Bulletin 910

Water Systems for Small Communities

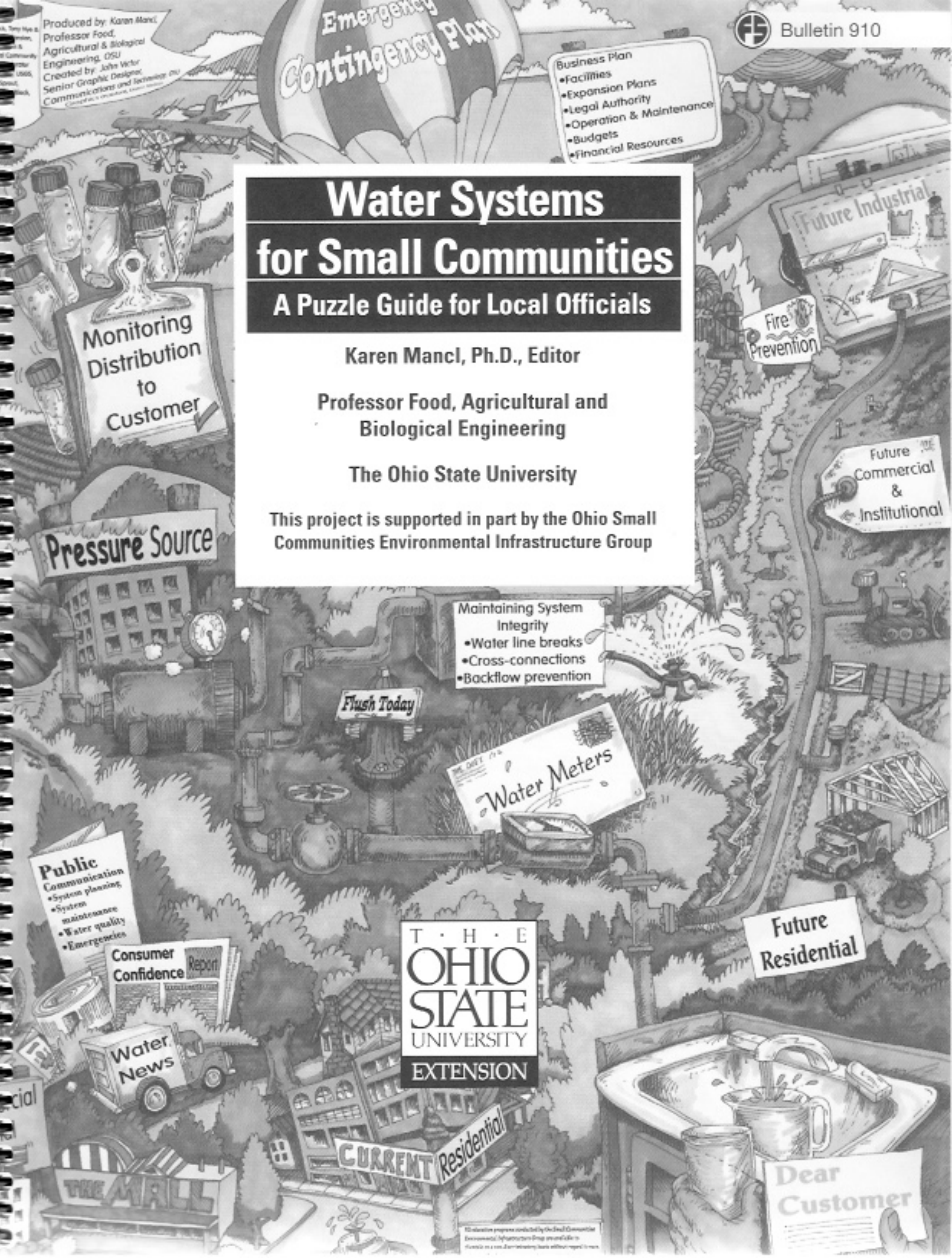
A Puzzle Guide for Local Officials

Karen Mancl, Ph.D., Editor

Professor Food, Agricultural and Biological Engineering

The Ohio State University

This project is supported in part by the Ohio Small Communities Environmental Infrastructure Group



THE OHIO STATE UNIVERSITY EXTENSION

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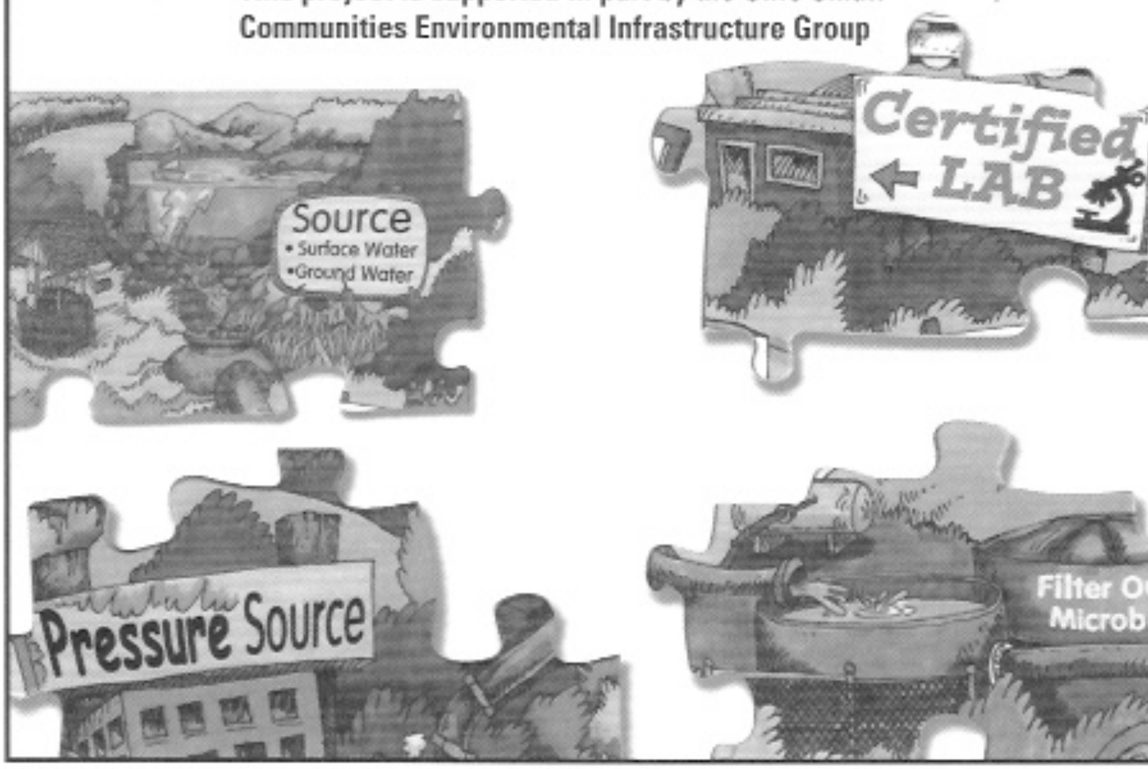

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Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension

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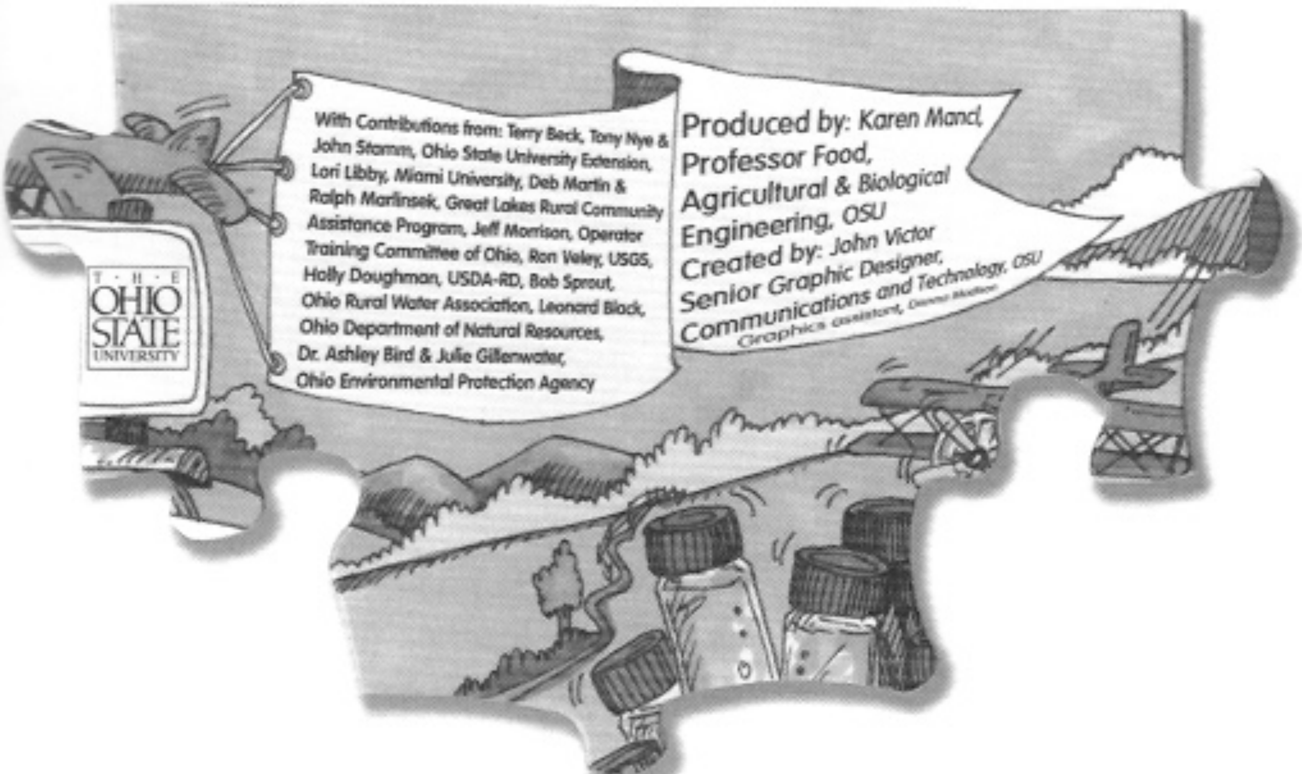
1/04—3M—207160

#1 The Role of Local Officials in Providing Safe Drinking Water

Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University
Terry Beck, Wayne County Extension Agent, Ohio State University Extension
Ron Veley, U.S. Geological Survey



Before exploring the components of a water system, discuss in small groups the following questions about the expectations for water systems in small communities.

Imagine traveling outside the United States.

In what parts of the world would you feel free to drink the water?

- Everywhere in the world
- Only certain areas of the world
- Nowhere outside the United States
- Only certain parts of the United States
- Nowhere

Where in the world can you always turn on the faucet and have enough water to wash clothes or take a shower?

- Everywhere in the world
- Only certain areas
- Nowhere outside the United States

In your community, what do people expect from their water supply?

Do they expect their water will always be safe to drink?

- Don't know
- Yes
- No

Do they expect to always have enough water to meet their needs?

- Don't know
- Yes
- No

Do they expect their water to be pleasant to use?

- Yes
- No, they expect their water will be hard
- No, they expect their water will have iron in it
- No, they expect their water will sometimes have a bad smell
- No, they expect their water will corrode their household plumbing

Who should be able to supply water in your community? (Rank in order of importance)

____Private wells are able to provide enough water of acceptable quality

____Whoever can provide the community water at the lowest price

____Whoever can develop an adequate and protected source of water for the community

____Whoever can be counted on to make sure the water in the community is safe to use

____Whoever can be relied on to provide adequate water supplies to support community development.

____The community must maintain control of water supply to control its economic destiny.

Safe Drinking Water

In a small town who is responsible for providing safe water?

Individual wells are private. The water supply quality, protection, and reliability are the responsibility of the land owner.

When a water system supplies 25 or more people or to 15 or more service connections (such as homes, schools, or businesses), the system becomes a community water system and the responsibility of the community or other owner. Community water providers have several important responsibilities. They must:

- Provide safe water
- Provide reliable water service
- Guard the public health and safety
- Protect the water source
- Comply with state and federal regulations
- Manage the system, finances, and personnel
- Ensure the training and safety of the system operator

What is the responsibility of local elected officials in providing safe water?

If water is provided as a part of a municipal utility

—Local officials become water providers.

If a private provider is supplying water in the community

—Local officials enter into contracts and provide oversight for water service in representing the interests of the community.

#2 Water Systems for Small Communities

Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University
Lori Libby, Center for Public Management and Regional Affairs, Miami University

Providing safe, reliable drinking water in a community is an involved process. Many elements must come together to ensure that a community has the capacity to develop and sustain a water system.

The big picture is sometimes overwhelming to local leaders as they work to make the right decisions for their community. In this program, the important components of a water system have been laid out as the pieces of a puzzle. They indeed fit together to serve the customers. If a piece is missing, the customer immediately or eventually suffers.

The puzzle and workbook were developed by a team of water supply, community service, and educational professionals from the Ohio Small Communities Environmental Infrastructure Group. The puzzle and workbook serve as one guide through a small community water system.

Puzzle—Small Community Water System

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Workbook—Small Community Water System

Produced by: Karen Mancl, The Ohio State University

#1 The Role of Local Officials in Providing Safe Drinking Water

Terry Beck, OSU Extension

Ron Veley, U.S. Geological Survey

#2 Water Systems for Small Communities

Lori Libby, Miami University

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Tony Nye, OSU Extension

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Lenn Black, Ohio Department of Natural Resources

#5 Current Commercial and Institutional Water Use

Lenn Black, Ohio Department of Natural Resources

#6 Current Industrial Water Use

Lenn Black, Ohio Department of Natural Resources

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Lenn Black, Ohio Department of Natural Resources

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Ron Veley, U.S. Geological Survey

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Karen Mancl, The Ohio State University

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Karen Mancl, The Ohio State University

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Ashley Bird, Ohio Environmental Protection Agency

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Ashley Bird, Ohio Environmental Protection Agency

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Ashley Bird, Ohio Environmental Protection Agency

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Jeff Crisler, Ohio Environmental Protection Agency

#22 Monitoring Drinking Water Sources

Jeff Morrison, Operator Training Committee of Ohio

#23 Monitoring Drinking Water for Contaminants

Todd Kelleher, Ohio Environmental Protection Agency

Ashley Bird, Ohio Environmental Protection Agency

#24 Monitoring Water Distribution Systems

Jeff Crisler, Ohio Environmental Protection Agency

#25 Water Testing Laboratories

Todd Kelleher, Ohio Environmental Protection Agency

#26 Water System Monitoring Recording and Reporting

Todd Kelleher, Ohio Environmental Protection Agency

#27 Water System Operation and Maintenance

Julie Gillenwater, Ohio Environmental Protection Agency

#28 Certified Water System Operators

Julie Gillenwater, Ohio Environmental Protection Agency

#29 Water System Management

Karen Mancl, The Ohio State University

#30 Personnel Management

Julie Gillenwater, Ohio Environmental Protection Agency

Lori Libby, Miami University

#31 Training for Water System Personnel

Jeff Morrison, Operator Training Committee of Ohio

#32 Water System Owner, Authority or Board

Lori Libby, Miami University

#33 Business Plan or Capacity Assurance Plan

Joni Molter, U.S. Department of Agriculture Rural Development

Holly Doughman, U.S. Department of Agriculture Rural Development

#34 Water System Emergency Contingency Plan

Jeff Morrison, Operator Training Committee of Ohio

#35 Financial Management of Community Water Systems

John Stamm, OSU Extension

Holly Doughman, U.S. Department of Agriculture Rural Development

Lori Libby, Miami University

#36 Technical Assistance for Water Systems

Joyce Gray, Great Lakes Rural Community Assistance Program

#37 Public Communication

Tony Nye, OSU Extension

Lori Libby, Miami University

Holly Doughman, U.S. Department of Agriculture Rural Development

Small Communities Environmental Infrastructure Group

The Small Communities Environmental Infrastructure Group was formed in Ohio in 1990 by state, federal, local, educational, and service agencies that provide educational, technical, and financial assistance for environmental infrastructure projects. These agencies saw a need to coordinate efforts to assist small governments with the difficult task of developing, improving, and maintaining water and wastewater systems.

The goal of the group is to assist small communities in identifying the most appropriate resources to help the communities resolve problems associated with environmental infrastructure. To this end the group has established three committees.

- **Financing committee**—coordinates financial resources administered by state and federal agencies by compiling a financing directory and by holding bimonthly (the second Friday of even months) financing coordinating meetings with communities seeking assistance. The committee evaluates, makes recommendations, and continues to work with communities to obtain whatever financial assistance is available.
- **Curriculum committee**—offers workshops for local officials on water and wastewater systems. For information on workshops and other water and wastewater publications, check the website, *www.ag.ohio-state.edu/~setll.*
- **Technology transfer committee**—develops resources for technical consultants and regulators on underutilized technologies appropriate for Ohio's small communities. The committee established a resource library house at the Operator Training Committee of Ohio offices at 3972 Indianola Avenue, Columbus, Ohio. Members of the committee have also collaborated on writing and publishing new manuals on wastewater treatment technology.

#3 Water System Customers

Tony Nye, County Extension Agent, Ohio State University Extension
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University

Water that is safe to drink and pleasant to use is the expectation of people living and traveling in the United States. Whether in a small town, a big city, or even a rural restaurant, people drink the water worry free.

Safe to Drink

Water systems are expected to deliver water to their customers that is safe to drink. Drinking water should not cause disease or result in acute or chronic toxicity. To ensure safe drinking water, the U.S. Congress directed the U.S. Environmental Protection Agency to establish maximum contaminant levels called primary drinking water standards. These maximum contaminant levels establish a "ceiling" that all water systems must meet and strive to always stay below. The purpose of the primary drinking water standards are to protect the public health.

Primary drinking water standards fall into five categories.

1. Pathogens cause disease. Bacteria, viruses, and parasites are tested for and controlled throughout a water system. Cloudy water, measured as turbidity, can contain bacteria. Therefore, the turbidity of drinking water must be monitored and reduced to minimize the threat of waterborne disease.
2. Some minerals and metals can be toxic at high enough levels in drinking water. Metals, like lead, and minerals, like nitrate, must be monitored for and kept below maximum contaminant levels.
3. Some organic compounds can be toxic if present in drinking water at high enough levels. Chemical solvents that may be used as degreaser and in dry cleaning, fuels like gasoline and fuel oil, and pesticides used on lawns, gardens, and farms can sometimes impact water supplies.
4. Radionuclides are considered toxins if in drinking water. Primary drinking water standards have been set for a range of radioactive materials.
5. Disinfection byproducts are toxins that can form in drinking water during the water treatment process. Water systems must monitor for and make adjustments to their treatment process to control disinfection byproducts.

Maximum contaminant levels for drinking water are constantly reviewed and updated as new research is considered. To obtain the latest primary drinking water standards check the US EPA web site *(www.epa.gov/ogwdw/regs)*.

Pleasant to Use

Water that is safe to drink may not always be pleasant to use. Secondary drinking water standards are recommended to protect the public welfare. These aesthetic contaminants are listed in Table 1.

Secondary drinking water standards are advisory. However, in Ohio, community water systems must remove high levels of iron and manganese.

Table 1. Secondary Drinking Water Standards

Contaminant	Standard	Symptoms
Chloride	250 mg/l	Salty taste, corrodes pipes, blackens stainless steel
Copper	1.3 mg/l	Bitter or metallic taste, blue-green stains
Fluoride	2 mg/l	Brownish discoloration of teeth
Iron	0.3 mg/l	Bitter or metallic taste, brown-orange stains, iron bacteria, rusty sediment
Manganese	0.05 mg/l	Bitter or metallic taste, black stains
Sulfate	250 mg/l	Bitter taste, scaly deposits, laxative effects
Total Dissolved Solids (TDS)	500 mg/l	Salty or bitter taste, scaly deposits
Zinc	5 mg/l	Metallic taste
Color	15 color units	Visible tint
Corrosivity	noncorrosive	Pitted or leaking pipes, metallic taste, staining
Detergents	0.5 mg/l	Soapy taste, frothy, cloudy
Odor	3 threshold odor number	"rotten-egg," septic, musty, or chemical smell
pH	above 6.5	Bitter or metallic taste, pitting of pipes
	below 8.5	Soda taste, slippery feel, scaly deposits

Hard Water

Another water quality concern for water system customers is hard water. No stan dards have been set for water hardness, but water systems may choose to treat water to reduce hardness to minimize customer complaints. Guidelines for judging water hardness are listed in Table 2.

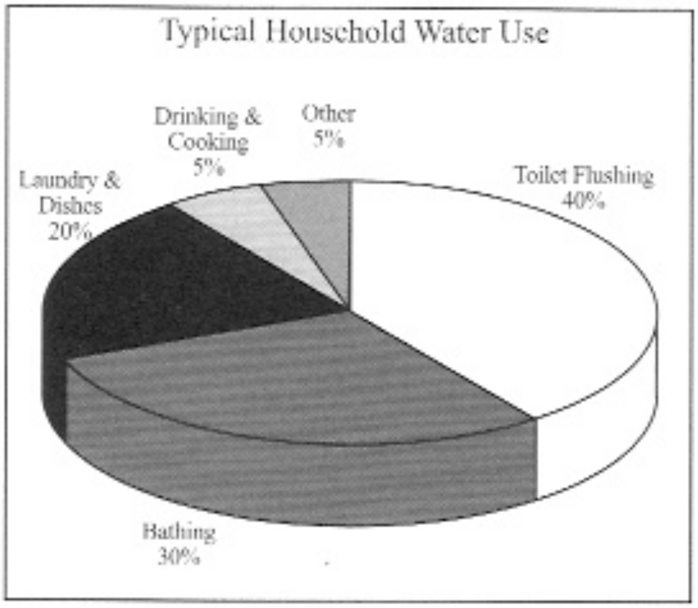
Table 2. Guidelines for Water Hardness

Concentration (Grains per gallon)	Level of Hardness
below 1.0	Very soft
1.0 to 3.5	Soft
3.5 to 7.5	Moderately hard
7.5 to 10.5	Hard
10.5 and above	Very hard

#4 Current Residential Water Use

Lenn Black, Environmental Specialist, Division of Water,
Ohio Department of Natural Resources
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University

Water is used in and around homes for a variety of purposes. Cleaning, bathing, drinking, and flushing wastes are the primary uses of water. The average person uses 50 to 75 gallons of water each day. Only 5% of that (2 to 4 gallons) is actually consumed by people through drinking and cooking. The highest percentage, 40 percent, is used to flush toilets.



The increasing use of low-flush toilets is having a positive impact on household water use. Beginning in 1990 all new and remodeled homes are required to install low-flush toilets. Low-flush toilets use 1.6 gallons per flush rather than 3 to 5 gallons per flush for a conventional toilet. Communities should encourage property owners to convert, whenever possible, to low water using fixtures (Table 1).

Table 1. Examples of Water Conserving Fixtures

Conventional fixture	Gallons used	Water-saving fixture	Gallons used
Toilet	1.6 per flush	Air-assisted toilet	0.5 per flush
Shower head	4–6 per minute	Low-flow shower head	2.1 per minute
Faucets		Faucet flow-control aerator	
Bathroom	4–6 per minute	Bathroom	0.5 per minute
Kitchen	4–6 per minute	Kitchen	1.5 per minute
Top-loading clothes washer	40–55 per use	Front loading clothes washer	22–33 per use

Irrigation of lawns and gardens can greatly increase summer water use. Lawn watering recommendations for Ohio are 1 inch per week. For a 1/4-acre of lawn that equals 6,788 gallons for each week over the growing season. For a 12-week growing season that can amount to 81,450 gallons of water per lawn.

#5 Current Commercial and Institutional Water Use

Lenn Black, Environmental Specialist, Division of Water,
Ohio Department of Natural Resources
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University

Typical commercial and institutional water use is considered on a per employee basis (Table 1). The general water use per employee is 45 gallons per day.

Some commercial establishments have special water needs. For example, food service will use large amounts of water for cleaning. Car washes and laundries are other examples of high water users. Among institutional water users, hospitals have a high demand for water.

Commercial water users are:

- Retail
- Laundry
- Food service
- Service buildings
- Hotel/motel
- Car wash
- Horticultural

Institutional water users are:

- Schools
- Hospitals
- Nursing homes
- Community buildings
- Swimming pools
- Fountains
- Parks and campgrounds

Water use from commercial and institutional users will most likely be seasonal. Weekend/week day variations are also common. Water is used for bathrooms, food preparation, cleaning, air conditioning, and irrigation.

Table 1. Estimates of Water Use for Businesses and Institutions

Business/Institution	Water Use (gallons/person/day)
Swimming pool	10
Country club (nonresident)	25
Homes, institutional	75–125
Camp ground	25
Picnic areas	
with showers and toilets	20
toilets only	10
drinking fountain only	3
School	
with cafeteria, gym, and showers	25
with cafeteria only	20
no cafeteria, gym, or showers	15
Restaurants	7–10 gallons/customer/day
Service stations	10 gallons/vehicle/day
Motels	40 gallons/bed space/day
General commercial	45 gallons/employee/day

Commercial and institutional users may provide for some or all of their water needs through an individual system. If this water is used by employees or the public, it is classified as a public water system and must meet regulatory requirements as a system that serves people where they work (nontransient, noncommunity water supply) or where people visit (transient, noncommunity water supply).

Some institutional water users are government buildings. Unfortunately, in many communities it is common to provide water at no cost to these types of buildings. This practice discourages water conservation and can result in large amounts of unaccounted-for water. A viable water system needs to account for and be compensated for all of the water it provides to users.

#6 Current Industrial Water Use

Lenn Black, Environmental Specialist, Division of Water,
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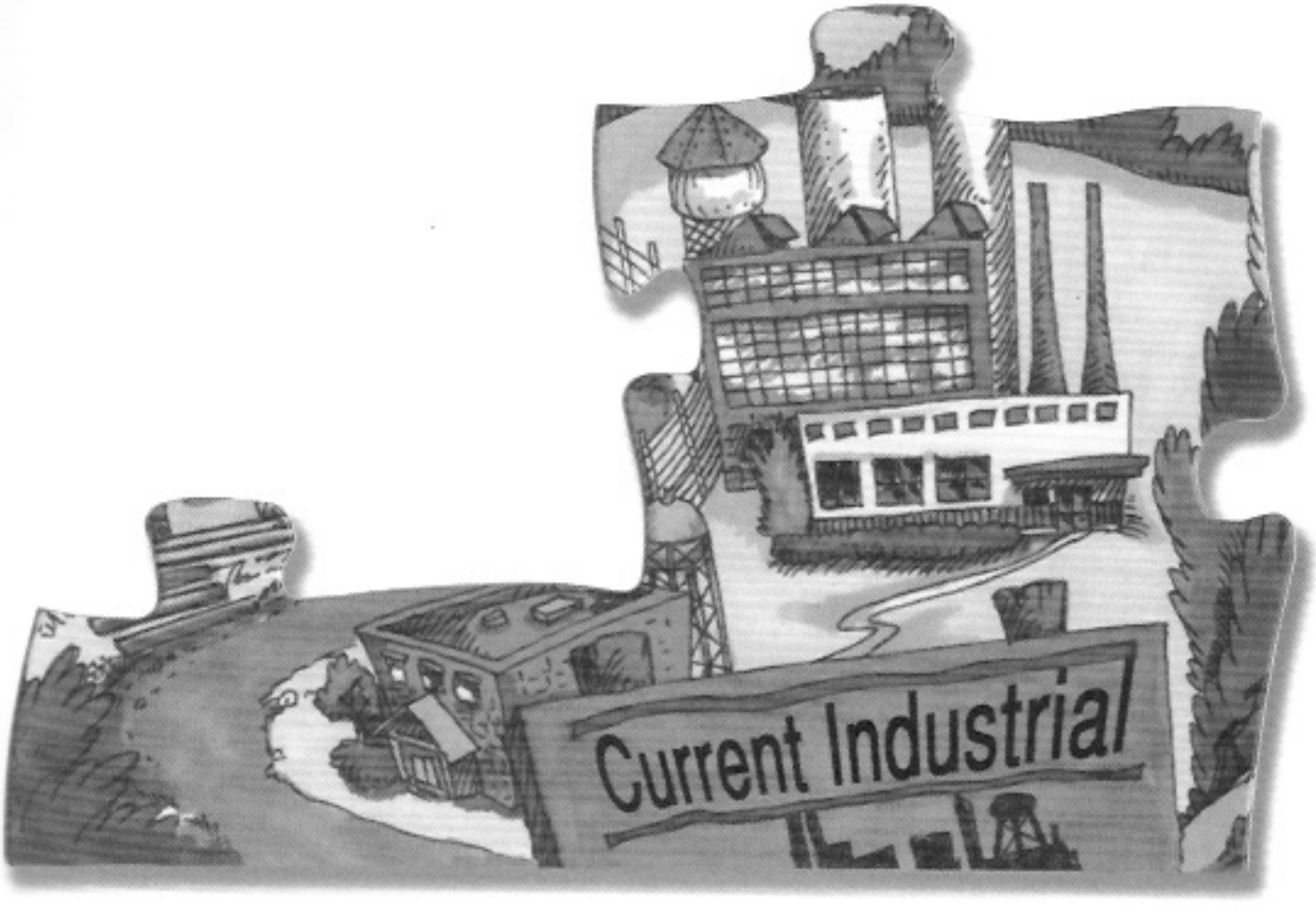

Changes have occurred in industrial water use over the last 20 years. Older steel and rubber manufacturers have shifted their practices or have moved out of Ohio. Food processing is now a major water-using industry in the state. Manufacturers continue to adopt water conservation practices to save money. As a part of their water conservation measures, many industries are reusing water for cooling and irrigation.

Current industrial water users need water for a variety of activities. High quality water is needed for product and processing. A good example is the use of water in food processing and beverage production. High quality water is also needed for cleaning operations. Lower quality water may be used in cooling and irrigation at an industrial site. Water provided for the employee restrooms and food service areas must meet the requirements of a public water supply.

Industries draw water to meet their needs from two major sources. Some provide for some or all of their water from their own source. If this water is used to serve employees, however, the industry is operating a nontransient, noncommunity water system and is subject to meeting all regulatory requirements. Some industries purchase some or all of their water from a community water supply. It is not uncommon for an industry to do both. For example, they may draw cooling water from a well on the site and purchase water from a community water supply to serve the employees.

Large water users often expect lower water rates. Unfortunately, these types of policies discourage water conservation. Water rates must be considered carefully to recover the cost of producing and delivering water to an industrial user to maintain a viable water system.

#7

Future Residential Water Use

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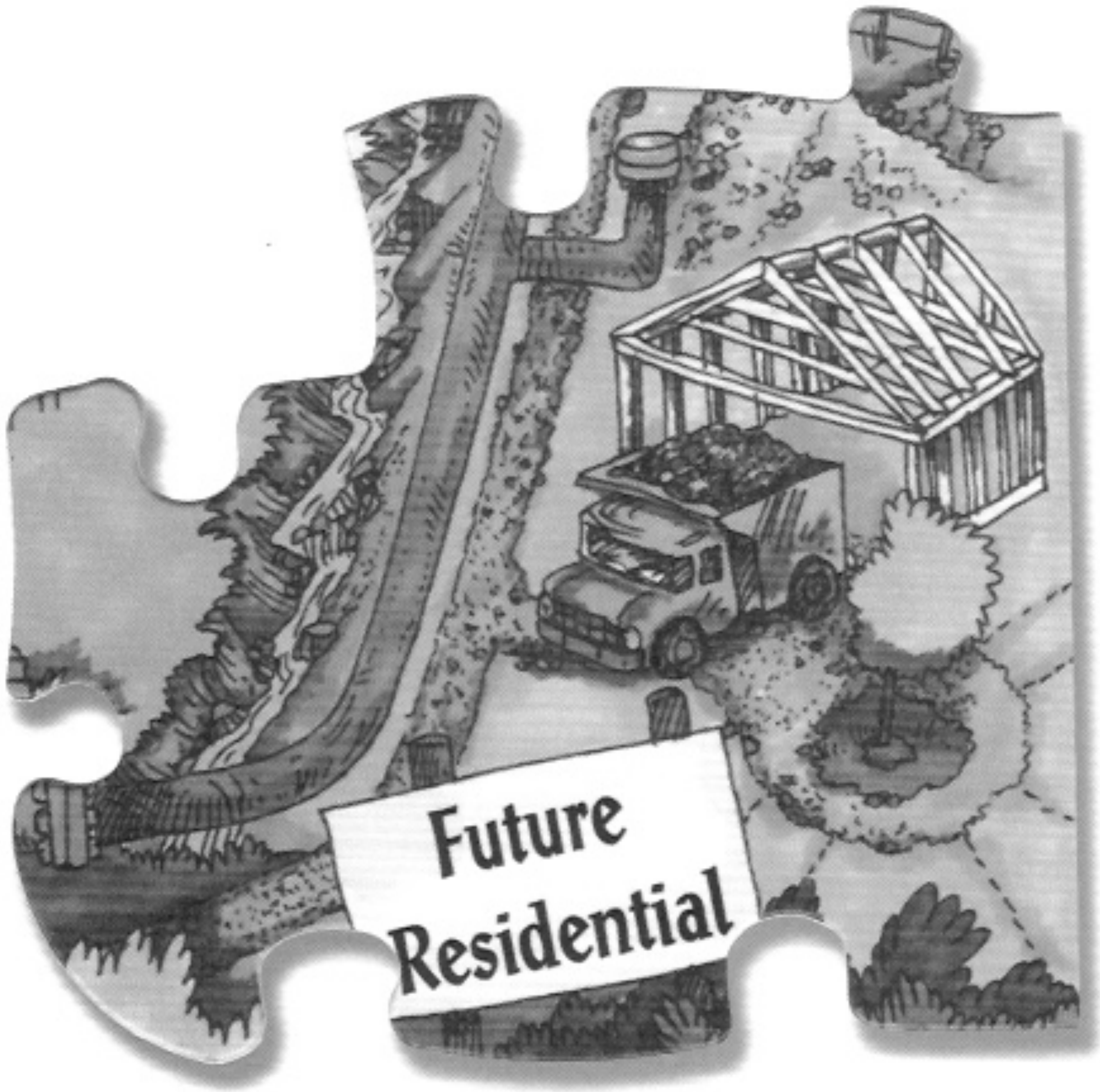

Future residential water use has two components. One is additional users within the current service area. The second is expanding the service area.

Current Service Area

Predicting increases within the service area is relatively straightforward. The simplest method is to reflect past population growth into the future. Adjustments to these projections can be made based on known development patterns.

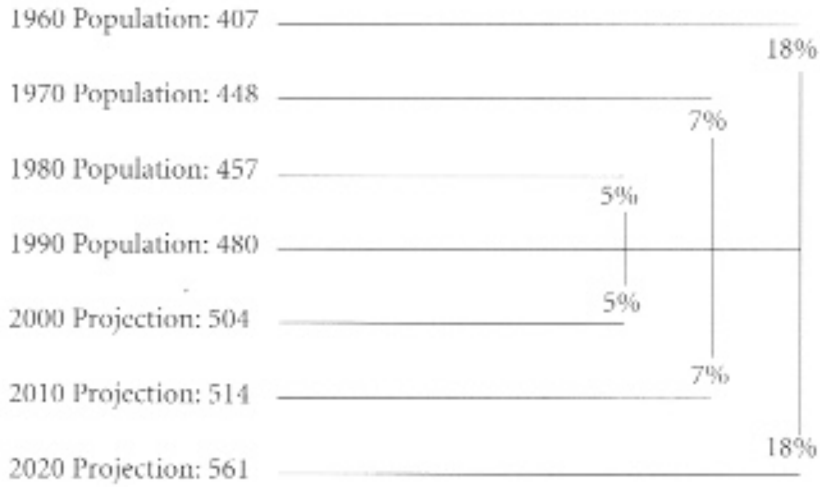

Figure 1. Example of a simple population projection reflecting past population growth.

Expanding Service Area

Predicting service area expansion is much more speculative. Expanding water service into new areas is a critical part of community planning. When planning for future residential service be sure to keep in mind the need to establish loop or grid systems. Loops and grids enable most customers to maintain water service even when a water line break or necessary water line maintenance occurs. Straight line service is unreliable and when used is a sign of poor planning.

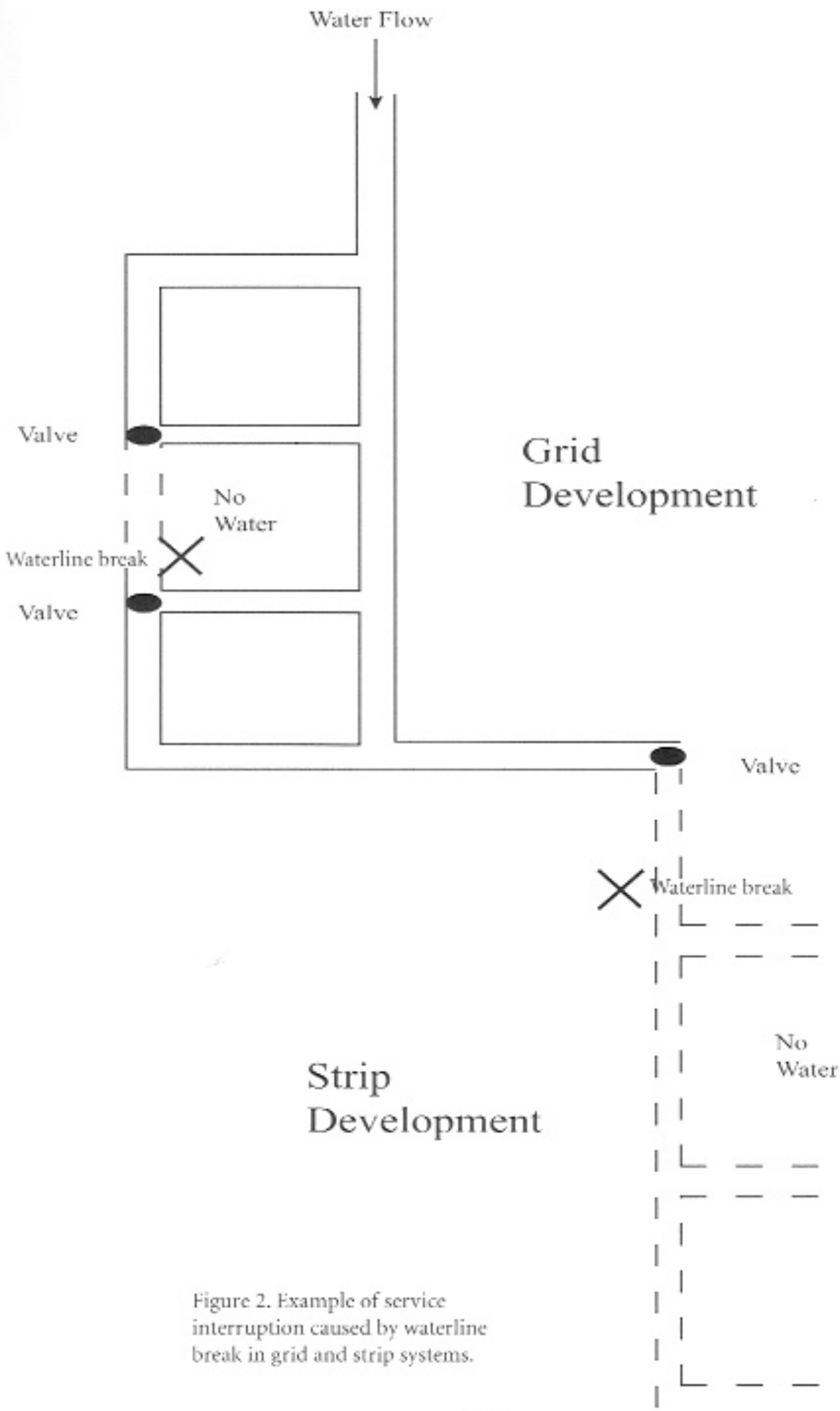

Figure 2. Example of service interruption caused by waterline break in grid and strip systems.

#8 Future Commercial and Institutional Water Use

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Ohio Department of Natural Resources
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
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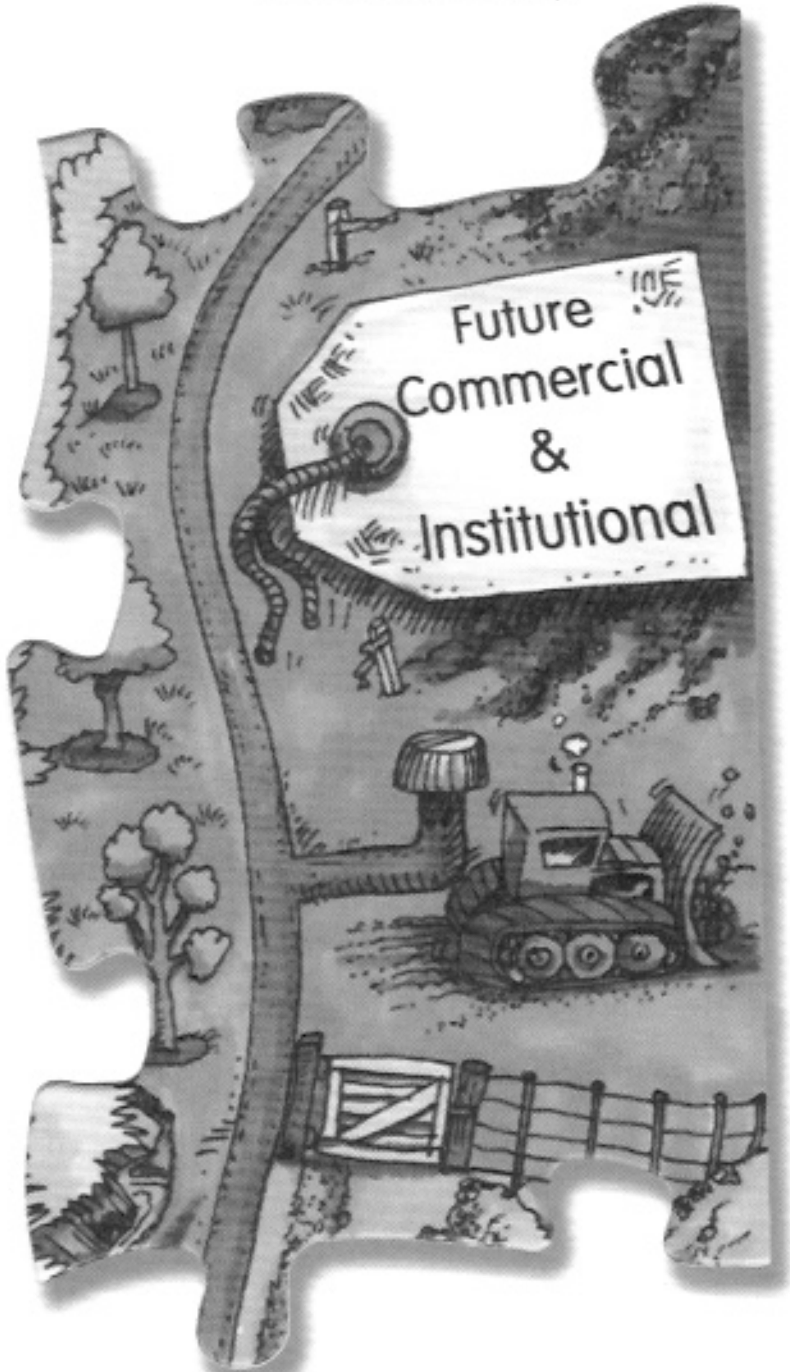


Retention and expansion of existing businesses and institutions should be a major focus of a stable small community. The current water users may be restricted by the quantity or quality of their existing water supply. Their future plans and needs should be a consideration in the development and improvement of a community water system.

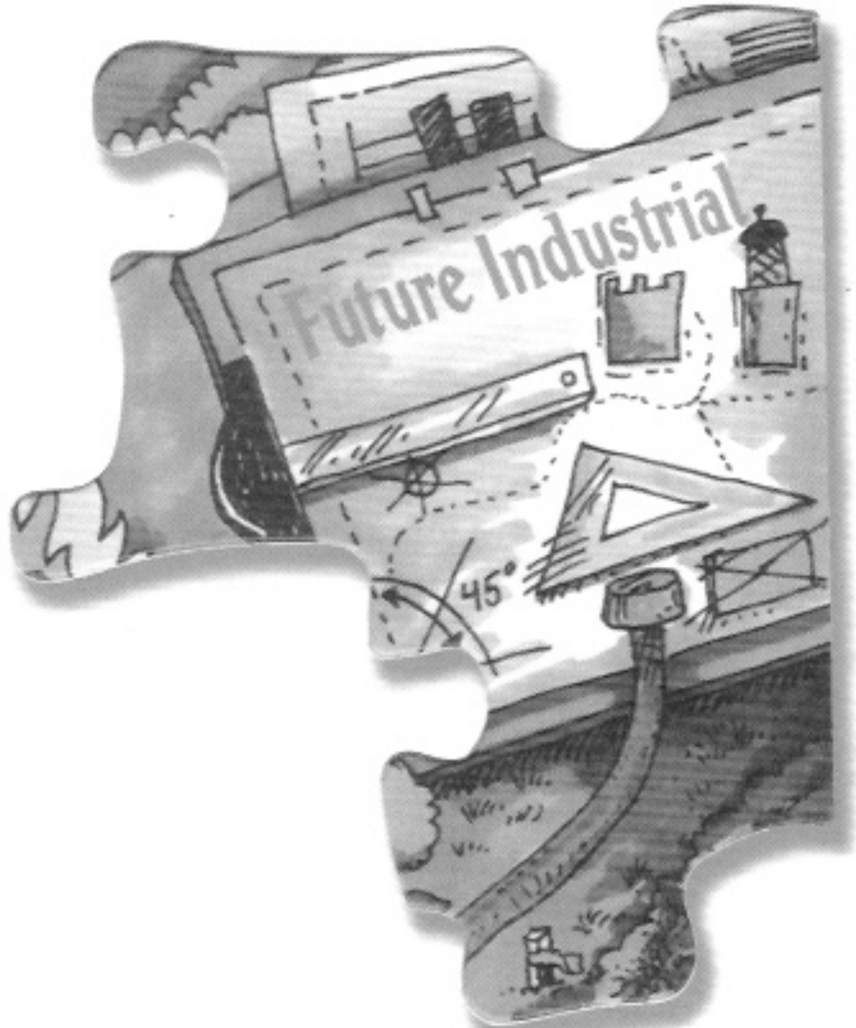
Businesses and institutions that have their own private water supply may now feel burdened by the increasing regulatory requirements that have been put in place to protect employees, business customers, and institutional visitors. These facilities may now wish to become a part of a community water supply. For example, schools with their own water supply are considered nontransient, noncommunity water systems and some are struggling to keep up with new regulatory requirements.

New commercial and institutional development plans are more speculative. Downtown revitalization projects will likely increase water needs. Planned development at highway interchanges also comes with a need for water. Water service must be a part of all future commercial and institutional development plans.

#9

Future Industrial Water Use

Lenn Black, Environmental Specialist, Division of Water,
Ohio Department of Natural Resources
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University



Planning for industrial development is tied to the water available both in quantity and quality. The nature of the supply can shape community planning for industrial development. A community that has access to large volumes of high quality water will be attractive to industries like brewers, bottlers, food processors, and energy producers. Many of the high-tech industries that so many communities wish to attract require extremely high quality water.

Industries have varying water demands. All industries need some water for employee restroom facilities. In addition, industries may use water in production, cleaning, or cooling. Water demand is expressed on a per employee basis.

Industry	Water Use (gallons/employee/day)
Apparel and other textile products	24
Chemical and allied products	1,068
Electronic and other electric equipment	216
Fabricated metal products	378
Food and kindred products	843
Furniture and fixtures	149
Industrial machinery and equipment	184
Instruments and related products	116
Lumber and wood products	651
Miscellaneous manufacturing industries	213
Paper and allied products	2,944
Petroleum and coal products	1,852
Primary metal industries	584
Printing and publishing	38
Rubber and miscellaneous plastic products	323
Stone, clay, and glass products	413
Textile mill products	512
Transportation equipment	235

Investing in water supply capacity and infrastructure is a difficult challenge for small communities. Many communities have set aside land for an industrial park. To effectively attract industries these industrial parks must have water service in place. The development of water service for industrial needs is no guarantee that industries will move to your community. However, if it is not available, an industry will move to where the water is. Attracting industry is part of a larger community plan where water supply is just one necessary component.

#10 Water Sources for Fire Protection in Small Communities

Tony Nye, Extension Agent, Clinton County, Ohio State University Extension
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University

Large cities use the public water supply for fire protection. Large fire hydrants connected to large diameter water pipes deliver the necessary flowrate for fighting fires. The water stored in the community reservoirs and water towers is often adequate without disrupting service.

Small community water supplies, however, may not be adequate for fighting fires. Flush hydrants, required to maintain the distribution system, are not fire hydrants and do not provide adequate water flowrates for fire protection. The volume of water stored in small community water towers is generally not enough to fight most fires. Using potable water sources to fight a fire will likely disrupt customer service for a day or more. Most rural water supplies can provide only enough water for "first aid" in starting to control a fire until adequate water from other sources can be brought to the site.

Volume of Water Needed

Firefighters need quick access to large volumes of water to control and put out a fire. While more water is generally better, the minimum water volumes and flowrates are recommended by the National Fire Protection Association.

Minimum volume and flowrates for adequate fire protection are calculated for each community. Local fire companies survey the number, type, construction material, contents, and proximity of structures in a community. The minimum water supply is calculated from:

- the cubic feet of each structure,
- its occupancy hazard classification, and
- its construction classification.

Occupancy hazard classifications range from 3 for severe hazards, such as lumberyards, feed and grain mills, or fuel storage, to 7 for light hazards, such as a dwelling, school, or office building. Construction hazard classifications are based on the building material. A construction hazard classification of 0.5 is for fire resistant concrete, brick, or stone buildings while a classification of 1.5 is for wood frame construction.

Minimum water supply values increase as the buildings are closer together. The values increase by 1.5 times if structures are closer than 50 feet apart.

A community may have enough water to provide fire protection but the water must be applied quickly to control a fire. The rate at which water flows to a fire is controlled by the capacity of the pipes, hydrants and the water pressure. The flowrate per water "stream" should be at least 500 gallons per minute and sustained for at least 60 minutes to control a fire. If the structures are close together, higher flowrates are needed. Large structures, such as a hospital or school building, may require more than one water stream, requiring more water. If structures are close together, the risk of a fire spreading increases, so higher minimum flowrates are recommended.

Flush Hydrant

Fire Hydrant

Structure separation	Minimum fire flow (gal/min)
less than 30 feet	1,000
30 to 100 feet	750
more than 100 feet	500

Providing Water for Fire Protection

Fortunately, small communities have several options available for the development of water reserves for fire protection. For example:

- Large and high hazard sites can construct elevated water storage tanks.
- Cisterns and swimming pools can serve as a developed water source.
- Natural and constructed bodies of water, such as ponds, quarries, mines, springs, and even wastewater treatment lagoons can be improved to provide water for fire protection.

Water bodies in Ohio are subject to environmental conditions such as freezing weather and droughts. Many water bodies have steep banks, making access in an emergency difficult. Communities that plan to use these sources for fire protection need to do five things.

1. Map the location, volumes, and type of each water supply. This map should be provided to the fire alarm dispatcher.
2. An all-weather road must lead to each water source.
3. A dry-hydrant that matches local fire equipment should be installed at each water source. Details on dry-hydrants are in Ohio State University Extension Fact Sheet AEX-422, available at your local Extension office or on the Ohioline web site at *http://ohioline.osu.edu*.
4. Inspect each water source regularly to note any changes in water level or access and correct any problems.
5. A usage agreement should be obtained for each water source located on private property. An example agreement is shown below.

Fire companies will use one or more pumper trucks to transport water to the fire scene. Therefore, travel distance is critical in getting water to a fire in a timely manner. A community should have multiple sources of water throughout the area rather than rely on only a central source.

Using a Community Water Supply for Fire Protection

If a community chooses to use the public water supply for some or all of its fire protection needs, the spacing of fire hydrants must be considered. The large hydrants served by large pipes are more expensive than those required for domestic use. Careful placement of fire hydrants can keep costs reasonable while still providing adequate fire protection. The distance from a dwelling to the nearest fire hydrant ranges from 250 to 500 feet and is a factor in setting fire insurance rates.

Example

Water Usage Agreement*

We the undersigned owner(s) of a lake or pond located at ______________________ do hereby grant the ______________________ Fire Department permission to maintain a dry hydrant and access roadway to said lake or pond to be utilized for emergency fire suppression purposes.

All other uses of said pond or lake shall be after notification and permission of the owner.

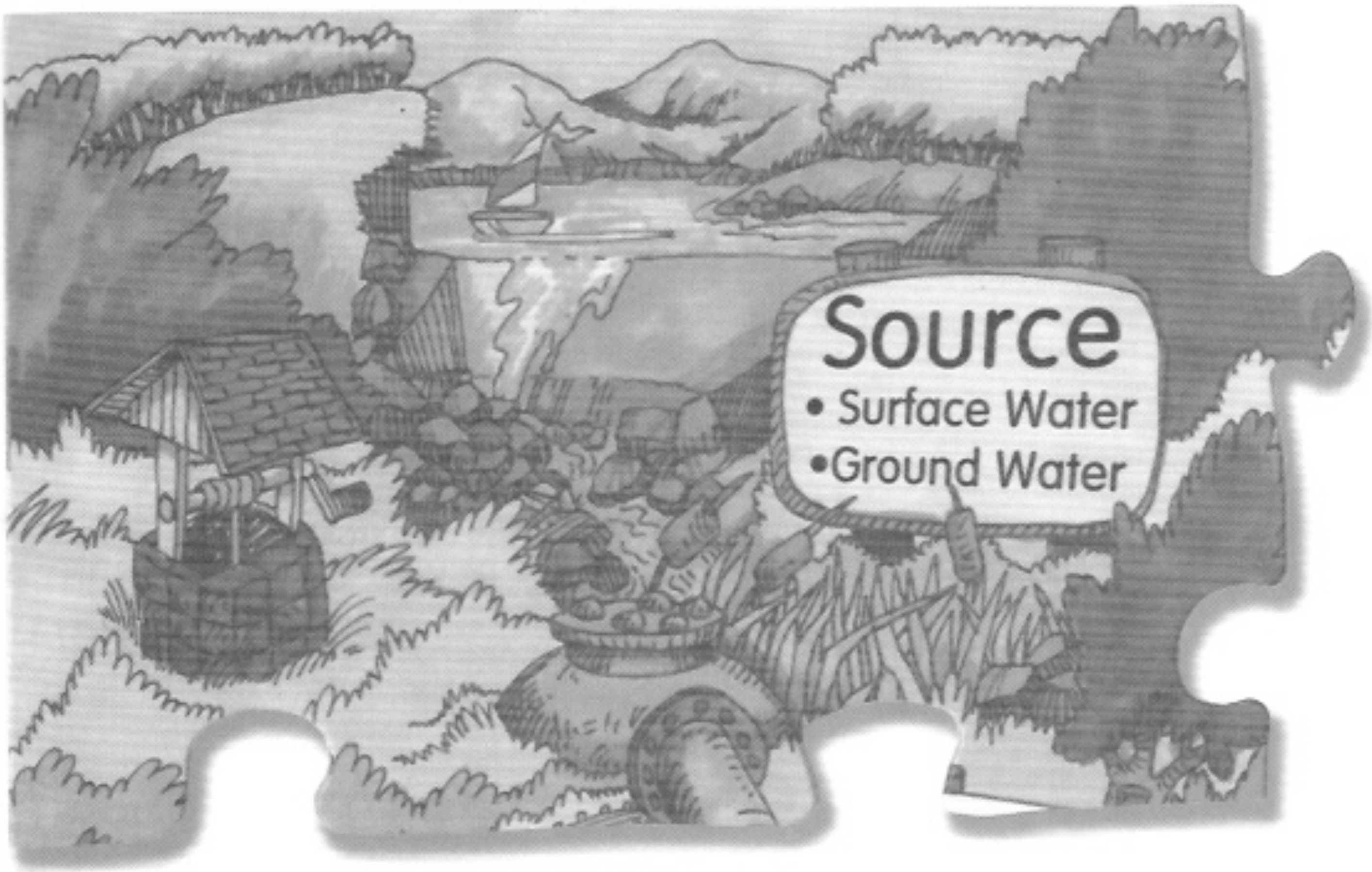
*After: National Fire Protection Association, 1993.

Community Fire Protection Program

As a part of developing a fire protection program in your community, talk to your local insurance provider about fire insurance costs and requirements. More importantly, talk to your local fire company about ways to improve fire protection in your community through the installation of dry hydrants in water bodies in and around the community. The local water system manager should be consulted about the potential and costs of using the community water system for fire protection. Also contact the National Fire Protection Association for more detailed information on its standards for Water Supplies for Suburban and Rural Fire Fighting (NFPA 1231). The Association's phone number is 617-770-3000 and its web site is *www.nfpa.org*.

#11 Sources of Drinking Water for Small Communities

Ron Veley, U.S. Geological Survey



To provide an adequate and sustainable water supply for customers, a water system must develop a water source. The principal water source alternatives are direct use of surface water and ground water, or purchase of water from another water supplier. Water conservation is another option for a community to extend a water source to serve the needs of customers.

Surface Water

The two most common surface water supply alternatives for small communities are offstream reservoirs and onstream reservoirs. An offstream reservoir is an earth structure designed to store water. A pipeline and a pumping station, if gravity flow is not possible, are required to transport water from a natural source to the offstream reservoir. Onstream reservoirs, as the name implies, are designed to impound water within the source's main channel. The main components of an onstream reservoir are the dam (earth, metal, or concrete) and the spillway. Both types of reservoirs can be designed for multiple uses, such as public water supply, industrial water use, and recreation. Onstream reservoirs also can provide flood control.

One difference between the two types of reservoirs is their ability to make full use of the potential water capture rate. The capture rate is a measure of a reservoir's ability to intercept runoff from precipitation and snowmelt. The offstream reservoir's design inhibits runoff as a water-replenishment source.

The principal environmental concern with onstream reservoirs is their disruption of a stream's ecosystem. The onstream reservoir transforms part of a free-flowing stream into a ponded, controlled water source. The transformation changes the nature of the ecosystem, which can lead to losses or changes in the plant and animal species associated with the stream's natural ecosystem.

Ground Water

A ground water supply for a small community typically consists of either two large wells or a system of smaller wells that collectively supply sufficient water to meet community needs. Ground water yields are variable throughout Ohio. Yields in northwestern Ohio are commonly 100 to more than 500 gallons per minute per well, whereas yields in the southeast are more likely to be less than 5 gallons per minute.

Most of Ohio's ground water supply meets the Ohio Environmental Protection Agency drinking water standards without treatment except for disinfection. Some ground water will require treatment to reduce high levels of iron, and softening to reduce water hardness is common. Potential contaminants to water supply sources resulting from human activities include leachate from on-site septic systems, hydrocarbon leaks and spills, brine from oil and gas drilling, toxic metals from mining and industrial activities, and pesticides.

Purchased Water

Some communities choose to purchase water from outside sources rather than develop a new surface or ground water source. The community that exercises this option may give up control over certain aspects of the water supply system and thus may not be an active participant in decisions affecting its water supply. The most notable loss of control lies in establishing water rates.

Water Conservation

One solution to problems of increasing water demand is to try to reduce the demand through water conservation programs rather than seek to meet the demand by developing or expanding water supplies. Supply-side management programs, which reduce water losses in the delivery system, include water audits and leak detection. Demand-side management, which reduces water use by modifying customer behavior, can be accomplished through ordinances, incremental water rates, and education. Successful water conservation programs may reduce revenues initially, therefore a community may need to adjust its water-rate structure so that revenues equal the cost of providing water to its customers.

After: Veley, R. J. 1992. Advantages and Limitations of Water-Supply Alternatives. Water Fact Sheet USGS Open-file 92-119.

Summary of Advantages and Limitations of Water-supply Alternatives

Advantages	Limitations
Surface Water—Offstream Reservoirs	
• Site flexibility compared with onstream reservoirs • Potential for incremental development • Selective withdrawal of source water • Mitigation of environmental disruption • Multipurpose use	• Operation and maintenance expenses commonly higher than for onstream reservoirs • Lower capture rate compared with onstream reservoirs • May require a lowhead dam
Surface Water—Onstream Reservoirs	
• No pump or pipeline from source to reservoir required • Higher capture rate compared with offstream reservoir • Multipurpose use	• Potential contamination from point and nonpoint sources • Dam/spillway expense • Environmental disruption
Ground Water	
• Generally less expensive to develop than surface water • Operation and maintenance less expensive than for surface water • Environmental disruption associated with surface water development is avoided	• Quantity and quality may be inadequate • Recharge area requires protection
Purchased Water	
• Reduced capital expenses • No source development expenses • Water-treatment facility unnecessary	• Loss of autonomy • Limited control of water rates
Water Conservation	
• Increased water source longevity • Infrastructure projects delayed • Reduced treatment expenses	• May reduce revenues initially

#12

Source Water Protection

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Why Protect the Water Source?

"An ounce of prevention is worth a pound of cure." While this is an old proverb, it can be all too true for a water system. Drinking water contaminants are difficult and expensive to remove from water. A single accident can contaminate a water supply for decades. In some unfortunate cases, communities have had to abandon their water supply and develop a new one in response to contamination.

Communities make a tremendous investment in the development of their drinking water infrastructure. Installing pipe and building water towers and treatment plants are expensive projects for a community. Protecting the source of water protects that investment.

Stepwise Approach to Source Water Protection

For Groundwater Supplies	For Surface Water Supplies
Step 1. Identify the protection area (Figure 1). • 5-year time of travel Ohio EPA is currently delineating the 5-year time of travel areas for existing water systems. New water systems may have to delineate their own 5-year time of travel areas. Consulting hydrogeologists have this skill. • 1-year time of travel An inner management zone based on the 1-year time of travel is also delineated as the most critical area to focus protective actions. Susceptibility of groundwater sources varies throughout the state. The Ohio Department of Natural Resources has published maps called DRASTIC maps, which predict the potential for contamination. In general, the highest yielding groundwater sources tend to be the most vulnerable.	**Step 1. Identify the protection area (Figure 2).** Watersheds are the land area that drains to one spot, like a water system intake. Watersheds are rather easy to outline using topographic maps. Since it is difficult to protect the entire watershed, critical areas, called corridors and emergency management zones, are identified. • The corridors are at least 10 miles upstream of the intake, 1,000 feet on either side of the principal stream and 500 feet on either side of tributary streams. • The emergency management zone is 500 feet upstream and 100 feet downstream of the water intake. If a spill occurs in this zone, no actions can prevent contaminants from entering the water system.

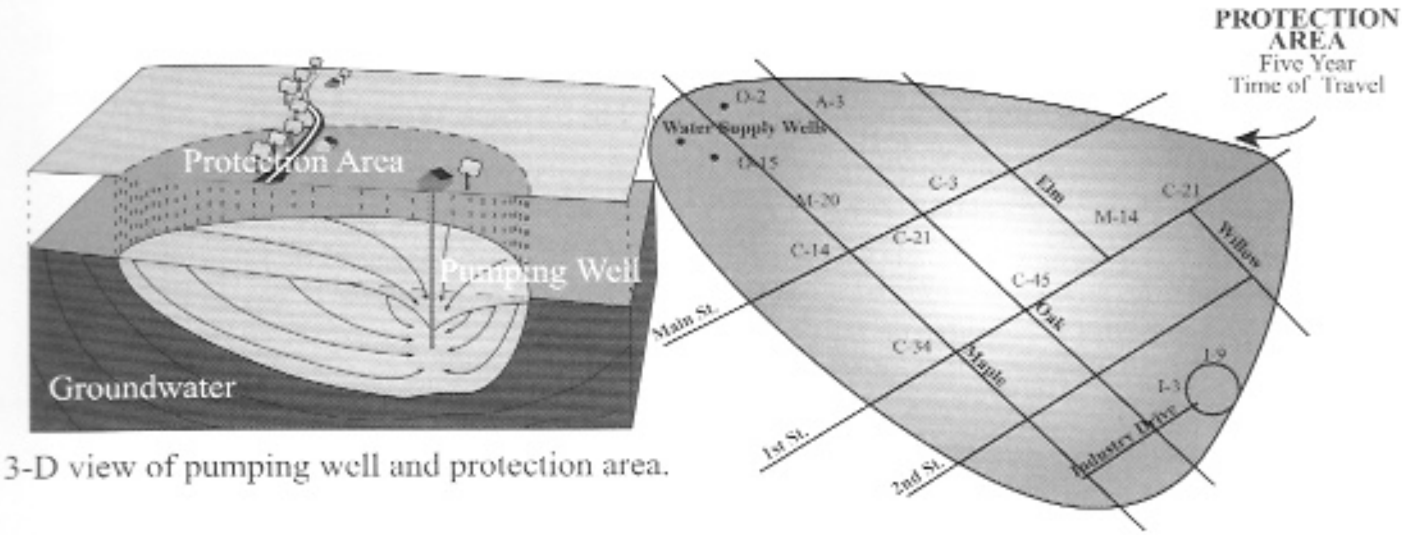

Figure 1. Delineation of time of travel zones to establish groundwater protection areas.

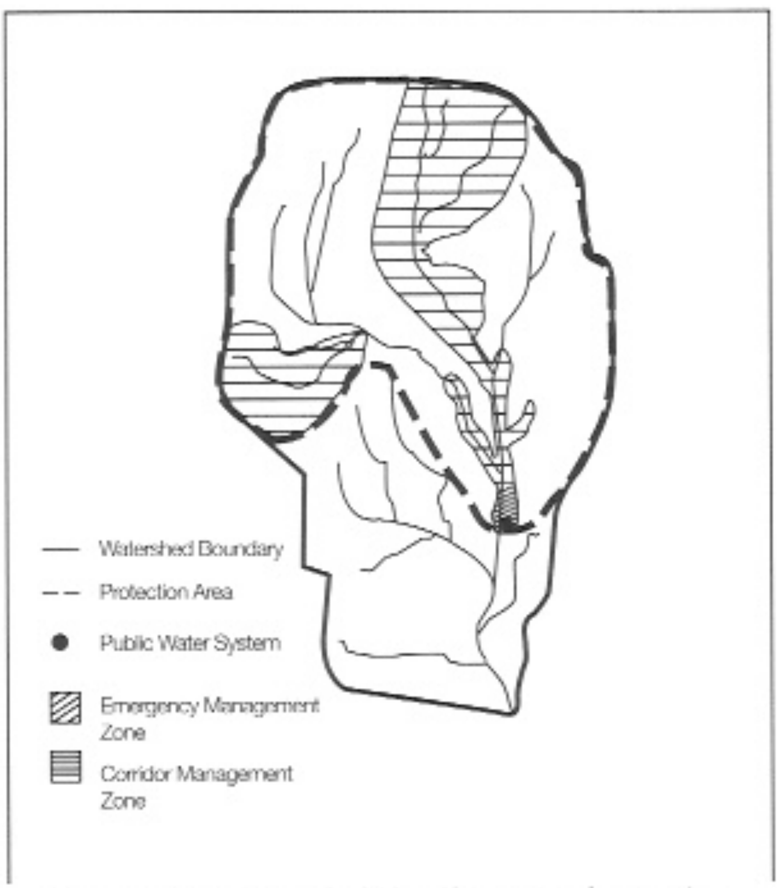

Figure 2. Map of watershed identifying critical protection areas and emergency management zones.

For Groundwater Supplies

Step 2. Inventory activities that can threaten the water source (Table 1).

The soil is the most important barrier protecting groundwater supplies. Activities that occur within the soil or beneath the soil layer create a greater threat.

Direct—subsurface activities

- wells
- mining activity
- underground storage tanks
- injection wells and drainage wells
- septic systems
- excavated lagoons, ponds, and quarries
- dumps

Surface activities that one would think of as a threat to a water supply are mediated by the soil. Chemicals concentrated by some surface activities may overwhelm the protective nature of the soil and threaten groundwater quality.

Indirect—surface activities

- road salt storage
- landfills
- overapplication of wastes and chemicals to land
- spills

For Surface Water Supplies

Step 2. Inventory activities that can threaten the water source (Table 1).

Activities that discharge pollutants directly into a stream create the greatest threat.

Direct—discharges

- sanitary and storm sewers
- spills and transportation accidents

Plant buffers along stream corridors help to protect surface water supplies. Activities that result in bare soil next to a stream or ditch threaten water supplies.

Indirect—soil disturbance activities

- strip mining
- construction
- cultivation

Table 1
Example of potential contaminant sources list.

Map Code	Source	Name/Address Somewhere, OH 99999	Source of Information
A-3	Animal waste storage/treatment*	Happy Heifer Dairy 176 Oak St.	Field survey
C-3	Auto repair shop	We Fix It 21 Main St.	Field survey
C-14	Dry cleaner	Ace Cleaners 95 Main St.	Field survey
C-21	Gas station	40 Main St.	BUSTR
C-34	Paint store	26 S. 1st St.	Field survey
C-45	Veterinary office*	10 S. 1st St.	Field survey
I-3	Chemical plant	2 Industry Way	RCRIS
I-9	Machine/metalworking shop	We-Fab Metal 6 Industry Way	Field survey
M-20	Road maintenance depot	126 Maple St.	Field survey
O-2	Chemical drums/storage	Water Plant	Site visit
O-15	Sewer lines*		Site visit

* Potential Pathogen Source

Step 3. Identify protection strategies.

Communities can be very creative in finding ways to protect their water. Some of the strategies a community may choose are:

- Adopting zoning ordinances to control where activities that threaten the water supply can occur. For example, the underground storage tanks used in places like gas stations may be excluded from a groundwater protection area.
- Purchasing or leasing undeveloped land in critical source water protection areas.
- Using local tax code to encourage land owners to limit activities in the protection areas.
- Identifying hazardous materials transportation routes in and around your community.

Step 4. Communicate with the public.

Include discussions of pollution prevention activities in public meetings and in schools. Work with the local news media to highlight the cost and benefits of source water protection. Hold household hazardous waste collection events and recycling programs. Most importantly, put up signs to identify the source water protection area along with a phone number to report an accidental spill.

DRINKING WATER
PROTECTION AREA
REPORT SPILLS
1-800-282-9378

Cost of Source Water Protection

Cost	Resources Available
Identifying the protection area (Step 1) is the most critical and probably the most expensive step for a small community. Professional hydrogeologists have the training and capability to outline the critical zones and corridors. Their expertise and time is the major cost to the community. Source water delineation studies typically cost from $5,000 to $15,000 for a small community.	The state of Ohio is sponsoring the delineation of existing water supplies. Ohio EPA staff plans to complete this task by 2003. New systems may have to delineate the source water area themselves. Some communities have cooperated with local universities to support source water delineation as a student project. The students gains a research project while the community supports a local educational institution.
The inventory of activities in the protection area (Step 2) is a simple listing. Identify both direct and indirect threats to the water source. Mark the location of each activity on a map. Using local expertise to create this inventory takes a few hours of time. If an outside professional is hired it can cost from $500 to $5,000.	In small communities knowledgeable local residents and community employees can work together to list and map activities. Ohio EPA plans to include an inventory of activities along with the delineation for existing water systems with the help of a water system employee.
Protection strategies (Step 3) require the coordination and cooperation among planning, construction, transportation, utility agencies, elected officials, and property owners. Cost to implement protection strategies comes from: • meeting time to plan and develop the protection program. • outside expertise to advise and mediate discussions. • purchase of critical land areas and development rights for land. • remediating threats or cleaning up spills that have already occurred on private property.	Many state and local resources are available to help develop protection strategies. Some examples are: • OSU Extension can bring in expertise on land uses and help mediate community discussions. • Ohio EPA can help establish linkages with other communities that have successfully developed protection strategies. • Ohio Fire Marshall has an active program on the installation, upgrading, repair, and closure of underground storage tanks.

continued......

Cost	Resources Available
• politically unpopular decisions about limiting activities that threaten water supplies.	• Local health departments can help provide information on household sewage systems and private wells in the protection area. • Local fire departments play an important role in emergency response to chemical spills. • Local law enforcement can help establish and implement transportation routes for hazardous materials.
Communication with the public (Step 4) needs creativity and special planning. Messages about source water protection must be delivered frequently and in a variety of ways. Professionals can help in delivering effective campaigns. Printing, distribution, and time in public gatherings will be the true cost to the community.	Many state and local resources are available to help develop communication programs. Some examples are: • OSU Extension and Ohio Farm Bureau can help develop and deliver community, agricultural, and youth programs in source water protection. • Ohio EPA has materials and brochures that can be used and customized. • Ohio Environmental Education Fund offers grants for the development of unique educational programs. • Ohio Department of Transportation provides road signs for state routes and interstates that run through source water protection areas. • US EPA has information on source water protection on their web site with links to other useful sites.

#13 Water Distribution System: Pipes, Valves, and Flush Hydrants

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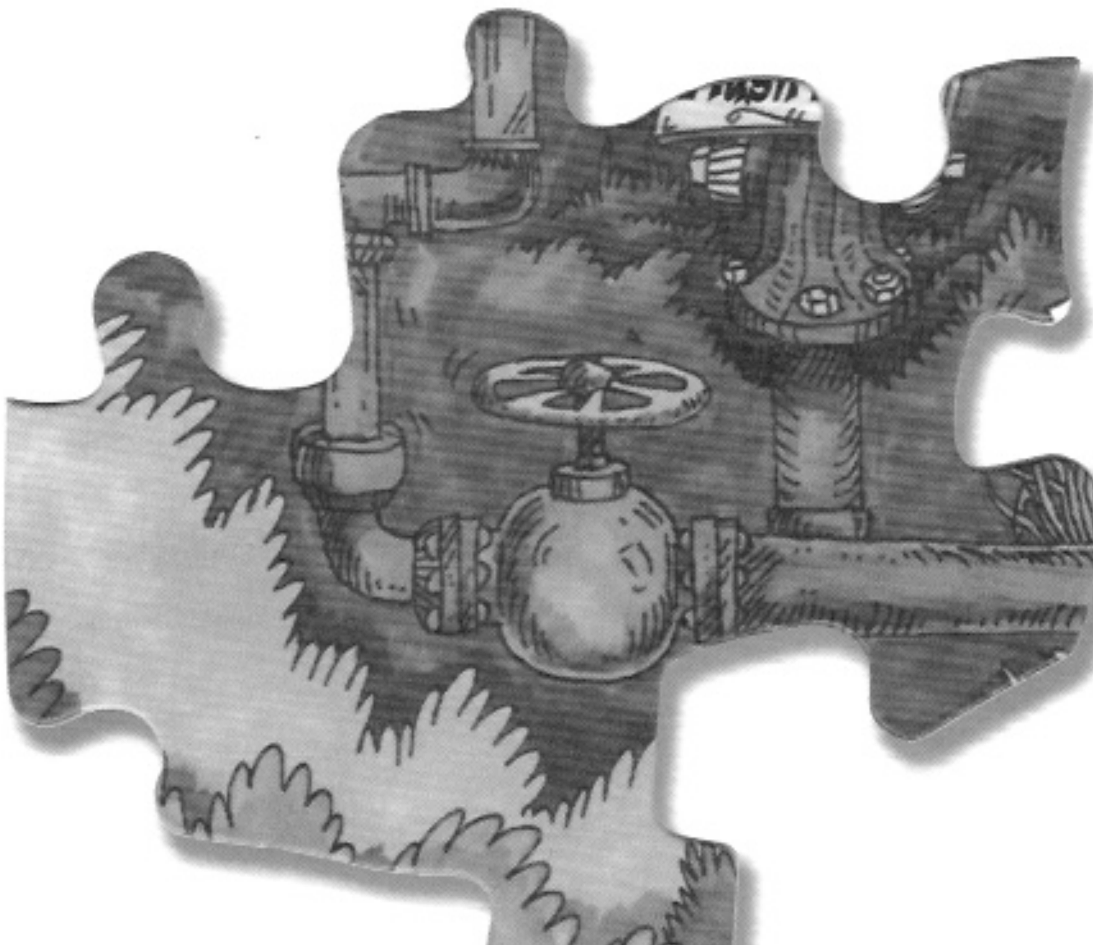


Developing a system to distribute water to customers is a big investment for a community. Because a water distribution system is intended to serve a community for more than 50 years and it is buried and difficult to access, careful planning and consideration is needed.

Water distribution systems have three major components: pipes, valves, and flush hydrants. Each part plays a role in ensuring adequate water service and in maintaining quality water.

Because the pipes and valves are buried, a detailed map is needed to gain quick access to the system for maintenance and repairs. A map is also an important planning tool for upgrades and expansions. It is common for an experienced operator or town employee to have detailed knowledge of the location of all distribution system components. Relying solely on memory, however, can put the distribution system at risk if problems occur when the responsible person is unavailable. A detailed map ensures that the investment in the community infrastructure is documented, and can be studied and shared with interested parties.

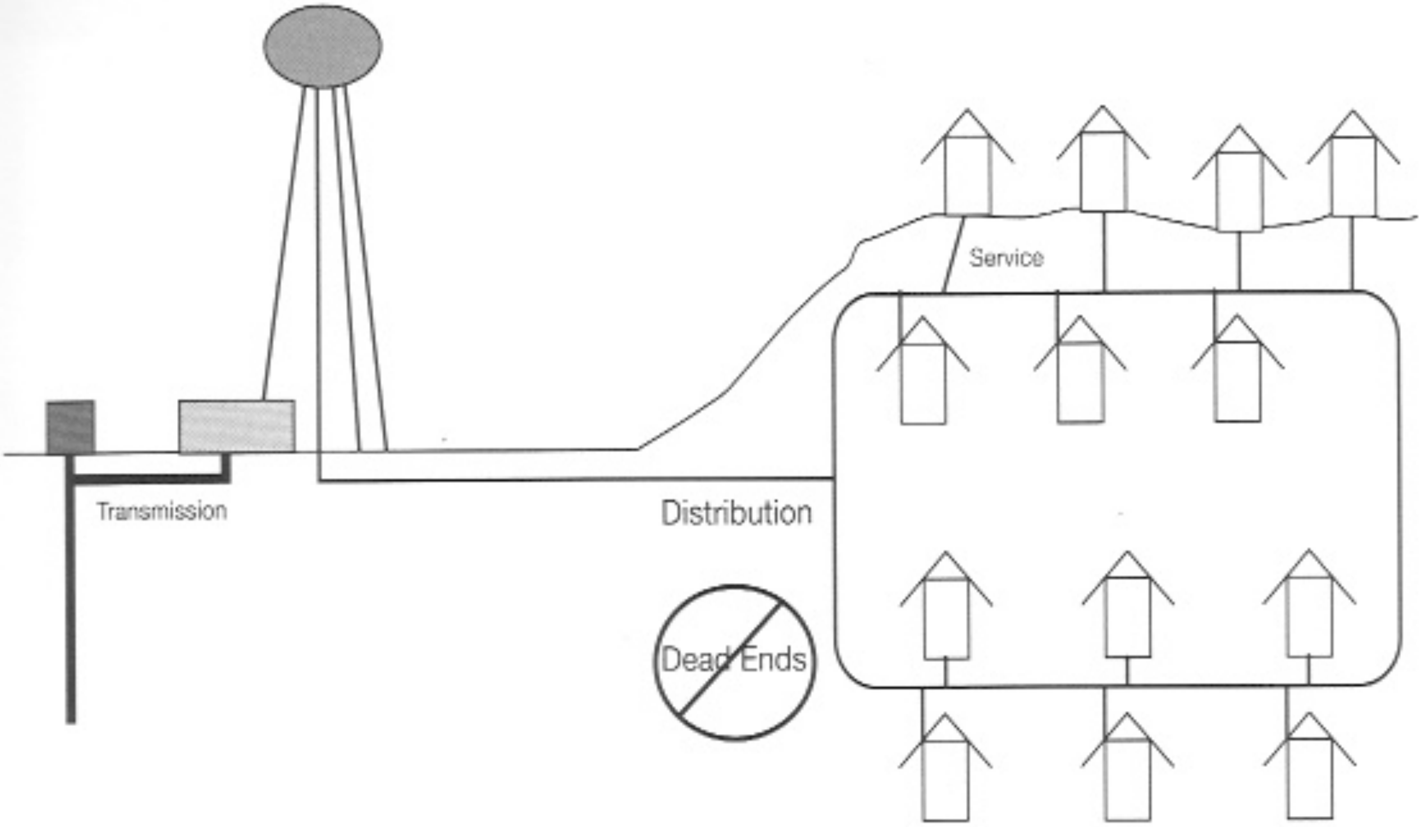
Pipes

Water pipes should be laid out in loops to avoid dead-ends that create stagnant water. Water pipes must be buried at least 48 inches below the ground surface in Ohio to protect them from freezing.

Two types of water pipes are needed in a water system—transmission lines and distribution lines. **Transmission lines** are the pipes that carry the water from the source to the storage system. Transmission lines are the largest, thickest pipes in the system making them the most expensive. When planning a water system, try to keep the treatment and storage tanks close to the water source to reduce the cost of transmission lines.

Distribution pipes carry water out to the users. To protect water quality, water pipes must be at least 10 feet from sewer pipes and laid in separate trenches. The absolute minimum diameter for a distribution pipe is two inches. A six-inch diameter pipe is the minimum needed for fire flows and for serving fire hydrants.

Since water pipes will be used for at least 50 years, most communities look ahead to expanded service and often use bigger pipe than the minimum. Too large a pipe, however, can lead to water quality problems. If water stands too long in large pipes, the chlorine residual diminishes, metals can dissolve in the water, and biological films can grow.



Valves

Values are a critical part of a water system and are often an afterthought. Valves isolate portions of the water system for servicing. By carefully considering the placement of valves, water system repairs and maintenance can be conducted with minimal loss of service.

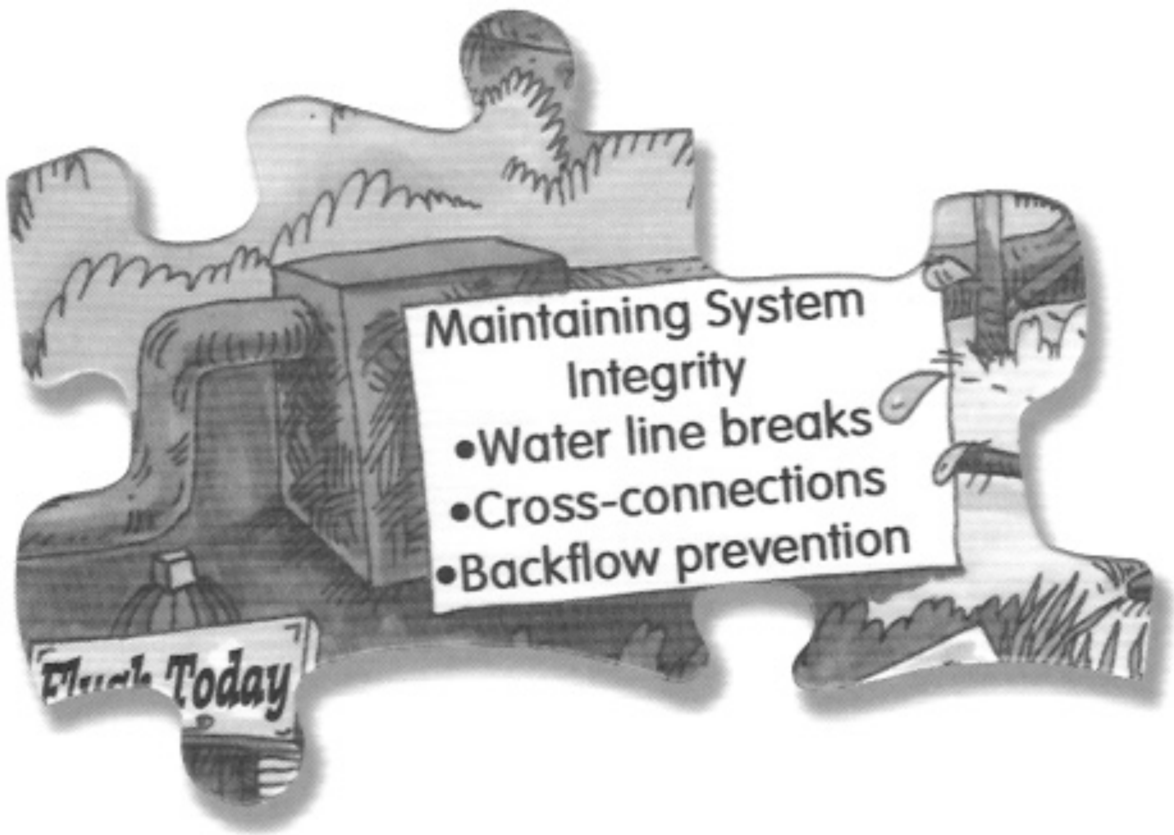
Valves that are not used for years may not function when the need arises. Valves can stick and even break if neglected. A valve exercise program is a necessary part of water distribution system maintenance.

Flush Hydrants

Flush hydrants are the most visible part of the water distribution system. They must be at the end of all lines to remove accumulated corrosion products from dead-ends. Flush hydrants should also be installed throughout the system to provide for periodic flushing to maintain high water quality. Sometimes people mistake flush hydrants for fire hydrants. Fire hydrants are larger and are often connected to larger pipes.

#14 Maintaining Water System Integrity

Jeff Morrison, Assistant Director, Operator Training Committee of Ohio
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University



Water system customers expect an uninterrupted supply of safe water. Water systems must consider the fact that the distribution system, once buried, will be used for over 50 years and will require continuous thought and attention. Water system operators often find themselves choosing between two approaches to maintaining system integrity: 1) reacting only to emergencies, or 2) acting to prevent problems from occurring.

The most desirable approach is to develop an active program of strategies to prevent problems and service interruptions.

In maintaining water system integrity, operators address three issues: 1) water line breaks, 2) flushing water lines, and 3) preventing cross-connections.

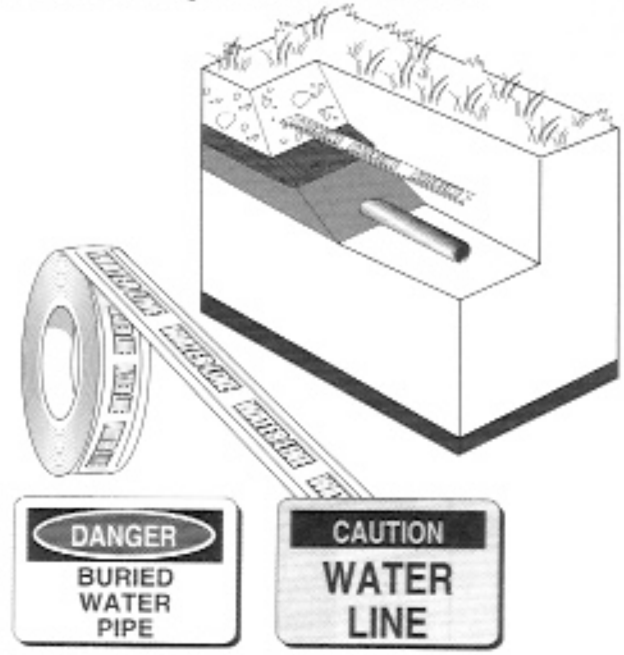
Water Line Breaks

Improper installation of water lines is the root cause of most water line breaks. Water lines should be bedded to minimize stress as the ground shifts, freezes, and thaws. Water hammer can also break water pipes. Water hammer occurs when a valve or hydrant is closed too quickly. Accidents also break water lines. Traffic accidents sometimes break off hydrants. Excavations can also hit and break water lines.

Prevention of water line breaks starts with proper pipe installation. Installers must always follow the manufacturer's recommendations in bedding pipe, backfill with granular fill, and bury pipes below frost depth.

Regular valve maintenance guards against rapid shut-offs that cause water hammer. Valve exercise programs are one tool in checking valves on a regular basis.

Detailed information on water line locations aid in the reduction of excavation accidents. Detailed maps are one step. Another strategy is burying labeled, metal tape above the pipe in the trench. It is hoped that the tape will be dug up, identifying the water line below before the pipe is hit as shown in Figure 1. In areas with a high risk for excavation hazard, surface paint marking and signs are tools to warn excavators and prevent water line breaks.



Timely repair of water line breaks reduces water loss and minimizes traffic hazards, especially in winter when ice can form. Remember, operators require special support when repairing water lines. **Operators must never repair a line alone!** Someone must be standing by in case of an emergency. Traffic control is essential if a portion of the road is blocked to repair a leak.

Water pressure is reduced during a water line repair, creating the opportunity for contamination. The following steps protect the customers during a repair:

- Notify Ohio Environmental Protection Agency of repair.
- Issue boil water order for affected customers.
- Reestablish pressure after the repair.
- Disinfect repaired line by adding high levels of chlorine (shock chlorination).
- Flush line to remove excess chlorine and debris.
- Test water to ensure safety.
- Send test results to Ohio Environmental Protection Agency.

Flushing Water Lines

Water use varies throughout a water distribution system so sediment can accumulate in spots resulting in taste, odor, or iron problems that inconvenience customers. A loss of chlorine residuals at stagnant spots can result in a public health risk. Flushing the water lines is one tool operators can use to maintain water quality and water capacity.

Water systems develop flushing programs for the following five reasons:

1. Emergency flushing is used to remove contaminated water from the water system.
2. Customer complaint flushing is initiated when water becomes colored, or has an off taste or odor.
3. Routine flushing is an active program used in areas with repeat customer complaints.
4. Dead-end flushing is conducted at least annually on all dead-end lines. Flushing as often as every two weeks may be needed at some dead-end lines to avoid customer complaints.
5. Maintenance flushing removes accumulated sediment and corrosion that reduces the water carrying capacity of the pipe.

It is important to optimize a flushing program in a water system. Excessive flushing wastes water. Also, operators must take steps to protect pavement and property to reduce damage during system flushing.

Flush Hydrant

Fire Hydrant

Preventing Cross-Connections

Polluted water entering a drinking water supply through a cross-connection threatens the health of customers. Seemingly innocent situations can result in illness and even death. A hose connected to the water system submerged in a puddle, tank, or bucket containing pollutants is an example of a cross-connection. An active cross-connection and backflow prevention program is required to protect the customers.

A water system at a central Ohio mobile-home park became contaminated when a water softener waste line was directly connected to a drain and the sewer backed up. The cross-connection was easily eliminated by installing a proper air gap between the potable water system and the sewer drain.

Water systems are required to have an ordinance to ensure backflow prevention and cross-connection control. The ordinance covers the installation and maintenance of backflow preventers at potential risk locations in the water system, such as:

- Factories
- Gas stations
- Mortuaries
- Hospitals and clinics
- Beauty salons
- Fish and bait stores
- Grocery stores
- Restaurants

The ordinance also includes an inspection program to ensure that cross-connections do not occur and that backflow prevention devices are not compromised.

#15 Water System Pressure Sources

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Karen Mancl, Professor Food, Agricultural and Biological Engineering,
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Water system pressure ensures customers an adequate flow of water into their home or business. Pressure also provides adequate flow to fire fighting equipment. Even more importantly, water pressure protects the quality of water by making sure that any leaks in the system result in clean water leaking out, not contaminated water leaking in.

Water pressure in a community water system is measured in pounds per square inch (psi). Household water pressure should range from 50 to 60 pounds per square inch. A minimum of 20 pounds per square inch is required by law.

Water pressure will likely vary throughout the system. The highest points in the community and the most distant connections will have the lowest pressure. The lowest points in the community and those closest to the pressure source will have the highest water pressure. Water systems use booster pumps and pressure reducing valves to moderate pressure within the system.

Pumps

Pumps at the water plant are the source of water pressure throughout the system. In some systems the well pumps provide the water pressure for the system. If pressure is reduced through the water treatment process, high-service pumps deliver water to the system at adequate pressure.

Maintaining Water Pressure

Water systems have three options to maintain pressure throughout the system. A community may use a combination of all three approaches to provide adequate water pressure to customers in different parts of their service area.

Tank and Booster Pump

The tank and booster pump combination is probably the most reliable method of supplying pressure to a water distribution system. When water demand causes the level in the tank to drop, the booster pump starts. The pump supplies the demand for water with excess backing up into the tank. When the tank reaches the upper limit, the pump shuts off.

By having the tank, constant pressure is put on the system by the height of the water in the tank. The tank provides a greater, more steady volume of water as well. During short power outages, the tank can provide pressure to the system. The Ohio Environmental Protection Agency requires that elevated storage be adequate to hold a one-day supply of water to the areas it serves without pumping.

The tank and booster pump combination requires a lot of space and is the most expensive to engineer and construct. The tank and booster pump system is suited for a large service area. Even if the initial service area is small, it is easy to expand.

Hydropneumatic System

The hydropneumatic system consists of a pressure vessel and a pressure pump. The pressure vessel contains water with a pressurized air space to provide the pressure for the system. With water demand, water flows from the vessel, increasing the air space as well as decreasing air pressure. This lower pressure signals the pump to start. The pump meets the demand with the excess volume backing up in the pressure vessel. This decreases the air space and increases the pressure once again. When the upper level is reached, the pump shuts off. The newer pressure vessels have a neoprene bladder to separate the air space from the water.

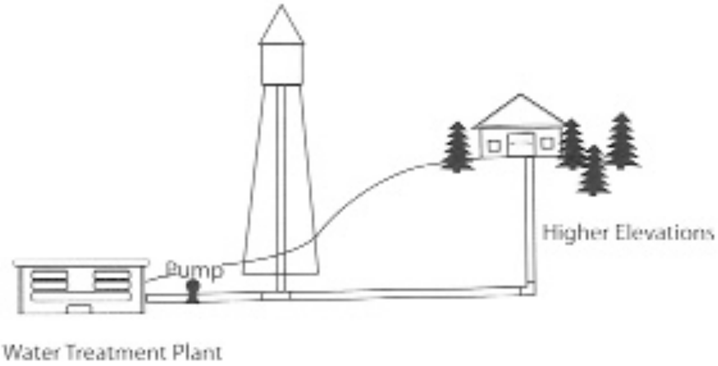
These systems are common in homes with an individual well system. They typically provide adequate pressure but low volume. They are ideal for a rural water system that has a limited service area that is elevated from the main line resulting in inadequate pressure. Hollows, cul-de-sacs, and small trailer parks utilize these to increase pressure. Some water systems have small hydropneumatic stations added as the system expands. These stations are relatively inexpensive to engineer and construct and are often available as package units.

Some of the problems with hydropneumatic stations are that while they provide adequate pressure, they provide limited volume. In some instances, with the nonbladder pressure vessels, air may be forced into the water lines if the demand for water exceeds pump capacity. Also, if the air space in the vessel is lost due to leakage (waterlogging), the pressure pump will stop and start too frequently, resulting in erratic pressure and low water volume. Also, pressure will not last long during power outages.

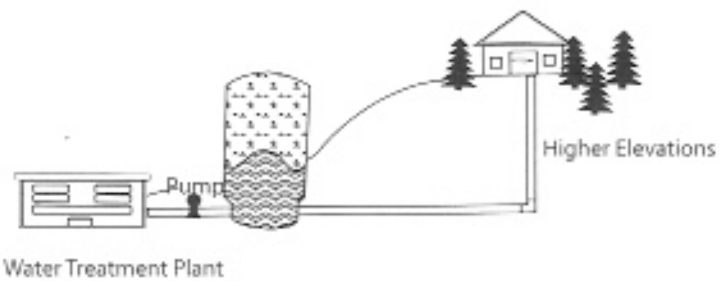
Variable Demand Pressure Pump

Variable demand pressure pump systems consist of a continuous-run pump with control values to divert flow not needed for demand around the pump and back into the pump intake. A similar system uses a variable speed motor reostatically controlled by pressure. These systems are utilized in much the same way as hydropneumatic systems. They can handle larger sections and can provide more volume. They require careful engineering, are rather expensive to purchase, but take up the least space.

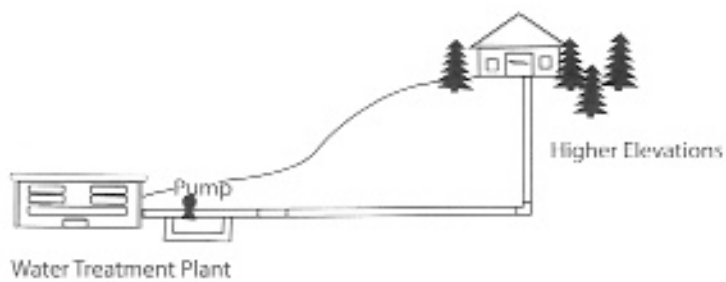
Some of the problems encountered with these systems are their high operating cost due to the continuous-run feature, higher maintenance frequency, and the total and immediate loss of pressure in a power outage.



Booster pump to an elevated tank



Hydropneumatic systems



Variable demand pressure pump

Comparing the Systems

	Merits	Limitations
Elevated tank with booster pump	Most reliable (stores large water volume) Least expensive to operate Can provide fire protection	Most expensive to construct Requires two sites: one for pump/one large site for tank
Hydropneumatic systems	Lower construction costs Requires only one site	Less reliable (stores small water volume) No fire protection
Variable demand pressure pump	Lowest construction cost Requires only one small site	Least reliable (no water storage) High operating costs

#16 Water Storage

Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University

Water towers are icons on the rural landscape and help people locate small communities from miles away. Elevated water tanks are the most visible portion of a water system. In addition to providing water pressure, these large tanks provide water storage. Water storage systems meet several needs.

Meeting Peak Demand

The demand for water at one time of the day may exceed the yield in gallons per minute of the water source and the treatment plant. Water storage tanks accumulate water throughout the day so it is available to meet peak demand.

Tanks

Storage tanks are made of concrete, painted bolted or welded steel, glass fused steel or factory coated epoxy steel. Concrete is the only material suitable for in-ground storage. Welded painted steel is the only material suited for elevated tanks. All types of tanks can be placed on top of the ground, but material selection means trade-offs. The most expensive materials need little maintenance, while lower cost materials require more maintenance.

Reserve Capacity

Storing enough water to meet community needs for at least 24 hours allows for flexibility in the operation of the water system. Treatment units can be operated during a standard day shift to fill the tank, storing water for night-time use. Reserve capacity in storage helps a community deal with power outages and water system emergencies.

Reserve capacity is also important for stream water sources if a contaminant spill occurs. The water system can turn off the intake as the contaminants flow by, drawing instead from clean water in storage.

Fire Protection

Water in storage is available to help fight fires. Remember, many small water systems cannot afford to store enough water to fight fires with potable water. In these cases, the drinking water system supplements the other water sources to fight fires.

Can You Store Too Much Water?

Yes. Finished water is treated with chlorine to provide residual disinfection throughout the distribution system. If stored too long, the chlorine can dissipate, losing the residual protection. Also, water stored too long can taste stale and pick up metallic tastes from tanks and pumps.

#17 Water Meters

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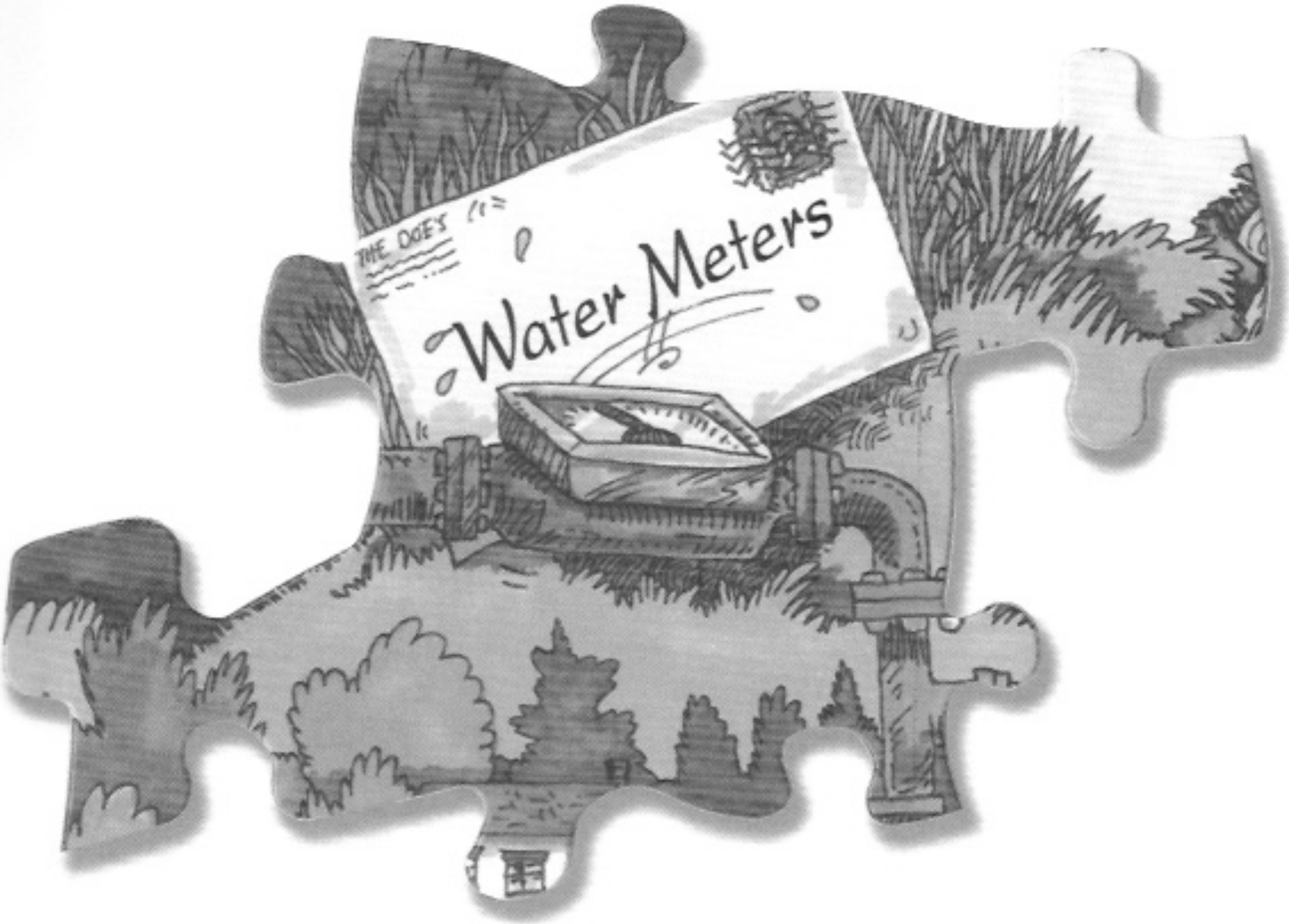

Since water systems are in the business of providing water to customers, water meters can be thought of as the system "cash registers." Water meters keep track of the product provided to the customer and can form the basis of billing for the service. Water meters serve four functions in a water system.

1. Monitoring Water Loss

Water loss is a part of all water systems. It takes water to treat water. Water is lost in backwashing filters, for example. Storage tanks and reservoirs sometimes overflow and lose water, and water is lost during hydrant flushing. Also, since water distribution systems are under pressure, any leaks result in water loss as the system is designed to leak out.

All water systems will lose 10% of the water they draw from the source in the operation of a water system. Typical water loss may be as high as 50%. Small systems should strive for about 20% water loss. Systems should be alarmed and take corrective action if more than 50% of their water is lost.

Water is lost to leaks, overflows, and even theft. Water is unaccounted for at unmetered taps, like hydrants, and taps with broken or worn meters. In some cases, water meters are missing in public buildings.

2. Water Conservation

When people know how much water they are using and have to pay for it, they may choose to conserve water. When unmetered systems add meters, they can expect a 10% to 40% drop in water use. Water conservation helps extend the life of a water system and enables a system to grow without expanding the source or treatment capacity.

3. Fairness

It is only fair that households and businesses that use the most water pay the most to support the water system. Meters at each connection are the tool to keep track of who uses the water. As the water system requires upgrades or expansion, information on water use will help in gaining customer support. Many financial institutions lending money to water systems now require meters to insure that every customer is paying their fair share.

4. Customer Contact

Meter readers may be the only water system employee the customers see. Meter readers can serve as ambassadors for the water system. They can share information on water conservation, upcoming maintenance, and upgrades in service. They can also listen to customers' concerns and bring them back to management.

#18 Removing Aesthetic Contaminants from Drinking Water

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Water may be safe to drink but may not be very pleasant to use. Contaminants that make the water taste or smell bad or look cloudy or colored are considered aesthetic contaminants. Some water has high levels of dissolved minerals that cause deposits to form in plumbing and interfere with cleaning.

In contrast, most toxic contaminants cannot be detected by smell, taste, or appearance. Aesthetic contaminants may not only make water unpleasant to use, but may cause customers to distrust the quality of their water, rejecting it in favor of better tasting, but less reliable water supplies or more expensive home water treatment or bottled water.

Aesthetic contaminants include:

Minerals	Metals	Naturally occurring organic compounds	Chemicals
Total Dissolved Solids (TDS)	Iron	Color	Chlorine
Calcium hardness	Manganese	Taste	
Magnesium hardness			
Chloride			
Hydrogen Sulfide			
Sulfate			

Iron and manganese discolor laundry and plumbing fixtures, and produce an unpleasant taste in beverages made with the water. Community water systems in Ohio are ***required*** to remove iron and manganese from drinking water where present.

Water systems have three options to remove iron and manganese.

Oxidation followed by filtration

Oxidizing agents, like air or chlorine, react with iron and manganese dissolved in water forming particles that can be filtered out. The filters must be cleaned by backwashing to remove the trapped particles.

Oxidizing filters

Filters filled with a special oxidizing media, sometimes called greensand, react with the iron and manganese dissolved in water forming particles. The particles are trapped in the filter. Oxidizing filters are cleaned by backwashing and reactivated with a potassium permanganate solution.

Lime-soda softening

The lime/soda softening process, described under hardness, also removes iron and manganese.

Some public water systems ***may choose*** to remove other aesthetic contaminants making the water more pleasant to use and saving the customers the trouble and expense of treating their water in their home or purchasing bottled water.

Hydrogen sulfide gives drinking water a rotten-egg smell. Groundwater supplies in northwest Ohio and in the coal mining regions of Ohio have hydrogen sulfide. It can be removed from water in two ways. Water systems often use both techniques.

Air stripping

Hydrogen sulfide is a dissolved gas and will come out of water when the water is mixed with large volumes of air. Water is usually sprayed over plates constructed of woven wire, perforated materials, or slats. Sometimes the water is sprayed over containers filled with coarse media. Fans force additional air up through the falling water droplets.

Oxidation followed by filtration

Oxidizing agents, like chlorine, react with hydrogen sulfide forming sulfur particles that can be filtered out. The filters must be cleaned by backwashing to remove the trapped particles.

Hardwater is caused by high levels of calcium and magnesium dissolved in water. Mineral deposits form inside plumbing and in water heaters, and the minerals combine with soaps and detergents to form films and gray deposits. Calcium and magnesium can be removed from water through two types of treatment processes.

Ion exchange water softeners

In public water systems, these are larger versions of a home water softener. Tanks filled with a special resin, called zeolite, are charged with sodium. As water moves through the resin, the calcium and magnesium are exchanged by the resin for sodium. Periodically, the resin must be recharged with sodium in the form of brine (sodium chloride salt). Since sodium is added to the water, the community needs to make an informed decision about adding extra sodium to their drinking water. Federal law requires informing local health departments about adding sodium to water so that they can in turn notify area physicians.

Lime/soda softening

The chemistry of the water is changed to precipitate, to settle and filter out calcium and magnesium from water. First quicklime and soda ash are added raising water pH and causing the precipitate to form and settle out. The resulting water has a high pH and is still saturated with calcium and magnesium. Carbon dioxide is then added to bring the pH back down to normal levels and redissolve the remaining calcium and magnesium. A certain level of calcium and magnesium in water is desirable because it protects the distribution system and customers' plumbing from corrosion.

Dissolved salts, measured as total dissolved solids (TDS) over 500 mg/l, can give water a salty taste. Much of the salty taste comes from high levels (over 250 mg/l) of chloride. If sulfate levels exceed 250 mg/l, sensitive individuals may experience diarrhea. Salts dissolved in water are difficult to remove. Membrane treatment technologies are available to desalinate water.

Reverse Osmosis (RO)

Reverse osmosis systems have historically been low yielding and high energy consuming, and producers of large volumes of wastewater. Membranes used in RO systems have carried a high replacement cost. Recent advances in low-pressure reverse osmosis and nano-filtration are making this water treatment approach more feasible.

Taste and odors may occur seasonally when leaves and algae blooms in lakes and reservoirs release naturally occurring organic compounds that dissolve in water. The chlorine added to water to kill pathogens can react with these naturally occurring organic compounds creating additional odors and tastes. Public water supplies use two treatment technologies to reduce taste and odors.

Potassium permanganate

Potassium permanganate is a purple/black crystal. When dissolved in water it acts as a strong oxidizer. Added just after water is brought into the water system, potassium permanganate oxidizes naturally occurring organic compounds to less objectionable compounds.

Activated carbon

A black powder (PAC) or granules (GAC) of activated carbon is added to the water early in the treatment process to adsorb naturally occurring organic compounds. The PAC is then settled and filtered out of the water before distribution. GAC may be incorporated into water filters or used in separate contactors after filtration. GAC is monitored as it adsorbs naturally occurring organic compounds and must be replaced when exhausted.

If water systems use both potassium permanganate and activated carbon, they cannot be added at the same time. At least 15 minutes of reaction time must be provided for the potassium permanganate before the activated carbon is introduced to avoid interference.

High chlorine levels can also lead to customer complaints of taste and odor. Careful adjustment of chlorine levels insures safe water to customers, while minimizing chlorine taste and odor.

#19 Filtering Microbes from Drinking Water

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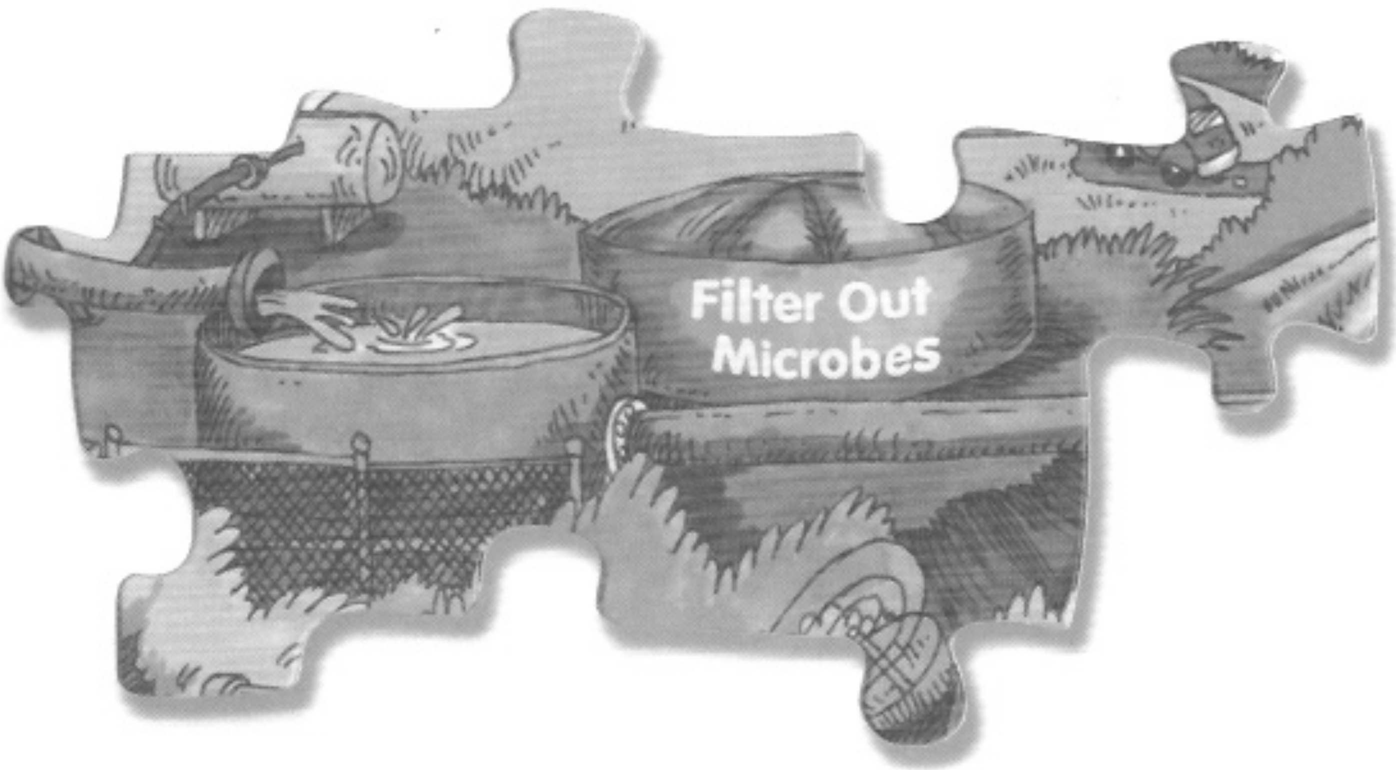

Microorganisms are a part of the natural environment. Most have little or no effect on human health. Some microorganisms are beneficial and even essential to human health. Unfortunately, a few microorganisms cause disease when they are present in drinking water. Waterborne diseases have caused serious illness and even epidemics. Listed below are common waterborne diseases along with their symptoms.

Waterborne Diseases

Waterborne Disease	Causitive Organism	Source of Organism in Water	Symptom
Gastroenteritis	Rotavirus Salmonella (bacterium) Enteropathogenic E. coli	Human feces Human or animal feces Human feces	Acute diarrhea or vomiting Acute diarrhea or vomiting Acute diarrhea or vomiting
Typhoid	Salmonella typhosa (bacterium)	Human feces	Inflamed intestine, enlarged spleen, high temperature; sometimes fatal
Dysentery	Shigella (bacterium)	Human feces	Diarrhea; rarely fatal
Cholera	Vibrio comma (bacterium)	Human feces	Vomiting, severe diarrhea, rapid dehydration, mineral loss; high mortality
Infectious hepatitis	Hepatitis A (virus)	Human feces, shellfish grown in polluted waters	Yellowed skin, enlarged liver, abdominal pain; low mortality; lasts up to 4 months
Amoebic dysentery	Entamoeba histolytica (protozoan)	Human feces	Mild diarrhea, chronic dysentery
Giardiasis	Giardia lamblia (protozoan)	Human and animal feces	Diarrhea, cramps, nausea, and general weakness; not fatal; lasts 1 to 30 weeks
Cryptosporidiosis	Cryptoporidium (protozoan)	Human and animal feces	Diarrhea, stomach pain; lasts an average of 5 days

Source: Adapted from American Water Works Association, Introduction to Water Treatment: Principles and Practices of Water Operations, Denver, CO 1984

One of the critical goals of water treatment is to remove disease-causing microbes from water. The removal techniques vary based on the size of the microbe being removed. Parasites are the largest disease-causing organisms, followed by bacteria. Viruses are the smallest pathogens. Removing microbes from drinking water is a multi-step process. A variety of water treatment techniques are used to effectively and reliably filter out pathogens. For groundwater supplies filtration is a natural process, while artificial systems are used for surface water supplies.

Groundwater

The natural properties of unsaturated soil attract and trap pathogenic microbes. Once trapped, disease-causing organisms either die-off or become food for soil microbes. This wonderful, simple system protects groundwater from pathogens.

Surface Water and Groundwater Contaminated by Surface Water

Surface water sources have not been filtered through unsaturated soil. Also, some groundwater supplies are directly connected to surface water sources and can be contaminated with disease-causing microorganisms. To treat surface water, artificial systems substitute for the properties of natural soil. Four types of systems filter disease-causing organisms from surface water.

1. Slow-sand filters

Slow-sand filter systems have been used for over a century to treat drinking water. Water is ponded on the surface of more than a 1-foot deep layer of fine sand. The sand is colonized by natural soil microbes forming a layer of organic matter on the sand surface. Pathogens become trapped in the layer of organic matter, called a schmutzdecke, and are either preyed upon by the natural soil microbes or are periodically removed by scraping off a portion of the accumulated organic matter.

2. Membrane filters

First introduced for drinking water treatment in the 1980s, membrane filtration has been used in the food processing and pharmaceutical industries for decades. Simply put, membrane filters with very small pores strain out the parasites, bacteria, and in some cases, even viruses from water.

3. Bag and cartridge filters

Another approach to filtering out larger pathogens like parasites and some bacteria is to use filters constructed of wound fibers or bags filled with fibers. While initially less expensive than membranes, their reliability must be established. Bags and cartridges must be frequently replaced.

4. Rapid sand filters

Rapid sand filters are currently the most established and widely used method of removing pathogens from drinking water. Treatment occurs through a multiple-step process in a series of tanks as shown in Figure 1.

Surface water contains suspended particles, sometimes called turbidity, and pathogens that naturally repel each other. Chemicals, called coagulants, are first added to the water that can break down the natural repulsion and allow the suspended particles and the pathogens to stick together.

The next step is to gently stir the water to cause the particles to collide and form bigger particles called floc. Once the floc particles are large and dense enough, they are separated from the water in basins called settling basins or clarifiers.

The last step is to filter out any remaining turbidity in a tank containing specially selected sand several feet deep.

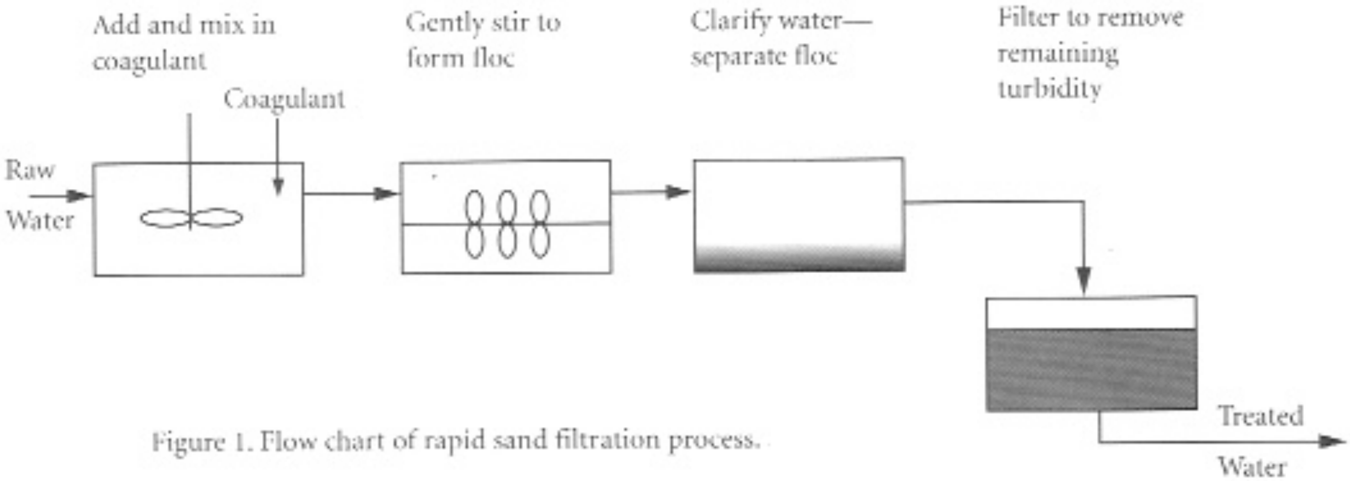

Figure 1. Flow chart of rapid sand filtration process.

Management of Filter Systems

Overall the final filtration of drinking water is the most critical step in pathogen removal. Proper water filtration through either natural, unsaturated soil, or artificial filter systems protects water system customers from disease.

To protect the public health, water filtration systems require careful:

- selection
- installation
- maintenance
- operation
- oversight
- administrative support

#20 Water System Disinfection and Byproduct Control

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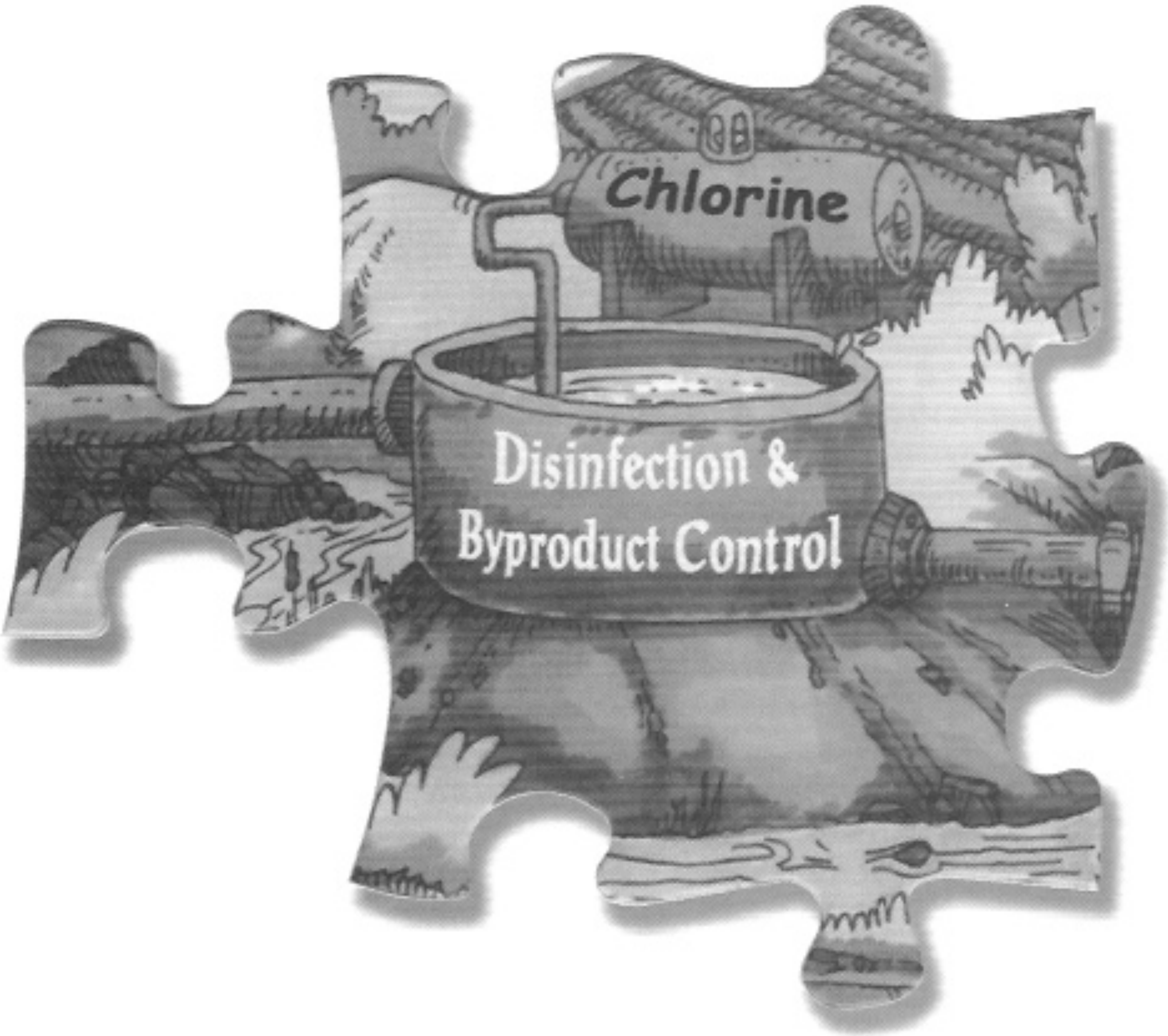

To protect the public health, a public water supply must be free from disease-causing organisms. Disinfection is one step in eliminating pathogens. Chlorine is the most commonly used disinfectant in public water supplies throughout Ohio. Other disinfectants are also being used. All disinfection systems have merits and limitations. Communities must decide which system gives them the merits they want with the limitations they are prepared to live with.

Purpose of Disinfection System

Disinfection is the last step in removing and eliminating pathogens from a drinking water supply. Surface water is first chemically treated, clarified, and filtered to remove particles and microbes. Fortunately, groundwater is often protected with a layer of unsaturated soil that filters out microbes.

The disinfectant is selected first to kill any remaining pathogens. It is not necessary to kill every microorganism (or sterilize) a water supply to disinfect it. The second purpose of disinfection is to provide a residual that continues to kill microbes throughout the distribution system. The residual guards against recontamination. Third, the residual provides a quick indicator of safe water.

How Chlorine Disinfects Water

Chlorine kills microorganisms, but it takes some time. Chlorine must be in contact with microorganisms for a few minutes to ensure disinfection. The amount of time depends on a number of things.

More chlorine	Less time
Higher water temperature	Less time
Higher water pH	More time
Cloudy water (high turbidity)	More time

Contact time is provided in storage tanks called clear wells. Once the necessary contact time is achieved, the water can be distributed to customers. One of the advantages of chlorine is that it continues to disinfect the water as it moves through the distribution system. This residual disinfection helps protect the customer from contamination after the water leaves the treatment plant. Chlorine residuals are also easily measured at taps throughout the system to verify that all of the customers receive safe water.

While chlorine does an excellent job of killing bacteria, it is not effective at killing parasitic cysts like Giardia lamblia or Cryptosporidium. Both of these organisms have caused outbreaks of diarrhea and gastrointestinal cramps in the United States. To overcome this limitation, surface waters from streams, lakes, or reservoirs must be clarified and filtered along with adding chlorine.

Methods of Adding Chlorine to a Water Supply

Three formulations of chlorine are used in water treatment systems: chlorine gas, liquid hypochlorous acid (bleach), or powdered hypochlorite (HTH). Chlorine gas and HTH must be dissolved in water before or as it is injected into the water system. Each also offers merits and limitations.

Chlorine Formulation	Merits	Limitations
Gas	Low chemical cost	Very hazardous
	Strong disinfectant	Needs special handling equipment Requires special training to use Requires separate, well-ventilated room Emergency planning required
Liquid	Easy to handle	Requires large volume
	Simple injection equipment	Loses strength in storage Highest chemical cost
Powdered	Easy to store	Requires mixing equipment
	Simple injection equipment	Medium chemical cost Loses strength in storage Forms deposits on equipment

Objections to Disinfection

It is surprising that some people object to disinfection of drinking water. Unfortunately, the disinfectants available today are not perfect and can introduce undesirable side effects.

One common complaint about some disinfectants is that they change the taste of the water or can create an odor in the water. While not unsafe, this interferes with some people's use of the water.

A more critical concern is the potential for some disinfectants to create toxic byproducts. Some disinfectants react with naturally occurring compounds in the water to create toxic combinations. For example:

Naturally occurring organic compounds + Chlorine + Time = THMs

Most surface water supplies contain naturally occurring organic compounds from the decomposition of leaves, algae, and other living things. Over time, these compounds, called precursors, combine with chlorine and form compounds called trihalomethanes (THMs). Some trihalomethanes are suspected carcinogens.

Because disinfectants are chosen for their ability to kill pathogens, they can present a hazard to water system employees and nearby residents. Disinfectants are often purchased in concentrated form to reduce cost and storage space, but these concentrates increase the hazard.

Other Choices

Because no ideal disinfectant exists, a community must make compromises. Listed below are some of the effective disinfectants used in small water systems. The merits and limitations of each are summarized.

Disinfectant	Merit	Limitation
Chlorine	Inexpensive Proven technology Easily measured residual Flexible formulation and equipment choices	Taste and odor concerns Can form byproducts (THMs) Safety hazard with chlorine gas
Combined Chlorine (with ammonia)	Long lasting residual Lower potential for byproducts	Taste and odor potential Weaker disinfectant Hazardous to tropical fish and dialysis patients Safety hazard with chlorine and ammonia gas
Ozone	On-site generation No taste or odor	Expensive Ozone off-gas hazard to operator No residual in distribution system Can form byproducts (bromates)
Iodine	No electricity needed Easily measured residual	Taste and odor concerns Health concerns of excessive iodine consumption Can form byproducts (iodized THMs)
UV	On-site generation No taste or odor	Electrical cost Careful equipment care and oversight No residual in distribution system Emerging technology

Strategies to Overcome Limitations

Don't be discouraged about all of the concerns with a disinfectant. The system designer and operator can both work to reduce or eliminate a limitation. For example, safety concerns can be addressed through:

- Design and installation of appropriate storage and feeding facilities.
- Training of operators to ensure safe use of disinfectants.
- Periodic review and oversight of equipment and procedures.
- Emergency contingency plans in place and communicated to all water system staff.

Taste and odor concerns are another limitation of some disinfectants, especially chlorine. Chlorine taste and odor problems occur when chlorine residuals are higher than necessary. This is a common problem in systems in rural areas with long distribution lines. The system designer and operator can both work to reduce or eliminate a taste and odor limitation through:

- Regular monitoring and adjustments to keep chlorine residuals adequate to protect customers without leading to offensive taste and odor.
- Installing and maintaining chlorine booster stations throughout the system to work to maintain a more constant and adequate chlorine residual that is neither too high nor too low to protect all system customers.

#21 Lead and Copper Corrosion Control in Water Systems

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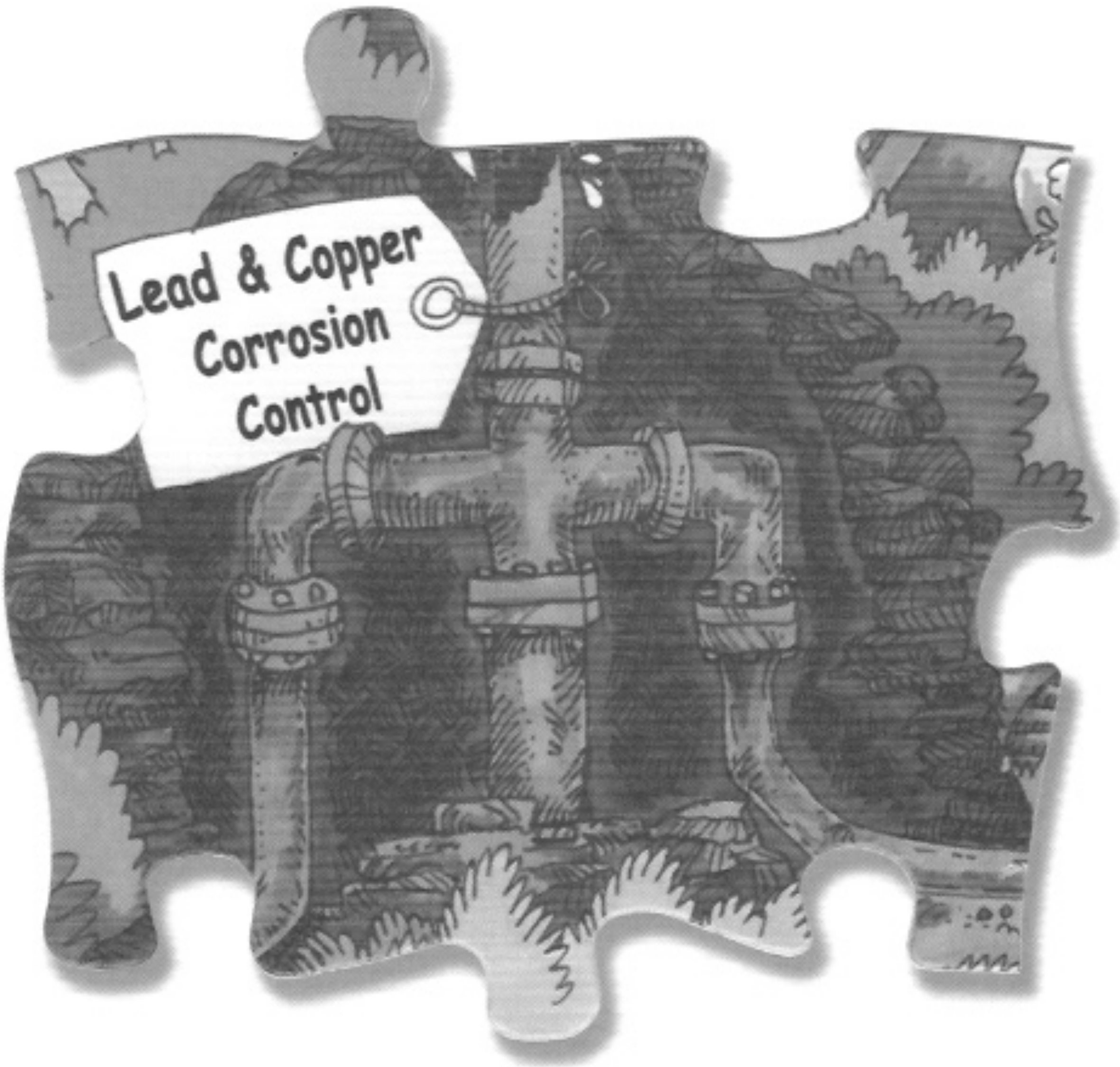

It is rare that lead or copper is found in water sources naturally. Since household plumbing is often constructed with copper pipe and brass fittings connected by solder that may contain lead, household plumbing is the most common source of lead and copper in drinking water. In very old water systems, lead pipes and fittings can still be found. If water distributed through the system is corrosive, metals can leach into drinking water.

Why is lead a problem?

Lead has no benefit in drinking water. Therefore, the goal for lead levels in water is zero. Lead can cause a variety of health effects when people are exposed to excessive levels for a short period of time. These effects include interference with red blood cell chemistry, delays in normal development in babies and young children, slight deficits in attention span, hearing, and learning ability in children. Slight increases in blood pressure occur in some adults. Lifelong exposure has the potential to cause stroke, kidney disease, or cancer.

To avoid even short-term exposure, an action level of 15 parts per billion (ppb) has been set by US EPA.

Why is copper a problem?

The most obvious sign of copper in water is green stains that develop on plumbing fixtures. At low levels copper is an essential nutrient. Copper is found in vitamin/mineral pills. However, at higher levels people can suffer stomach and intestinal distress, liver and kidney damage, and anemia. Persons with Wilson's Disease may be more sensitive than others to the effects of copper.

To avoid even short-term exposure, an action level of 1.3 parts per million (ppm) [that is 1300 ppb] has been set by US EPA.

To guard against exposure of lead to water system customers, the U.S. Congress added the lead/copper rule to the Safe Drinking Water Act when it was amended in 1986. The rule took effect beginning in 1991. While the rule is complicated, water systems throughout Ohio have worked to protect their customers and comply with the law. To review the rule check *www.epa.gov/safewater/dwh/c-ioc.html*.

How do water systems control lead and copper in drinking water?

Since lead and copper are rarely present in the source water, water systems must work to keep lead and copper from dissolving into their water from the plumbing in people's homes. Water systems go through a series of steps to deal with lead and copper concerns.

Step 1. Monitor, in customers' homes, water that has stood in their plumbing for at least 6 hours. In this way if the water is corrosive, the first glass of water drawn after a night of standing in contact with household plumbing will show the highest expected lead and copper levels.

Step 2. If at least 90% of the required household samples are below 15 ppb lead and/or 1.3 ppm copper, the water supply is **not required** to treat the water to reduce corrosion. However, the system must continue to monitor for lead and copper.

Step 2. If more than 10% of the required household samples exceed 15 ppb lead and/or 1.3 ppm copper, the water supply **must install** water treatment equipment to reduce the corrosivity of the water. If lead exceeds 15 ppb, the water supply must also notify their customers.

#22 Monitoring Drinking Water Sources

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Monitoring a drinking water source is one tool an operator uses to improve the efficiency of a system. Source water monitoring is done in four situations:

1. **Early warning of contamination** or changes in water quality is gained through periodically monitoring a water source. The frequency of this type of monitoring ranges from daily for a surface water source to monthly for groundwater. With monitoring information, a water system operator can make adjustments in their operation to minimize the impact of contamination on the water system. Actions that could be taken include making a shift in a water source to let contamination diminish, blending water sources appropriately, or adjusting treatment procedures to minimize costs while providing safe water to customers.

2. **Changes in water chemistry** occur quickly in surface water sources with weather and runoff. Water temperature, pH, and turbidity all affect water treatment processes and need to be monitored. Some water systems soften water for customers and need to monitor hardness and alkalinity to make necessary adjustments in treatment procedures.

3. **Contaminants present in a water source** at even threshold levels may require monitoring. While not an immediate health threat, increases in these contaminants can put them over legal maximum contaminant levels. In these cases, Ohio EPA will specify a monitoring frequency based on the nature of the public health threat.

4. **Source designation** testing is an issue for new groundwater sources. Regular testing of a well for total coliform bacteria and turbidity is required to prove that a groundwater supply is not influenced by surface water. This testing may be required for a year or more.

Continual evaluation of a water source may indicate a need to develop a different source. The expense of new water source development may be less than the continual testing and treatment of a source with poor water quality. Regular source water testing gives water system managers and operators the information they need to make decisions for the future.

#23 Monitoring Drinking Water for Contaminants

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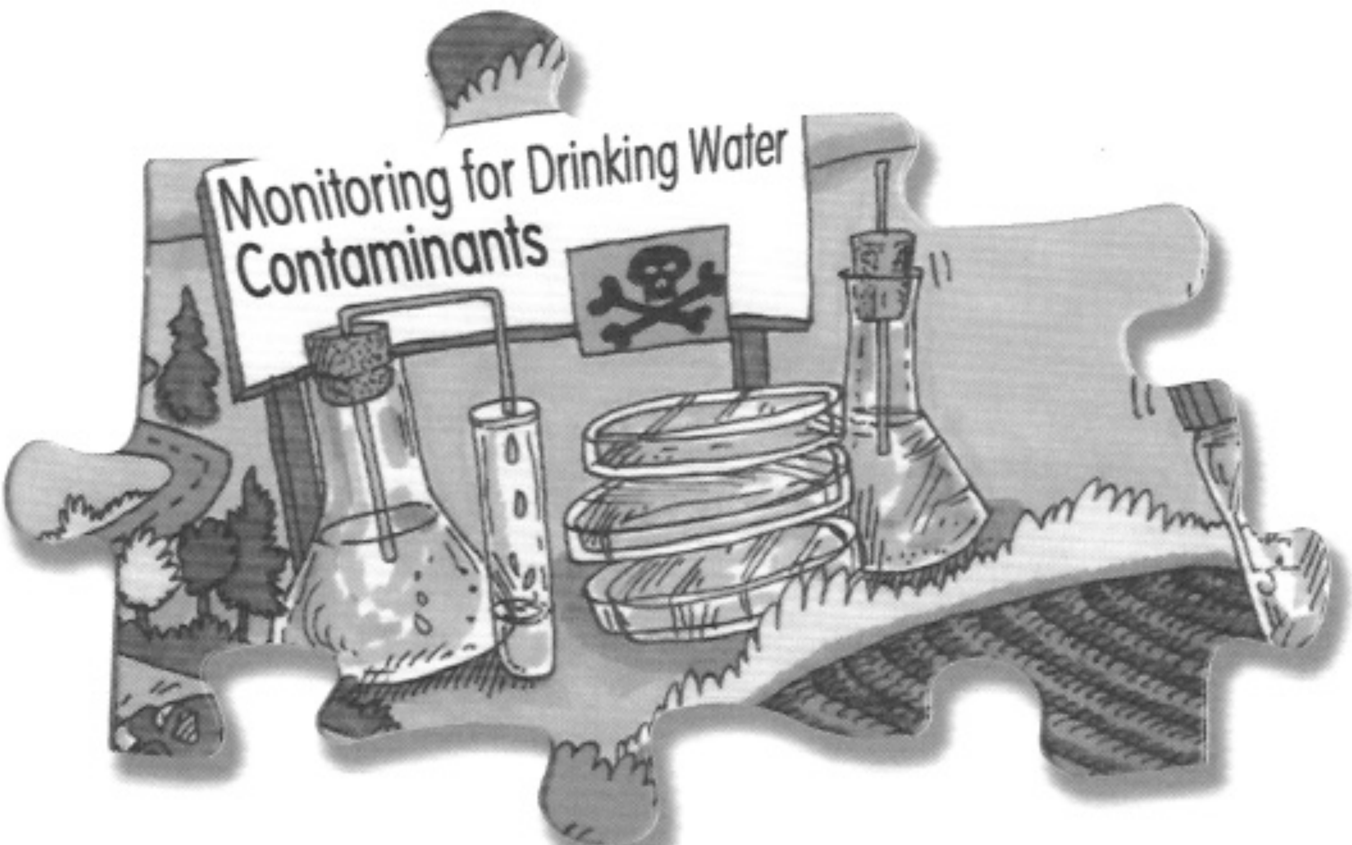


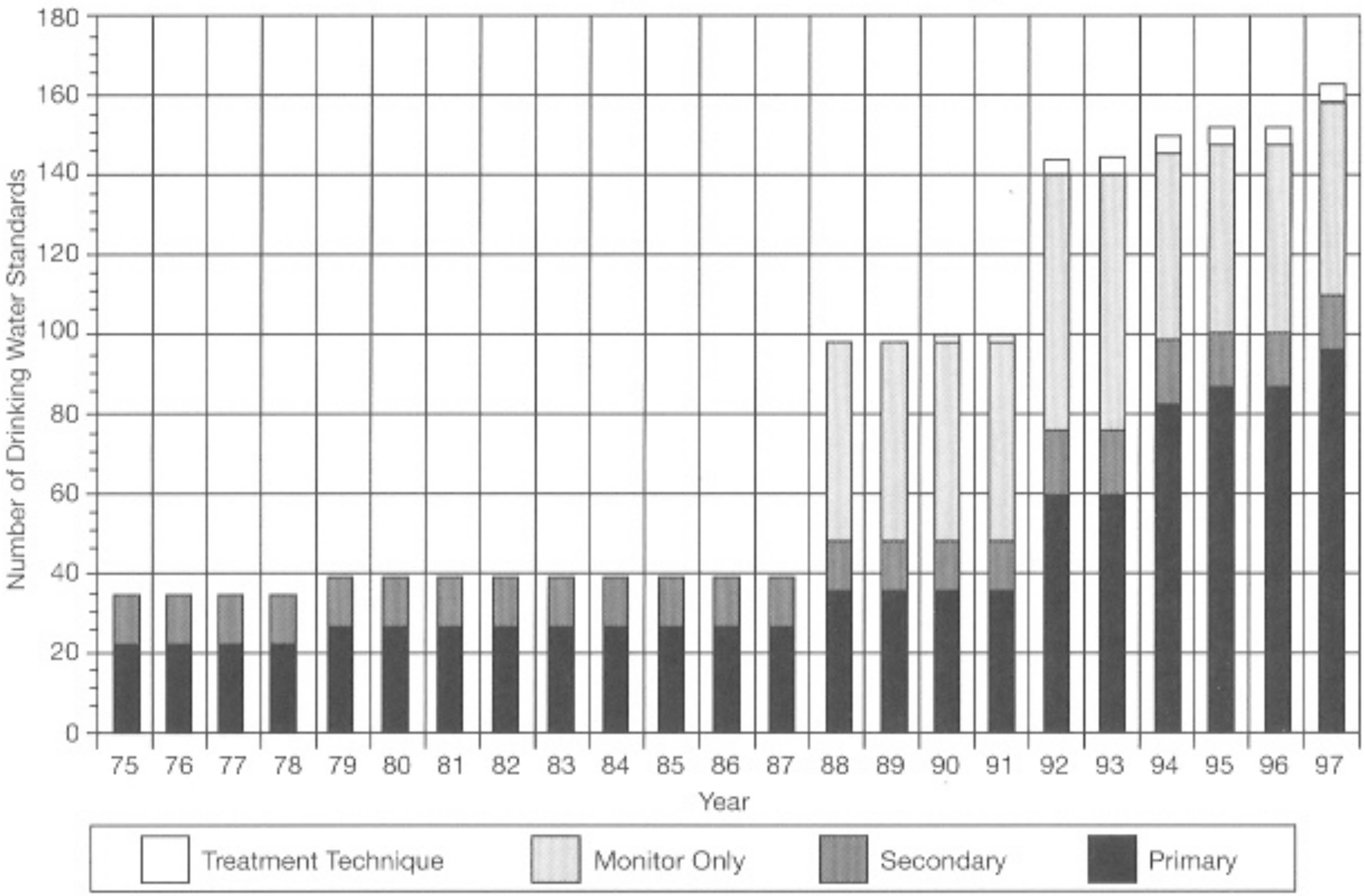
Because water testing is expensive, US EPA has put steps in place to minimize sampling requirements based on the number of customers, the water source, and the history of contaminant detection. If no contaminants are detected, monitoring schedules may be safely reduced. Due to the complexity of setting drinking water monitoring schedules for chemical contaminants, the monitoring schedules are prepared for each public water system by Ohio EPA Division of Drinking and Groundwater. Monitoring schedules for lead, copper, and bacteria are issued by the Ohio EPA district office.

Chemical Monitoring for Less Than 10,000 Population

	Type of Water System		
	Community (where people live)	Nontransient (where people work)	Transient (where people visit)
Nitrate	x	x	x
Nitrite	x	x	x
Radionuclides	x		
Asbestos	x	x	
Inorganic chemicals	x	x	
Volatile organic chemicals	x	x	
Soluble organic chemicals	x	x	
Disinfection byproducts	x	x	

New monitoring requirements are being enacted for disinfection byproducts. Surface water sources will be impacted first, followed by groundwater sources.

Figure 1. Number of drinking water standards imposed on community water systems from 1975 to 1997.



#24 Monitoring Drinking Water Distribution to the Customer

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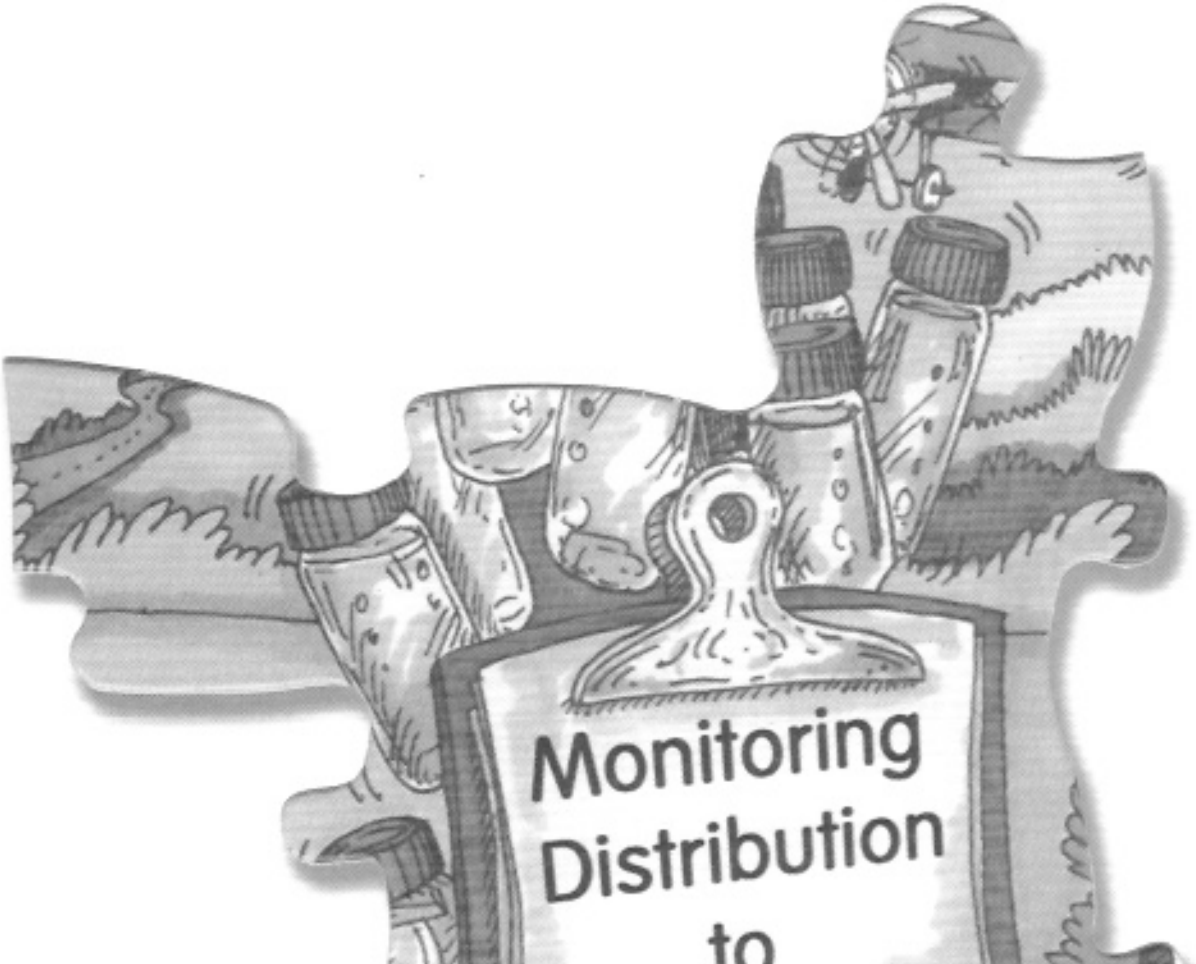

The quality and quantity of water can change as it moves through a distribution system.

- Water comes in contact with tanks, pipes, fittings, and fixtures.
- Contaminants may be drawn into a water system or even be forced into the system. Leaks, breaks, backflows, and cross connections all threaten water quality.
- As water is stored in a distribution system the quality degrades with time. Chlorine residuals dissipate; corrosion products, like lead and copper, may increase; and disinfection byproducts may form.
- Breaks and overflows can result in water loss and property damage.

Quantity

A simple yet overlooked aspect of distribution monitoring is rectifying meter readings with the water produced by the system. Differences in what is produced versus what is paid for could be the result of leaks, breaks, overflow, theft, and inaccurate, worn, or missing meters.

Disinfection Byproduct Monitoring

The monitoring program for disinfection byproducts began with the Safe Drinking Water Act of 1974. However, when rules were first adopted in 1979, monitoring was limited to large water systems and only one group of compounds known as THMs. Beginning in 2002 all surface water systems and systems that purchase water from surface water systems must begin monitoring for disinfection byproducts quarterly. Requirements for testing all groundwater systems will begin in 2004.

Since disinfection byproducts form with time and form more rapidly in warm water, the timing and sample location are regulated. For groundwater systems serving less than 10,000 people, samples must be taken when the water is warm and at points in the distribution system where the water is "oldest."

Bacteriological Sample Siting Plan

To ensure that every tap delivers safe water, the distribution system operator must check the quality of water at representative points throughout the system. A plan for checking the distribution system should include:

- Sample locations that are evenly spread throughout the distribution system.
- Instructions on how to properly collect samples.
- Certified laboratories available to run analysis.
- Instructions on response to positive bacteria tests.

Monitoring Program for Lead and Copper

During the mid-1990s all Ohio water systems conducted a lead and copper survey of their service connections. Based on those findings, segments of the distribution system were classified into one of three tiers. This initial survey forms the basis of ongoing monitoring with tier one receiving the most attention.

Monitoring Chlorine Residual

Chlorine is added to finished water to kill pathogens that may enter the distribution system. Chlorine residuals are easy to check as an indicator of contamination. Monitoring chlorine residuals is one of the most important tools available to a distribution system operator.

The goal for chlorine residual is to provide enough chlorine for customer protection (at least 0.2 mg/l free chlorine or 1.0 mg/l combined chlorine) but not too much to cause taste and odor complaints or form excess disinfection byproducts. Chlorine residuals must be monitored in two ways:

1. daily in the distribution system.
2. at the time and place where bacteria samples are collected.

#25 Water Testing Laboratories

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Water testing is an involved procedure. Special equipment, training, and protocols are necessary to maintain reliable results. Some water systems operate their own water testing laboratory. Most small systems, however, have difficulty justifying the training and facilities necessary to keep a lab certified. Fortunately, certified laboratories operate all over Ohio to conduct the necessary water tests for public water supplies.

Certified labs must undergo a quality assurance/quality control (QAQC) review by Ohio EPA staff to ensure that they generate reliable data. The review examines how they do water tests, that they are following test procedures, and that their results are accurate.

1. Laboratory plans for Certified labs are submitted to Ohio EPA to assess that a lab has appropriate equipment and adequate bench space.
2. On-site surveys review the analyst's credentials and performance. Laboratory records and quality control procedures are also reviewed. If deficiencies were noted, a check for corrections is included in the review.

   Certifications can be up to 3 years. Shorter times may be granted to labs if problems are noted.
3. Unannounced surveys are conducted based on concerns about data or if the lab has a history of problems.

Ohio EPA maintains a list of certified labs that is updated quarterly. The list shows each lab and the tests they are certified to conduct, but does not include prices. Water systems should shop around to get the most competitive prices.

The most up-to-date lab list is sent to public water systems each year with their list of monitoring requirements. The list is also posted on the web at *www.epa.state.oh.us/ddagw/pubs.html#certlabs*.

Examples of Cost

New water wells must be tested before they can be used by a community water supply.

Lab 1	$743.40
Lab 2	$1,451.00
Lab 3	$769.00
Average	$987.80

A new surface water source requires testing every 3 months over a year before it can be used by a community water supply. Testing averages $4,000.

Compliance monitoring for a wide range of contaminants is done on a yearly basis. In the first year these costs average $1,300.

It is important to establish a working relationship with a testing lab. Labs can be certified for different tests. They may be able to subcontract with another certified lab if your system requires additional tests. This simplifies a water system's billing and record keeping.

#26 Water System Monitoring Recording and Reporting

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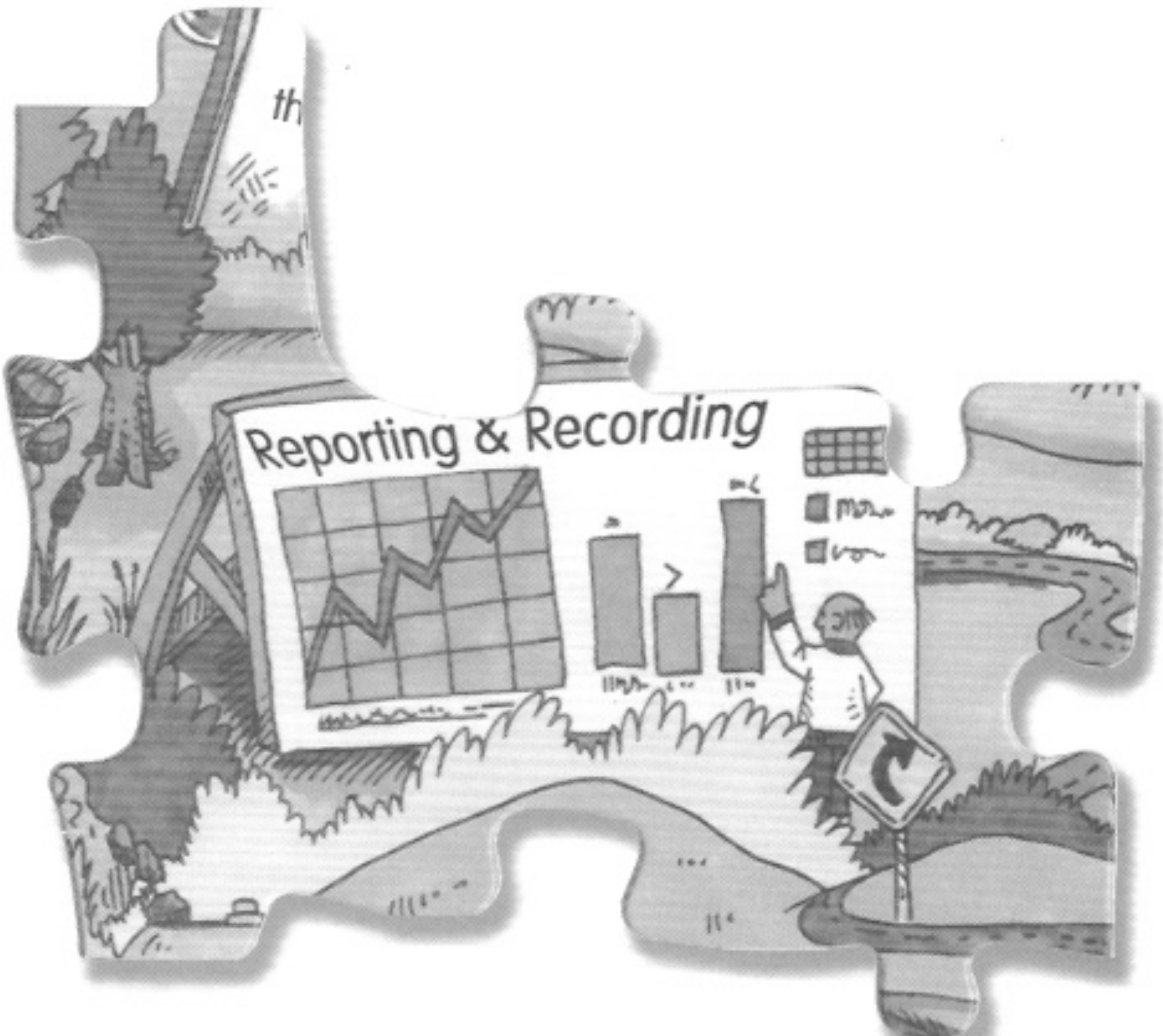

Any facility that produces a product and supplies it to customers must keep track of its operations. Water systems are no different. People who rely on reports are:

- operators who continually adjust, maintain, and troubleshoot water system components.
- managers who oversee water system performance.
- authorities or owners who must plan for the future and settle ongoing obligations.
- regulators who are charged with protecting the public interest, such as health and safety.

Water systems are required to submit monthly operating reports to the district offices of Ohio EPA. Many water systems work with laboratories to test the water and in turn submit the report. The water system is ultimately responsible for reporting to Ohio EPA. They must follow up with the lab to be sure the reports are sent in a timely manner.

Code numbers are used to link the result to the sampling point. The report must include:

1. Public water system name.
2. ID number—a 6 or 7 digit number assigned to the public water system by the Ohio EPA district office.
3. STU number—another 6 or 7 digit number assigned to the public water system by the Ohio EPA district office to designate each separate treatment unit in the system.
4. Contact person and phone number.
5. County name and address.
6. Sample monitoring point number—2 letters and 3 numbers assigned for each monitoring point. For example, DS001 would stand for distribution system at point #1.

Some of the reports generated at water systems include the following.

Drinking Water Operational Report

This report summarizes the amount of water being produced and includes daily water production, minimum chlorine residuals, and water chemistry as indicators of water treatment effectiveness.

Drinking Water Monthly Contaminant Report

This report summarizes the monthly bacteria test results. The report also includes the matching chlorine residual levels for each bacteria test.

Surface Water Treatment Report

Turbidity levels of the finished water are recorded and reported to guard against the introduction of pathogens that can "hide" in cloudy water. In addition, this report plots the disinfection practices of a water system to ensure adequate contact time between finished water and the chlorine.

Fluoride Operation Report

Monitoring results for fluoride and the amount of fluoride compound used daily must be recorded and reported.

#27 Water System Operation and Maintenance

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The weekend operator stops in at the water plant Sunday morning to conduct her routine checks. No chlorine residual is detected in the water being delivered to the town. After further inspection, she discovers the chlorinator is broken. She is unable to find the spare parts inventory in the file and finally finds it in a pile of paperwork. The inventory shows a spare chlorinator is on hand, but it is not in the storage area.

She calls the water superintendent who is running the annual church BBQ. He says that the spare chlorinator was used and a replacement has yet to be ordered. The superintendent has to issue a boil water order for the town. Since the Sunday paper is already out, public employees must be called in and paid overtime to go door-to-door to notify each customer. The church must also bring in bottled water for the BBQ.

The operator calls around to find a replacement chlorinator. Because it is on a weekend, she calls the supplier's emergency number to get overnight delivery. The supplier is able to supply the chlorinator at an additional premium charge.

Operation and maintenance (O and M) are essential practices in any reliable water system. Regular operation and preventative maintenance allows operators to detect and correct malfunctions before they turn into major problems.

Water system operations are all the necessary activities to **provide safe water** to the customers. Routine operations fall into three phases:

1. **Start-up**—the operator first checks the notes from the previous shift. Next, the reservoir levels are checked. The operator follows standard procedures for starting up equipment, along with checking and refilling chemical feeds.

2. **Daily operations**—water testing, washing filters, and checking chemical feeds are just some of the routine operations performed by the operator. Addressing calls from customers can also be an important part of daily operations.

3. **Shut down procedures**—after checking levels in the reservoirs, equipment and chemical feeds are turned off following standard procedures. Notes on the events of the day are logged for the next day before they are filed for future reference.

It is important to have standard documents to refer to and to record information on plant operations. An operations manual and a daily operations log are two necessary items in any water system. The operations manual serves as a guide for both daily operations and seasonal variations. Since things like changes in temperature or rainfall can change the conditions of the raw water, the operations manual helps to ensure that the customers can rely on a constant supply of safe water. It is important to note, however, that the manual still serves as a guide. Problems may occur that are not covered in the manual.

Operations Manual

Table of Contents

I. Start-up

  A. Facility plan with details on equipment locations

  B. Sequence of turning on pumps and equipment

  C. Map of plant showing detailed instruction cards for each piece of equipment

II. Daily operations for various raw water conditions

  A. Chemical dosages

  B. Testing

    1. Laboratory procedures

    2. Sampling locations

  C. Mixing energies

  D. Residual withdrawals

  E. Flow

  F. Loss of head

  G. Backwashing procedures

III. Shut-down

  A. Sequence of turning off pumps and equipment

IV. Detailed plan of valves at plant

V. Detailed plan of valves in distribution system

VI. Safety

Example

Daily Operations

Chemical Feeds	Log Weights	Time

Operator Comments:

Water Volumes	Water levels	Time

Operator Comments:

Water system maintenance consists of all necessary activities to **sustain and protect the water system equipment** for the owners. Routine maintenance falls into four phases:

1. **Routine lubrication and care of pumps and equipment**—All the mechanical equipment in a water system requires regular maintenance if it is to serve the system for decades. Equipment in water systems is in wet environments often exposed to corrosive chemicals. Routine care extends the life of the equipment saving the system money and most importantly guards against interruptions in service.

2. **Housekeeping**—Cleaning floors, mowing the grass, removing snow, and hauling away refuse are all necessary maintenance tasks in a safe and pleasant work environment. Unfortunately, if time is short and an operator must set priorities, housekeeping is often sacrificed to direct time to plant operations to provide safe water. While having a clean restroom or lunch area may not seem critical, poor housekeeping reflects poorly on the water system and reduces employee morale.

3. **Painting**—A water system is intended to serve a community for decades and unfortunately the original coat of paint on buildings, tanks, hydrants, and towers does not. Painting and repainting facilities and equipment is an ongoing maintenance responsibility for a water system.

4. **Spare parts and supplies**—Having the necessary parts, supplies, and replacement equipment on hand at all times guards against service interruptions, wasted time, and expensive shipping charges when the need arises. Even the most well-maintained plants will have breakdowns. Maintaining a spare-parts inventory keeps a minor problem from becoming a major crisis.

Maintenance Guide

Table of Contents

I. Equipment

  A. Maintenance schedule

  B. Written procedures for preventative maintenance

  C. Manufacturer's manual

  D. List of spare parts

II. Inventory of spare parts and supplies

  A. Record of inventory and replacement

  B. Supplier addresses

  C. Price lists for key parts

III. Routine housekeeping

  A. Key area

  B. Duty assignments

  C. Cleaning schedule

IV. Painting

  A. Key areas

  B. Duty assignment

  C. Painting schedule

Example

Maintenance Log

Today

  Sweep area #5

  Clean bathroom and lunch room

  Empty trash from lab

This week

  Lubricate pump #3

  Run emergency generator motor

  Mow around tank #2

This month

  Drain and clean basin #1

  Paint trim on building #2

  Restock cleaning supplies

  Run emergency generator under load

Repair record

  Today—had to repair leak in line #15

  Noticed a puddle by #2 chemical feed—check on it tomorrow

#28 Certified Water System Operators

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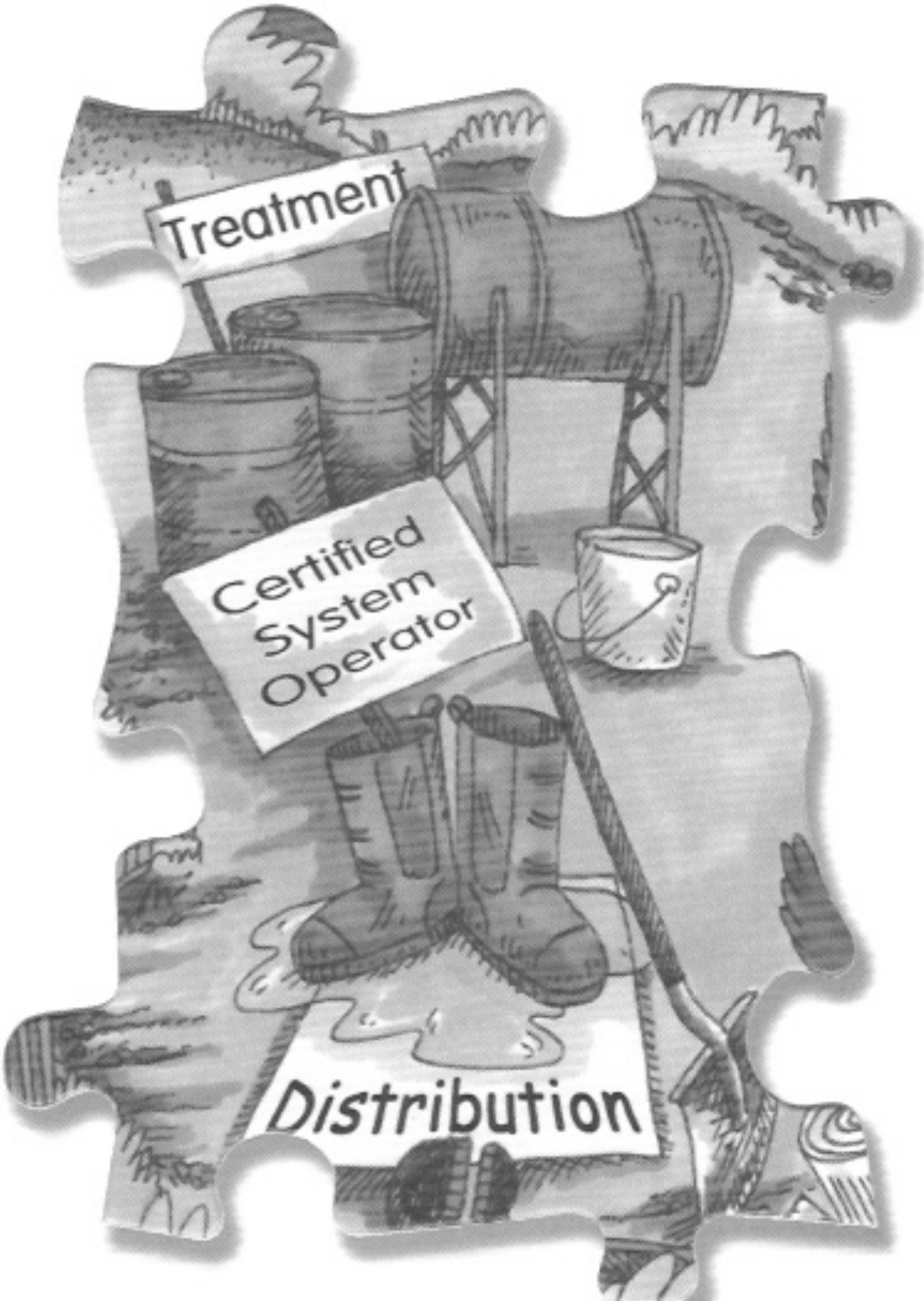
The Ohio State University



A certified operator is a trained professional who has passed a State of Ohio examination. The certified operator is on the front lines protecting the public health. In a small community with a small staff, certified operators are special people. They need to be:

- self-starters,
- able to work on their own,
- very responsible and dedicated, and
- a good representative of the water system to the customers.

All public water systems, both community and nontransient, noncommunity, serving more than 250 people must have a certified operator. A nontransient, noncommunity public water supply serves places where people work, such as a school or a business. Even a water system that purchases water from another water system for more than 250 people must have at least a certified Class I distribution operator.

The water source, groundwater or surface water, will determine the level of certification required in an operator. Public water systems that draw groundwater for at least 250 people must be overseen by at least a certified Class I water operator. Systems that serve as few as 25 people that use surface water or treat groundwater with precipitative softening must have a certified operator. Higher classifications for distribution and water operations are required for more complex water systems.

Operator certifications are granted by the State of Ohio, therefore, they are not tied to an individual water system. Operators, once certified, can move from water system to water system. With this in mind, it is important for a community to compensate professional certified operators at a competitive level. All too often certified operators for small systems choose to accept positions at larger facilities with higher salaries and better benefits.

Example

A person working in the maintenance department of a rural school system goes to the effort to work through the training and passes the exam to become a Class I operator. She is then put in responsible charge of the water systems for five schools in the district. After one year of oversight and operations of these five water systems serving 1,500 students, teachers, and staff, a job for a Class I operator opens up at a nearby city system. The job offers double the salary, improved insurance benefits, and two weeks vacation. The school district loses their certified operator and after notifying Ohio EPA they are put on a compliance schedule to find a properly certified replacement operator.

Because certified operators are professionals, they must keep up-to-date. Professional publications, meetings, conferences, and training sessions are all important in the development of a certified operator. The State of Ohio requires that certified operators obtain a minimum number of continuing education contact hours at professional training events to maintain their certification.

Typical Classification of Drinking Water Systems Serving 250–3,300 People

	Water Source	
Treatment Technology	Groundwater	Surface Water
Disinfection only	Class I	—
Iron removal	Class I or II	—
Ion exchange softening	Class I or II	—
Conventional surface water treatment	—	Class II or III
Precipitation softening	Class I or II	Class II or III

Operator Qualifications and Training Requirements

	Class I	Class II	Class III
Minimum education	High school graduate or GED		
Recommended training	OTCO Water I	OTCO Water II	OTCO Water II
Experience varies w/formal education	12 months	12–36 month	12–60 months
(for HS grad)	(12 months)	(36 months)	(60 months)
Testing	Difficulty increases w/level of certification		
Continuing education—hours	12 in 2 years	24 in 2 years	24 in 2 years
Renewal	$15 every two years		
Testing fee	$45.00	$55.00	$65.00

Testing is conducted in Columbus every April and October

OTCO is Operator Training Committee of Ohio, 614-268-6826

#29

Water System Management

Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University

The water system manager oversees the day-to-day operation of a water system. The manager serves several roles in making sure the water system runs smoothly, stays in regulatory compliance, and meets the needs of the customers.

Personnel Administration

The manager provides leadership for the water system staff. Manager responsibilities often include:

- Preparing job descriptions
- Hiring and firing staff
- Supervising orientation and training of personnel
- Supervising personnel evaluations
- Maintaining personnel records
- Monitoring compliance with labor laws

Fiscal Responsibility

The manager prepares the annual budget for the water system. He or she also must account for income, expenditures, loan payments, and audits. In meeting these responsibilities, the manager works with system clerk, accountant, and the system's financial committee. The manager must also control records, inventory, and investments.

Public Relations

The manager is often the person who communicates for the water system. This means being able to communicate at a variety of levels. He or she must share information with board members, provide timely reports to customers, and even prepare statements on the water system for the media. To do a good job, the manager must understand the information needs of different groups to provide what they need to know.

Liability Control and Insurance

Initiating and monitoring a safety program is one of the most important jobs of a water system manager. A growing concern is water system security and this is adding to the water system manager's responsibilities. Since unexpected events can still happen even with the best oversight, the manager must make sure the system carries adequate insurance coverage.

Intergovernmental Liaison

The manager communicates with a wide range of governmental units and agencies. He or she is required to prepare reports for several government agencies and needs to keep up with proposed changes in laws and regulations. The manager is often asked to represent the water system at meetings and on committees.

#30 Personnel Management

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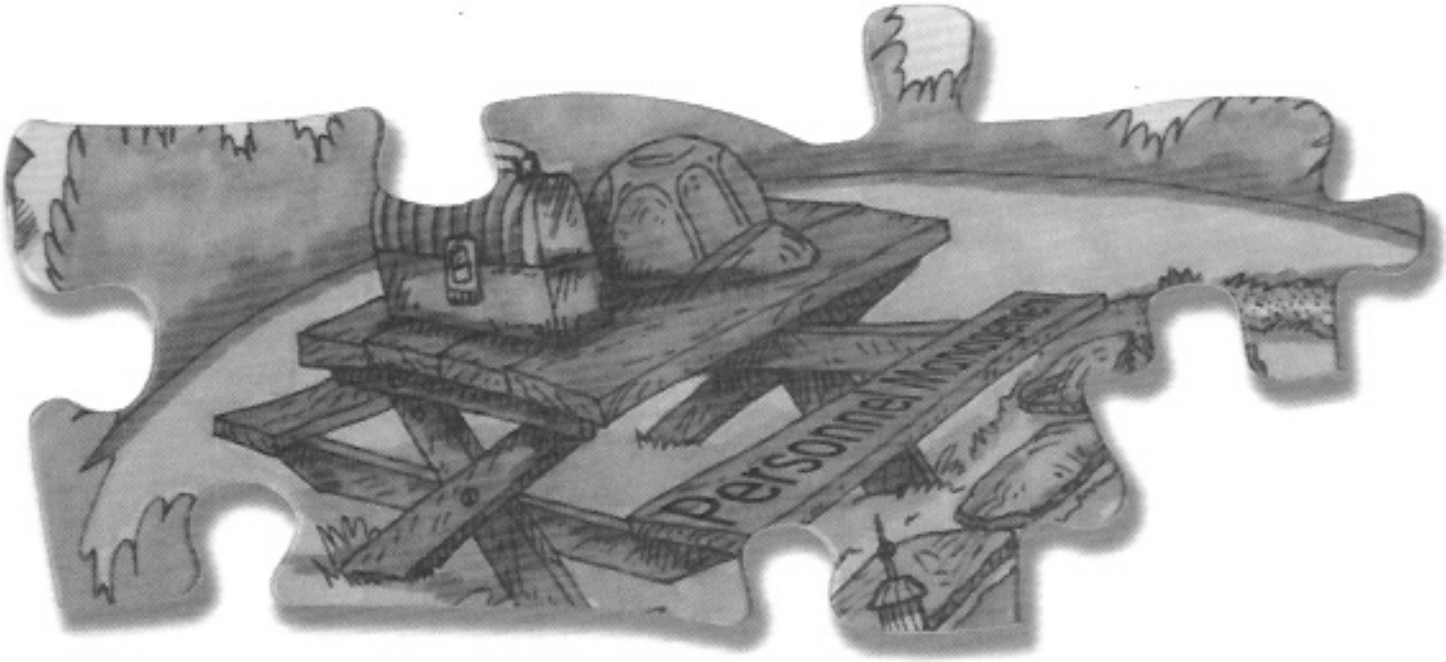

A range of knowledge and skills are needed to run a public water supply. Seldom can one person do the entire job. A group of full-time and part-time employees are often needed even to operate a small water system. In some cases a person with the necessary skills to work with the water system can provide similar services to other community departments. In this way, the water system can share employees with other important parts of the community operations.

The types of knowledge and skills needed fall into five categories.

1. **Certified operator**—All public water systems are required to have a certified operator in responsible charge. The level of certification depends on the water source, the system size, and the treatment complexity. Beyond the legal certification requirements, operators must have an affinity for water science, be mechanically oriented, and have problem solving skills. Good communication skills are also needed so that they can express operation details and emergency procedures to other employees, as well as deal directly with the public.
2. **Maintenance staff**—Protecting the investment in water system facilities and equipment is the responsibility of the maintenance staff. People in these positions perform routine maintenance on equipment, keep a current spare parts inventory, and keep the facility and grounds clean, painted, and mowed.
3. **Laboratory technician**—All drinking water supplies must be tested for regulatory compliance and to gather information to operate the water treatment systems. The time and qualifications of this person depend on how much of the testing is done at the plant. Small water systems often find it easier to send many of their water samples to an outside laboratory for testing. At a minimum, chlorine tests must be conducted at the water plant.
4. **Meter reader**—Since water meters are the "cash registers" for a water system, the person who collects water meter data must be very responsible. This person is also the water system employee who is most likely to interact with the public. A meter reader should always wear a clean official-looking uniform and have good communication skills.
5. **Clerk**—Billing customers, paying bills, and collecting income are just some of the important responsibilities of the water system clerk. The person in this position is responsible for the day-to-day management of the financial plan of the water system. Careful records must be kept to be accountable to lenders, regulators, and customers. Understandably, the clerk must be trustworthy and always act in a professional manner.

Regardless of the size of the water system staff, all staff members must understand their roles and expectations. To avoid confusion, four tools should be developed to aid in personnel management.

1. **Position descriptions** are the foundation of a personnel management system. These descriptions communicate the duties and responsibilities of the job to current and future employees. They are the basis for selection, recruitment, and performance evaluations and can be used to determine wages and benefits. Each position should have a description that includes the job title and definition, the job location and equipment used, the essential functions of the job, examples of the type of work performed, and a description of the required knowledge, skills, and abilities necessary to perform the job successfully.
2. **A policies and procedures handbook** documents what has been adopted by the authority or governing board. Because it communicates how the employee can expect to be treated, it sets the tone and establishes the em-

ployee-employer relationship. The handbook should include an organizational chart, supervisory chain of command, attendance policies, leave policies, dress code, employee code of conduct, disciplinary policy, and grievance procedures. It also includes the position descriptions, performance evaluation process, compensation schedule, benefits, and insurance programs. Statements regulating the acceptance of gifts and gratuities, outside employment, use of system equipment, and employment of relatives should also be in the handbook. This handbook may also refer to operation, maintenance, and occupational hazard and workplace safety manuals located at the work sites.

3. **Compensation schedules** establish how individuals are paid based on their education, training, certification, and the complexity and variety of the tasks, physical demands, and the work environment of the position. It provides a mechanism to compare across individuals among all departments and to compare how competitive wages are with other comparable employers in the area. The schedule should also contain the other ways employees are compensated, such as professional development, incentives, and seniority.

4. **Performance evaluations** provide both positive and constructive feedback to employees and offer an opportunity for employees to give input into job duties, work distribution, and occupational safety issues. Evaluations should be conducted annually or after any probationary period. During the evaluation session, it is customary to set goals for the next annual review. This allows for the accomplishment of goals to become an ongoing part of the evaluation process.

Respect for employees and the important jobs they do should be reflected by the water system authority or governing board to the customers. Leadership and employee pride contribute to customer confidence and satisfaction. Employees should feel rewarded and motivated for a job done well. Some ways to motivate employees and increase morale are through:

- Support for training and professional development.
- Fostering teamwork in the development of alternatives, solving problems, and increasing efficiency.
- Uniforms provided to illustrate professionalism and make a good public impression.
- Open communication through weekly staff meetings, reports at board meetings, and brainstorming sessions for planning and problem solving.

#31 Training for Water System Personnel

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Operating and maintaining a water system is an involved process. Changes in process control, safety concerns, new reporting and recording programs, and increasing regulatory requirements make ongoing training a critical part of water system management.

Training is also an important strategy for retaining staff. Most professionals want to grow and advance through their employment. Peer interaction and networking is another positive outcome of training.

Process Control Changes

Changes in technology are affecting all workplaces. Automation is one advance impacting water systems. While many processes now operate automatically, this does not mean the operator should not understand the process. Power failures, extreme weather events, and community activities can often overwhelm a system that is automated for average use. Operators need training in how to troubleshoot, override, and repair automated systems.

Computers are being used more than ever to control processes and monitor systems. Much of the reporting of water system performance is moving to the internet. Training on updated hardware and software is an ongoing need.

New technologies are being developed to provide safe drinking water and lower costs. Operators need to keep up-to-date with emerging technologies so they can advise local officials on what systems make sense in their management scheme.

Standards for safe drinking water continually change with new public health information. These new standards will be affecting process control practices in disinfection byproduct control, filtration to meet lower turbidity standards, and analysis for additional contaminants.

Safety

Safety training is an ongoing need in water systems. The safety of the employees, the public, and water customers is the focus of safety programs. Water system personnel should receive training in issues including:

- Chemical handling
- Confined space entry
- Traffic control
- Safe equipment use
- Equipment malfunction remediation
- First aid
- Cross connection and back-flow control

Reports and Record Keeping

The need to collect, record, and report information continues to grow. OSHA and environmental regulators have increasing reporting requirements. Lenders have report requirements, especially when the funds are from special grants. New requirements for consumer confidence reports now affect water systems.

Many water system employees, while skilled in operating and maintaining equipment, may require training in managing record keeping and generating meaningful reports.

Training Requirements

Ohio recognizes the need for ongoing training of water system operators. All certified operators must obtain from 6 to 12 hours of training each year to maintain their certification.

Planning for Training

Training takes resources so it should be a part of the business plan of the water system. A minimum of $1,000 per year for each full-time employee should be budgeted for training. The budget should also include paid time off to participate in training events. Many training resources are available on the internet. Operators should have access to internet services to stay up-to-date.

When planning a training program, consider the following array of resources.

- Events

  —workshops

  —conferences

  —field days/field trips

  —equipment demonstrations

- Publications

  —periodicals, such as AWWA Opflow, Rural Water Magazine

  —books

  —manuals

  —correspondence courses

- Audio/visual resources

  —videos

  —CD-ROMs

  —Internet/World Wide Web, such as *www.360water.com*

#32 System Owner/Operating Authority

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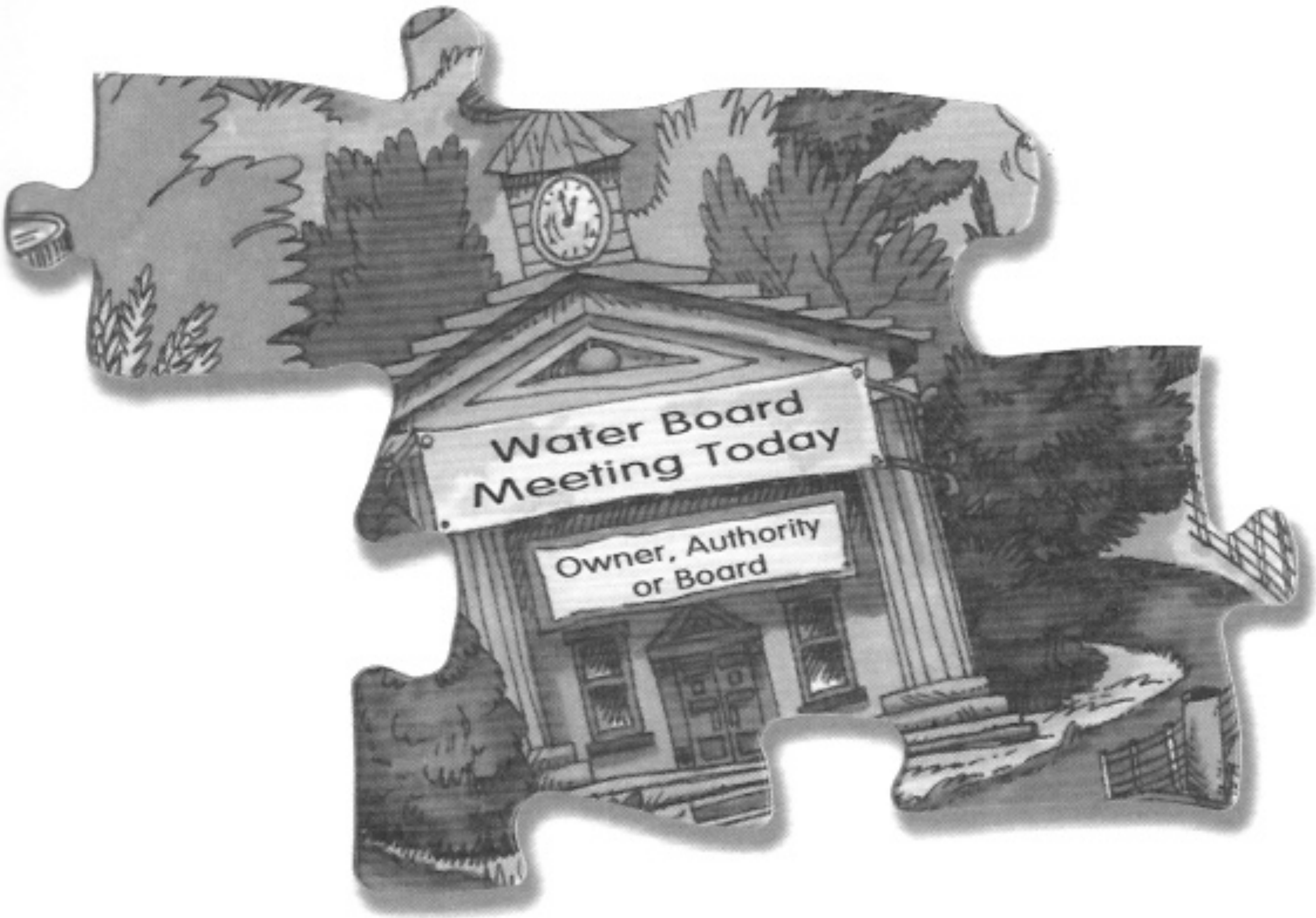

In Ohio, water systems are owned and operated by a governing body that was statutorily or legally granted the authority to be "in the water business." Such authority is granted by state statute, by local charter, or by a legal incorporation. The Ohio Environmental Protection Agency issues permits to operate to owners who construct and operate systems that comply with design standards and environmental regulations.

Types of Water Systems

Public Systems (Governmental)

Counties have legal authórity, granted by the Ohio Revised Code, to "preserve and promote public health and welfare" (ORC 6103.02). This means that a county can own, operate, and maintain a water supply treatment and distribution system. Having the legal authority also includes the power to fix reasonable rates and to adopt, publish, administer, and enforce rules and regulations necessary for providing water service.

Incorporated municipalities, both cities and villages, can also "construct or acquire waterworks for supplying water to the municipal corporation and its inhabitants and extend the waterworks system outside of the municipal corporation limits" (ORC 717.01). This authority is granted through "home rule" powers of local self-government and is granted by statutory provision or local charter.

Although **townships** do not have the authority to own and operate a water system, a township may contract to receive service from a county system, or individual residents may receive service from a nearby existing system, or residents may join together to form a water district.

Special Districts

Another form of water system authority is a special district. Water districts are created in a variety of ways. Interested parties, such as potential customers and/or a potential supplier, can legally incorporate for the purpose of supplying water. This is a private, legal agreement where members agree to fund the provision of water supply and distribution system through the contribution of fees and charges.

A regional water district, formed under section 6119 of the Ohio Revised Code, is also a legal entity but is more like a governmental institution, with the authority to assess tax levies to construct, maintain, or improve the system and is eligible for financial assistance from other intergovernmental sources.

Both types of special districts are often compared to other investor-owned utilities where the revenues generated from user charges or assessments are expected to fund the operation of the system.

Private Systems (Nongovernmental)

Many water systems are established with no relationship to a governmental authority. Individual wells serving a business or institution are one example. Mobile home parks that treat and distribute water to its residents are another example. Other examples are homeowner associations and recreational/vacation communities that form a water system under some legal agreement. Such systems are able to own and operate a water supply and treatment system, but still must meet environmental standards and generate revenues for construction, operation, and maintenance.

Governing Body Composition

Water systems are governed by a legislative body or board of trustees elected by either citizens or customers.

In counties, the board of county commissioners may have legislative authority to provide water service to the unincorporated areas of the county. They may form or join a regional water district or may join with a municipality within county boundaries or an adjoining county. While the commissioners are ultimately responsible for the system, administrative responsibilities are fulfilled by the appointment of a county sanitary engineer. The commissioners can identify an individual as sanitary engineer or establish a department under the direction of a utilities superintendent.

In cities, the council or commission, as the legislative body, defines how water service is to be provided. Generally, it is the legislative authority that is responsible for setting rates. Often an administrator, utilities superintendent, or department head is appointed and responsible for administrative functions.

For villages under the statutory plan of government, a separate administrative authority for public services and utilities is required, called the board of public affairs. This board of public affairs is responsible for supplying necessary public utilities, such as water works, electricity, natural gas, and other similar public utilities. For water systems, the board is responsible for the supply and treatment of water, the collection of all payments, the appointment of necessary employees, and is authorized to adopt policies and regulations necessary to operate and protect a system that is safe, economical, and efficient. The authority to set rates is retained by the village council, as the legislative authority.

For regional water districts, powers are vested in a board of trustees, who are responsible for the system. The function of the board of trustees is similar to governmental public systems; qualified individuals are hired to be responsible for the administrative functions and day-to-day operations of the system.

Functions of System Owner/Operating Authority

In general, the system owner or operating authority of a water system has been charged with protecting the general health and welfare of citizens by providing for a water treatment and distribution system that meets environmental standards and operates in a fiscally responsible manner that is accountable to its customers who are citizens, taxpayers, or members. Often this is accomplished by hiring or appointing a person or entity to be responsible for the administrative functions of the system. The establishment of governing principles or policies can ensure that the following elements are addressed.

- **Fiscal Condition:** Rates should be set at a level that covers all costs associated with the construction, installation, staffing, operation and maintenance, improvements, and expansion of the water treatment plant and distribution system. The revenues should not exceed the actual cost of the system to the point that customers believe the system is wasteful or inefficient, which can be perceived as "taxation without representation." How rates are structured is also important. Policy decisions can be reflected in the structure of rates and the enactment and enforcement of late fees and shut-off/hook-up procedures. Sound financial management practices are also necessary for the system owner/operating authority to obtain and retain public trust.
- **Physical Components:** Systems that protect their capital investments by maintaining an appropriate operation, maintenance, and replacement schedule are considered to be more responsible and efficient.

- **Managerial Responsibilities:** To effectively delegate administrative responsibilities, the system owner/operating authority must hire qualified staff that possess appropriate certifications, reward them with competitive wages and benefits, encourage their professional development, and provide a safe work environment.
- **Customer Accountability:** Along with authority goes accountability. It is imperative to communicate with customers. This can be accomplished through the publication of updates and announcements in a newsletter or billing statement, the submission of annual consumer confidence reports, convening public meetings, and providing guided tours of a facility.

Other Institutional Arrangements

Alternate structural arrangements are possible. A system owner/operating authority may decide to purchase water from an existing source and maintain a distribution system, lease a facility rather than construct and maintain their own treatment plant, or contract with an external provider for the operation of their facility. Although advantages are associated with each alternative, it is necessary to point out that these do NOT absolve an entity from the ultimate legal responsibility and ultimate accountability for providing public services, such as water.

#33 Business Plan or Capacity Assurance Plan

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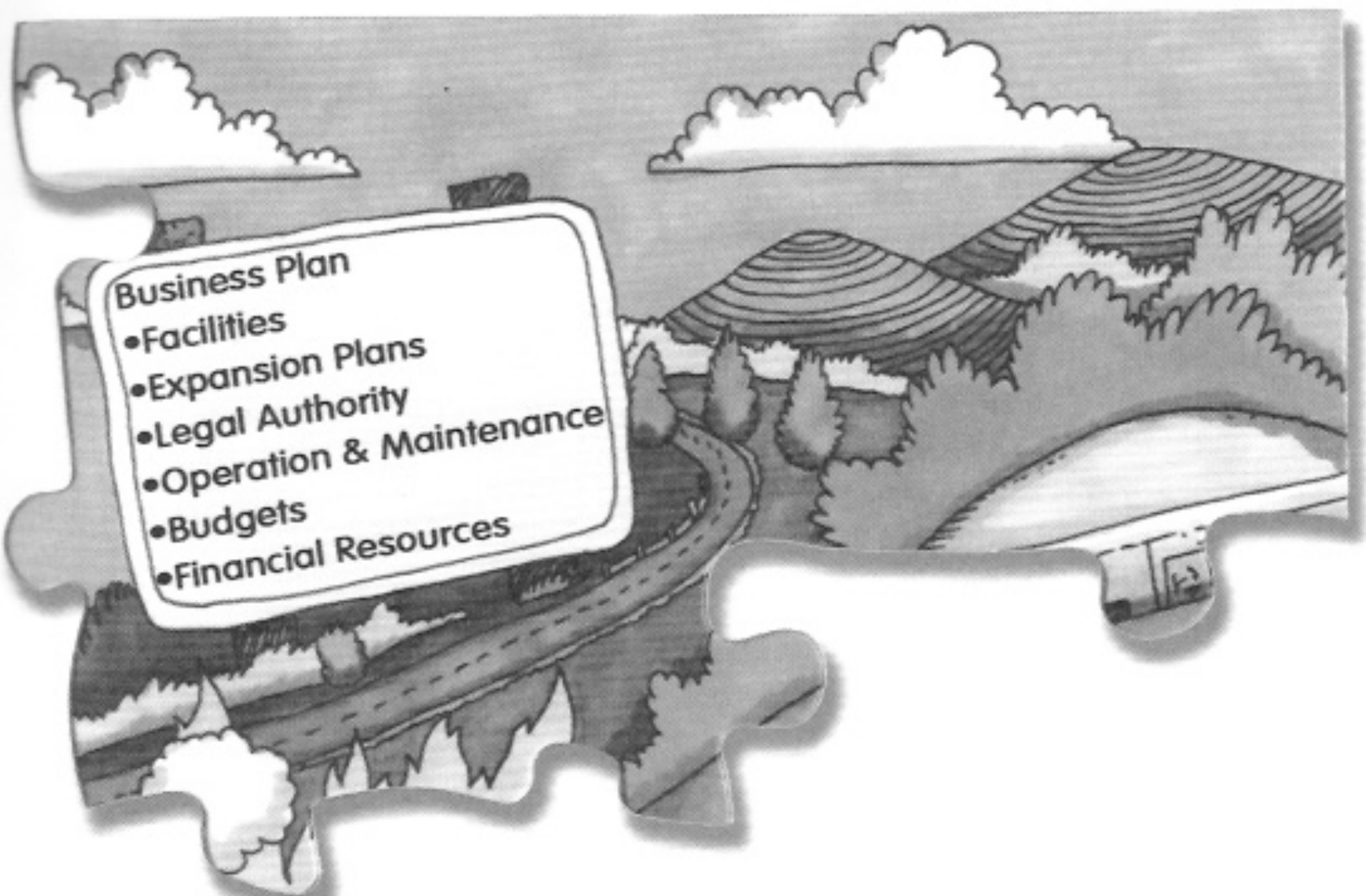
Holly Doughman, USDA-Rural Development
Karen Mancl, Professor Food, Agricultural and Biological Engineering,
The Ohio State University



A water system produces a product, has customers, collects revenue, and has employees like any business. Therefore, it should have a business plan.

A business plan is a formula or blueprint that a business follows to insure that it continues to be viable and grows. The U.S. Congress felt that providing safe drinking water is so important that a business plan is now required under the 1996 Safe Drinking Water Act amendments. The requirements tie receiving money from the Drinking Water State Revolving Loan Fund to the development and implementation of a plan to ensure the viability of a water system.

In response to the requirements, the Ohio Environmental Protection Agency is drafting business plan rules called "Capacity Assurance Plans," which bring together three components.

1. **The General Plan** identifies the scope of the water service and is intended to limit the number of surprises that occur as a water system operates by looking ahead 5 to 10 years. This plan requires continual updates and should include:
   - A description of the existing facilities.
   - An assessment of current and foreseeable actions needed to comply with the Safe Drinking Water Act.
   - A description of the alternatives considered and the rationale for alternative selection.
   - The facilities to be constructed in phases.
   - Any plans for expansion.
2. **The Management Plan** specifies the financial and personnel commitments needed to effectively manage and operate a public water system. The management plan includes:
   - Documentation of ownership accountability, including legal authority to construct, operate, and maintain the system.
   - A commitment to proper operation and maintenance, including meeting the certified operator requirements, emergency contingency plans, and an operation and maintenance manual.
   - The capability to communicate with and respond to customers and regulators.
   - A plan to use outside contacts and resources.
3. **The Financial Plan** for the next 5 years and records for the last 5 years. The plan should include:
   - Annual budgets.
   - Annual income statements.
   - Cash flow.
   - Amortization schedule for outstanding debt.
   - Evidence of financial resources to keep the system in regulatory compliance.
   - Documentation of the legal organizational structure, including the capability to borrow money, issue bonds, and credit rating.

A business plan should be easy to assemble from existing documents. By bringing together the three components, the complete picture of the water system can be assessed to make sure they are coordinated. The business plan shows the customers, the Ohio Environmental Protection Agency, and potential investors that the system has the capacity to assure safe water to Ohio's citizens.

#34 Water System Emergency Contingency Plan

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Customers expect uninterrupted water service. Unfortunately, uncontrolled events can threaten a water system. It is important to anticipate problems and establish action plans to avoid them to ensure that customers receive "fail-safe" service. In some cases problems are unavoidable. A system must be able to notify customers of an interruption in service and an estimate of how long it will last. Put plans in place to quickly resolve these types of water system emergencies.

Water systems in Ohio should be prepared for several types of problems. Some are natural, some are caused by people, and some are the result of equipment failure. Natural disasters that can affect Ohio communities are tornadoes, high winds, lightning strikes, floods, and drought. Interruptions in water service are sometimes caused by people from incidents like chemical spills, transportation accidents, power outages, vandalism, and even theft.

The U.S. Congress through the Safe Drinking Water Act requires states to adopt and implement a plan for the provision of safe drinking water in an emergency. Each public water system must adopt a plan that includes:

- communication to customers and regulators,
- alternate water sources, and
- inventories of equipment and materials.

The plan must also detail emergency procurement procedures for equipment, materials, and outside services and personnel assignments during emergencies.

Water systems can take six steps to prepare for emergencies.

1. Establish a chain-of-command.
2. Develop a dynamic plan document. Make sure all personnel have read it and know where it is filed. Post information out of the plan where it would be needed in an emergency. Update the plan every 6 months, especially contact names and phone numbers.
3. Talk to insurance providers about coverage for anticipated emergencies.
4. Establish an emergency contingency account, so cash is immediately available to correct problems.
5. Have necessary spare parts on hand.
6. Establish an emergency response support system.
   - Nearby water systems are an invaluable resource in an emergency. They can not only provide water, but may also lend equipment, spare parts, and experienced personnel.
   - Local businesses and industries may have resources that can help, such as emergency generators, tools, and skilled technicians.
   - Suppliers can be difficult to reach on weekends or holidays. Plan to have after-hours contacts and standing accounts with even infrequently used suppliers.
   - The National Guard has as its mission to restore order in an emergency. They have on hand equipment and trained personnel that can be called upon.

The best emergency contingency plan is one that is never put into practice. By thinking all likely emergency situations through, a water system may be able to avoid most emergency situations and be prepared to help their neighbors.

#35 Financial Management of Community Water Systems

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Three aspects of financial management must be considered with public water systems. The first and key element to successful financial management is balancing the funding necessary to provide a safe, reliable water supply with what the user can afford. Second, the use of public funds must be accountable to customers, state and county auditors, lenders, and regulators. Third, strategies can be developed to borrow capital funds to improve or extend water service with a plan in place to assess system users to pay back these obligations.

Balancing the Funding Necessary to Provide a Safe, Reliable Water Supply with What the User Can Afford

Determining the Budget

Funds to operate and maintain a water system come from the customers through their water bills. To determine how much is needed, break down the water system operation into important activities.

Personnel

Wages for full-time and part-time employees are just a part of personnel costs. Benefits, like insurance, must also be included in the budget. Include employee uniforms along with continuing education, training, and membership in professional organizations. Remember, retaining a certified operator is the most important element of a successful water system. Therefore, adequate personnel resources are critical.

Monitoring and Testing

Regular water testing is not only required for water systems, it is a necessary operation and maintenance tool. Water systems must budget funds to meet regulatory requirements for testing. If a water system has its own lab, then chemicals, supplies, testing equipment maintenance, and training all must be considered in the budget.

Operation and Maintenance

Everything from source water protection, water storage maintenance and cleaning, water treatment chemicals and equipment maintenance, pump repairs and maintenance, flushing and repairing water lines, and grounds cleaning and upkeep is included under operation and maintenance in the budget. Electricity, fuel, and even liability coverage can be easily overlooked. Remember, operations are tasks that are necessary to provide safe water and must be done. Maintenance includes tasks to protect the investment in the water system. It is easy to "skimp" on maintenance since it may not be required. However, neglecting equipment can result in greater expenses than performing routine maintenance.

Overhead

Billing, reporting, record keeping, communications, meeting space, and permit fees are just some of the necessary items that can be easily overlooked in a water system budget.

Depreciation

Facilities, equipment, and vehicles are all assets that lose value with time. Depreciation must be a part of budget considerations.

Emergency Contingency

Even in well-run water systems, emergencies occur. Funds must be available to respond quickly to an emergency. Receiving an insurance claim takes time, and in an emergency, waiting for a check from the insurance company before repairing or replacing a component in the water system may not be feasible.

Rate Studies

Water rates must be set to reflect the true cost of providing water to customers. Rate studies balance the cost of producing water with the water paid for by the customers. A water audit compares the amount of water treated with the amount recorded at the water meters. Discrepancies may be due to water leaks, malfunctioning meters, or even water theft. Customers provide revenues to a water system in a variety of ways. Regular bills for water use is the most obvious source of revenue. Hook-up charges, connect/disconnect fees, and late payment penalties are other sources of funds to a water system.

Rate structures can vary among customers. Discounts may be extended to large water users. Flat rates, ascending scales, or descending scales are used by water systems. Consider the community goals when selecting a rate structure. Ascending scales, with increasing charges for high water use, encourage water conservation. Lower rates for industrial water users may be needed to attract or retain an industry, but the residential customers must then make up the difference to keep revenues in balance with costs.

The Ohio Rural Water Association provides advice and technical assistance to small communities in how to conduct a rate study. Call 614-451-4020 for more information.

Accountable to customers, state and county auditors, lenders, and regulators

Remember to keep complete financial records. Records and inventories are subject to review and audit when public funds are involved.

Borrowing capital funds to improve or extend water service

Funding is needed upfront to pay engineers and contractors for the design and construction of water system improvements or extensions. Remember, these improvements must be paid for by the customers so a plan must be in place to repay these loans through revenues collected from customers. When servicing a debt, interest is added to the budget along with the costs of managing the loan. Planning ahead for these types of expenditures can help a community reduce its need to borrow money and the associated interest payment.

Capital improvement accounts can be included in the annual budget. By setting money aside for planned improvements, a community will gain interest rather than pay it.

Low-interest loans are available from some organizations to meet special goals. Low-income residents, elderly customers, and projects that produce jobs or that alleviate emergencies may make all or a portion of a project eligible for low-interest loans. A limited number of grants are also available to communities when they meet the goals of the granting agency.

Unfortunately, loans, especially loans from the federal government, can increase project costs to comply with the requirements of the lender. Be sure to consider the conditions and the impact on project costs before accepting loans or grants. Possible lender requirements are:

- meeting prevailing wage rates.
- minority vendor requirements.
- drug-free workplace policies.
- environmental impact or archeological investigations.

Raising Rates

The cost of providing safe water to customers can be calculated and is likely to increase in the future. Plan to raise rates in small increments to keep up with rising costs. It is never easy or popular to raise water rates, but a necessary large increase after years of no increases is especially hard for customers to accept.

Communicate with customers about the benefits and costs of their water system. When rate increases are planned, notify customers in advance so they can plan accordingly. Most of all, save for future capital expenditures. It benefits the community to keep capital improvement accounts in local financial institutions earning interest rather than paying interest to an outside lender.

#36 Technical Assistance for Water Systems

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The most important decision that local officials make in developing or upgrading a water system is who will provide the technical expertise to work through all the details. This task may seem overwhelming, but fortunately in Ohio many local, state, and private groups offer the necessary technical expertise.

Several organizations will need to be drawn on for a community to bring together all of the qualified technical experts needed to develop a successful project. Expertise will be needed in three general categories:

1. Technical
2. Financial
3. Managerial

Once a community has identified a problem with its existing water service, it can begin to identify technical people who can provide technical assistance.

First, seek out **local technical expertise**:

- Health department
- County engineer
- County Extension office
- Local university
- Nearby communities

Next, call on **state organizations** that provide technical assistance:

- Ohio Small Community Environmental Infrastructure Group
- Great Lakes Rural Community Assistance Program
- Ohio Rural Water Association
- Ohio Department of Natural Resources
- Ohio Environmental Protection Agency
- Ohio offices of USDA–Rural Development

Third, contact and interview **technical consultants**:

- Engineering consultants
- Consulting hydrogeologists
- Surveyors
- Financial institutions
- Vendors and suppliers

Costs of Working with Technical Assistance Providers

Working with technical assistance providers comes with costs. All of these people are professionals and must be compensated for their time. Some organizations can provide technical assistance to a community at no or reduced costs, because they receive their support from other sources. Many of these programs are heavily subscribed so be patient and be prepared to work with them to schedule meetings and wait until their services are available.

When working with state level technical assistance providers, you may have to make long distance phone calls and be prepared to travel some distance to meet with them.

Most importantly, as several experts get involved in a project, a real cost is "information overload." Each professional brings a unique perspective to a project, so don't be surprised if opinions differ.

Rewards of Working with Technical Assistance Providers

As the community leaders interact with technical professionals, they gain a greater appreciation for and understanding of the project. Local officials will be better able to communicate the details and the important decisions to the water system customers.

As a community begins working with a group of technical assistance providers, progress is made toward satisfying customer needs. The community also shows progress in meeting regulatory requirements.

The experience of putting together an expert team can have future rewards. Many of these same groups can be accessed again when the community faces another project or problem.

#37 Public Communication

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Communicating with the public about water system decisions is one of the most essential tasks of local officials. Water systems are supported and paid for by their customers and members of the community. Since elected officials are judged by the decisions they make during their term of office, effective communication about public water service gives the electorate the information they need to support the water system and the public officials who represent their interests.

The U.S. Congress recognized this need for public communication. When they amended the Safe Drinking Water Act in 1996, they made a minimum level of public communication mandatory. Congress felt so strongly about public communication that they imposed monetary penalties, criminal penalties, and even job loss if a water system fails to keep the public informed.

Public communication is essential and beneficial in four instances.

1. **System planning**—Customers and the general public benefit from being informed and involved in water system planning. As a water system improves and grows, decisions must be made about who will be served, placement of hydrants and storage tanks, land acquisition, easements, and levels of water treatment. At a minimum, customers and the general public appreciate being informed about the decisions being made. Some individuals will feel strongly about a particular decision and demand to be involved. While public hearings may be required by law to announce decisions being made on the expenditure of federal or state funds, public hearings are a poor mechanism for public communication. Instead, include a wide variety of interests early in the planning and decision making processes through brainstorming sessions, group discussions on the merits and limitations of all planned improvements, and community surveys. Customer complaints and the risk of legal action can be replaced by public support for the water system if customers have an opportunity to give meaningful input.
2. **System maintenance**—Keeping customers and the general public informed when planned water system maintenance is going to occur avoids problems and upset. Road closures or interruptions in service can be tolerated if individuals are notified and can plan for the inconvenience.
3. **Drinking water quality**—Customers are understandably interested and in some cases concerned about the quality of their drinking water. Congress required in the 1996 amendments to the Safe Drinking Water Act that water systems prepare an annual report for all of their customers about the quality of their drinking water. These Consumer Confidence Reports, while a legal requirement, if properly done can help build support for the public water system. The American Water Works Association (AWWA) has developed some tools to help small communities produce a Consumer Confidence Report that not only meets the legal requirements, but also helps present the information in a positive way. Contact AWWA at 800-366-0107 to learn more about these tools. Ohio EPA also provides guidance at *www.epa.state.oh.us/ddagw/ccr.html/*.
4. **Emergencies**—Congress also requires through the Safe Drinking Water Act that public water systems notify customers when health risks occur. Congress ordered the U.S. Environmental Protection Agency to set minimum drinking water standards to protect the public health. If required tests reveal that a water system exceeds one of these standards they must notify the public. Since the severity of these violations varies, three levels, or tiers, of notification requirements have been developed.

Tier 1—If short-term exposure presents significant potential for serious human health effects, customers must be notified within 24 hours.

Tier 2—If long-term exposure presents significant potential for serious human health effects, customers must be notified within 30 days.

Tier 3—Any other violations that do not directly affect human health must be included in the annual Consumer Confidence Report.

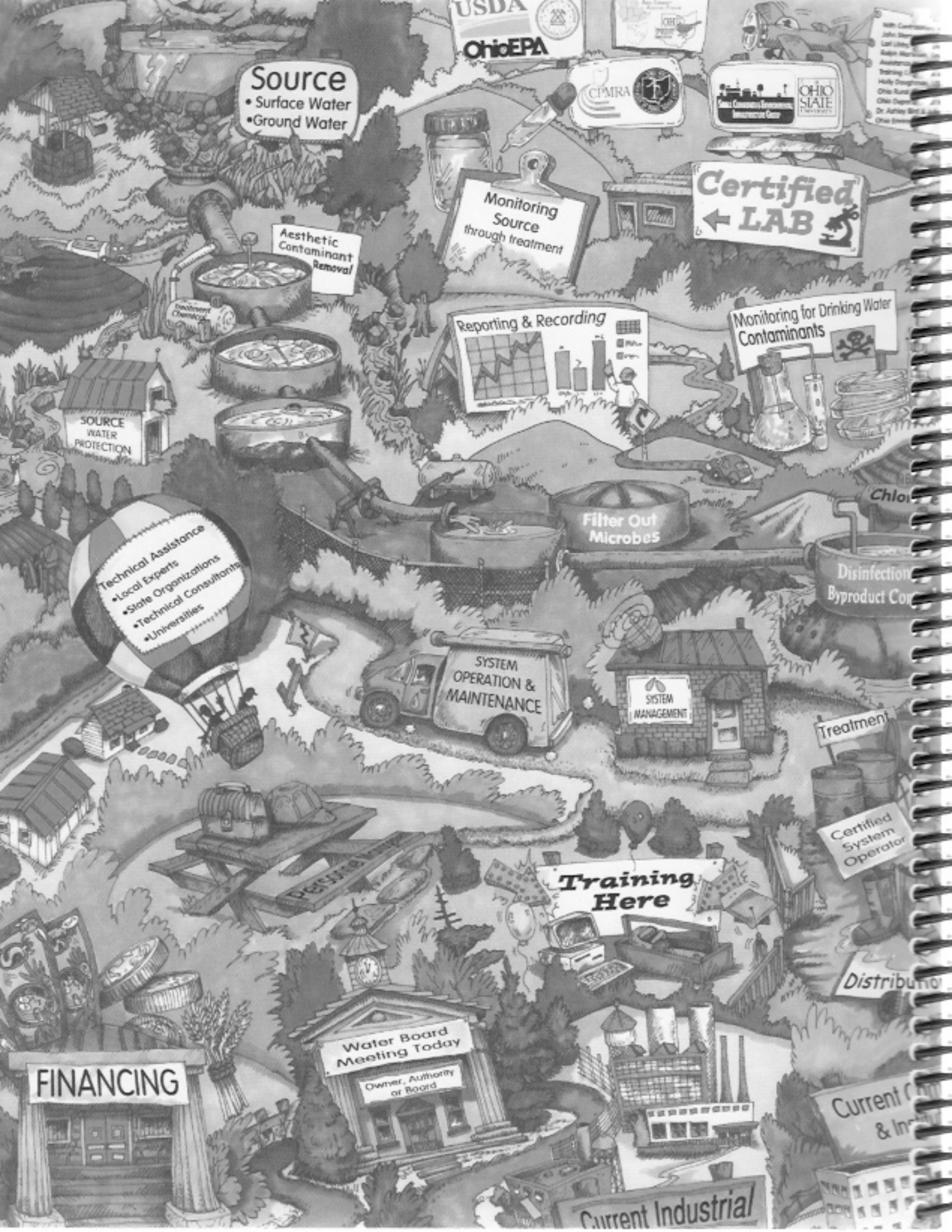
Methods of Communication

A range of interests in a public water system will be evident in any community. Some people will want to know details of decisions being made, while others will show little interest in their water system until a problem occurs. People also have preferences in how they receive information about issues that concern them. Keeping differences and preferences in mind, a variety of communication mechanisms are needed to effectively keep the public informed.

When developing a public communication plan, include the following considerations:

- The importance and value of safe drinking water in the community should be stressed and communicated frequently. For example, many people may not appreciate how many jobs are tied to reliable water service. Express how planned improvements will better protect public health or safety, increase reliability, and/or increase service.
- Keep initial messages about water system plans and issues short. Pictures can have a greater impact than written words. When communicating with the public, use simple graphs, diagrams, and photographs to help illustrate key points.
- Opportunities to learn more or how to get involved should be communicated to the public. A small, often vocal, percentage of people will want to take advantage of these opportunities. Forming a community advisory group is one mechanism to discuss upcoming issues, seek advice, build support, and help get the word out about the accomplishments of the water system.
- Use a variety of media to communicate with the public. Not everyone will see an article published in a local newsletter or posted on a community bulletin board, but everyone might see a notice in the water bill. Door-knob hangtags are a good method of notifying customers of upcoming maintenance activities that might close a street or interrupt water service. Think about where people in your community have time to study a notice on their water system. Programs at school events, paper placemats in local restaurants, or signs near busy intersections can be tools in getting information to the public. Also think about when and where people use water. Yard signs can help explain lawn watering recommendations as a part of a water conservation program. Small signs in bathrooms in public buildings can point out the benefits of improving water treatment. Signs near local ponds and lakes can stress the need to protect a water source or the need to develop fire protection systems.

Remember, legally required public communication for emergency notification, Consumer Confidence Reports, and public hearings are only the minimum communication that should occur between a water system and its customers. Responding to public concerns about their right-to-know, Congress mandated public communication for all community water systems. To gain public support, water system managers must go farther than what is required to sustain a safe, reliable water system in any community.



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