasingly more complicated, with nutrient removal almost always required for the major utilities that are most likely to adopt water reuse. Various treatment options can be employed to achieve a quality of reclaimed water that can be used in a dual distribution system. For example, filtration is generally employed in modern reclaimed-water facilities. The operation and maintenance of advanced physical and chemical wastewater treatment facilities are generally costlier than treatment for nonpotable reuse. If wastewater can be used productively, the savings in wastewater treatment can be passed on to users, making water reclamation and dual distribution systems more economically attractive.

POTENTIAL USES FOR RECLAIMED WATER

A dual distribution system is most appropriate when the nonpotable water can be used in a community. Examples include the following, which require varying levels of treatment.

Public uses:
- Park irrigation
- School campus landscaping and playground irrigation, median strips, and roadway right-of-way landscaping irrigation
- Recreational facilities, such as golf course irrigation (Figure 1-2) and tennis court wetting and washing
- Aesthetic impoundments (fountains, water features, etc.)
- Cemeteries and plant nurseries
- Firefighting (Figure 1-3)
- Toilet and urinal flushing

Industrial and commercial uses:
- Cooling-tower makeup water
- Boiler feedwater makeup water
- Stack gas scrubbers
- Process waters
- Construction, including concrete manufacture, soil compaction, and dust control
- Toilet and urinal flushing
- Cleaning and car washing
Agricultural uses:
- Restricted-access area irrigation
- Processed food crops
- Non-food crops
- Groundwater recharge with restrictions
- Sod farms
- Silviculture

Residential uses:
- Lawn watering
- Toilet flushing (in many states)

NONPOTABLE-WATER REUSE LEGISLATION

In some states, such as California, Florida, Arizona, and North Carolina, nonpotable-water reuse is prompted through legislation. The following paragraphs provide an introduction to the history of such legislation.

California

California has long recognized the benefits associated with reclaimed-water reuse. The state legislature declared that a substantial portion of future water requirements can be met economically through the beneficial use of reclaimed water. The legislature intends for the state to take all possible steps to encourage development of water-reclamation facilities so that reclaimed water may be made available to help meet California’s growing water requirements. Statutes added since 1973 prohibit the use of water from any suitable potable-water source for the irrigation of greenbelt areas, including golf courses, cemeteries, parks, and highway landscaped areas, when suitable reclaimed water is available. Additional uses have been added through subsequent legislation. Reclaimed water is considered suitable under the following conditions:
- The reclaimed-water source is of adequate quality for such use and is available;
- The reclaimed water can be provided to such greenbelt areas at a reasonable cost;
• Reclaimed-water use will not be detrimental to public health;
• Reclaimed-water use will not affect downstream water rights, will not degrade water quality, and is determined not to be injurious to plant life.

During the last 30 years, wastewater reclamation has been encouraged further by the Office of Water Recycling (OWR), a division of the California State Water Resources Control Board. OWR promotes treated wastewater reuse, identifies potential projects, and provides financial assistance with water reuse projects (California State Water Resources Control Board 1985). The growth of the use of reclaimed water has been fostered through a variety of legislative actions and rulemaking by OWR and other agencies.

Florida
Although rainfall averages approximately 59 in. (150 cm) per year in Florida, potable-water resources are limited. The Florida Department of Environmental Regulation has declared as policy that the state will “advocate and direct the reuse of reclaimed water as an integral part of water management programs...consistent with protection of the public health and groundwater quality” and “encourage the use of water of the lowest acceptable quality for the purpose intended” (Florida State Legislature 1988). This policy is expressed in the rules of the Southwest Florida Water Management District that state, “before a consumptive use permit (for water abstraction) is issued, consideration will be given to the lowest quality water which the applicant can use, (and if) such water is available, the consumptive use permit will be issued only for the use of the lower quality water” (Southwest Florida Water Management District 1985). More recently, the State of Florida passed a bill requiring a reevaluation of the discharge of wastewater into the ocean (State of Florida 2008). This law has significantly expanded the number of water-reclamation facilities and in turn dual distribution systems for conveying the available reclaimed water to an expanding customer base.

Arizona
Groundwater overdraft has lowered water levels by as much as 400 ft (122 m), resulting in increased pumping costs, degraded water quality, and land subsidence. The use of reclaimed water in Arizona is encouraged through several state laws that resulted from various historical events. In 1948, the US Secretary of the Interior advised Arizona that a comprehensive state groundwater management code was a prerequisite to federal authorization of the Central Arizona Project (a massive US Bureau of Reclamation project to bring Colorado River water to central Arizona irrigation districts and municipalities). In 1990, the legislature adopted the Groundwater Management Act (Arizona Administrative Code 1990a), which identified areas requiring implementation of specific water conservation programs to balance groundwater withdrawal and demand by 2025. Other legislative initiatives have resulted in stringent conservation, particularly of groundwater resources.

Critical in achieving the state’s water conservation goals is the reclamation of municipal wastewater. In response to mandated municipality-specific, per capita water-use targets based on a phased conservation program, some Arizona cities have developed dual water distribution systems. Filtered and disinfected reclaimed water is purchased in some areas at rates equal to that for potable water. Some cities require the use of reclaimed water on all new golf courses and parks and are considering mandatory retrofit for these irrigation uses.

The Arizona Department of Water Resources has provided further incentives for water reclamation by not including reclaimed water in calculating the average per capita municipal demand. Recent legislation authorizing underground storage and recovery provides a mechanism for subsurface storage to accommodate seasonal demands for
irrigation water typical of the arid Southwest (Arizona Administrative Codes 1990b, 1990c). Legal disputes over the identity and ownership of reclaimed water and water quality considerations for uses other than landscape irrigation remain to be resolved.

North Carolina
North Carolina, like Florida, has a reasonable amount of yearly rainfall, amounting to more than 40 in. on average across the state. Over the past decade, the state has experienced significant extremes in weather, ranging from serious hurricanes that have reached as far inland as the middle of the state (Charlotte) to three exceptional droughts. Further exacerbating water resource issues in the state is that the major metropolitan areas of the state (with the exception of Charlotte) are all located at the top of three major river drainage basins. (These rivers feed the second- and third-largest estuaries in the United States.) For the most part, all available water resource sites are fully developed and interbasin transfer is not permitted, so reclaimed water becomes a more serious planning consideration for all communities.

To address this issue, before any community can obtain a permit to upgrade either a water plant or a wastewater plant or build a new facility, a study must be done to assess the feasibility of developing reclaimed water. This is an important administrative step that ensures that water reuse will be taken seriously as a water resource.

ABOUT THIS MANUAL
The remainder of this manual is divided into six chapters to highlight different aspects of water reclamation and the development of dual distribution systems.

Chapter 2, Water Reuse Regulations and Guidelines, looks at existing state regulations and guidelines with particular emphasis on treatment, reclaimed-water quality, and monitoring strategies to ensure high-quality reclaimed water.

Chapter 3, Planning, focuses on the planning concepts for the development of reclaimed-water and dual distribution systems. This covers not only the various sources of reclaimed water but also the various distribution system options and the coordination among utilities providing the source water and the distribution.

Chapter 4, Engineering Design—Treatment, examines all aspects of the issues associated with the design of treatment systems from source reliability to appropriate treatment technologies that may be employed to create reclaimed water for specific uses. Monitoring needs to ensure that the reclaimed water meets treatment objectives is also discussed.

Chapter 5, Engineering Design—Distribution, looks at the variety of design challenges associated with dual distribution systems, including demand management, hydraulic modeling, system components, storage, and safeguards.

Chapter 6, Management, highlights at least eight areas of management issues, ranging from general management philosophies and the protection of public health to understanding the customer base (marketing) and how to manage customer needs.

Chapter 7, Financial/Economic Issues, provides an overview of the issues associated with the economics of dual distribution, including an overall procedure for evaluating and proving the business case for the development of reclaimed water and its associated dual distribution system.
REFERENCES


