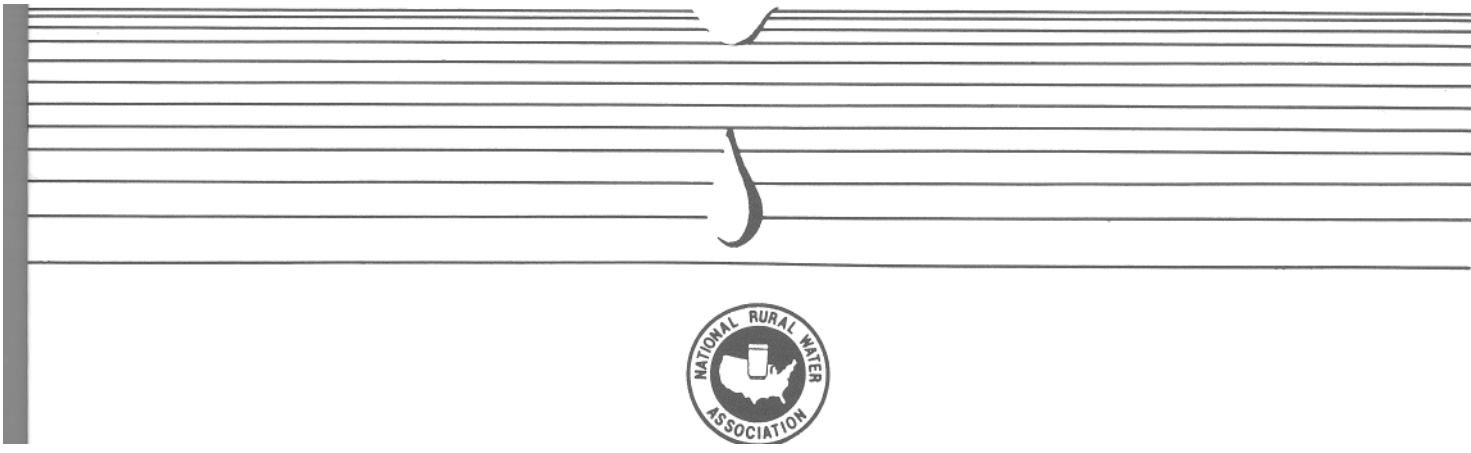
Training Guide

An Introduction to Water System Operation and Maintenance



An Introduction to Water System Operation and Maintenance

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RURAL WATER SYSTEM TRAINING GUIDE

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RURAL WATER SYSTEM TRAINING GUIDE

About this training guide …

This training guide is one of a series written for Board Members of water utilities.

For the purposes of this guide, the term “Board Member” refers to the individual who shares in decision-making. This includes directors and board members of rural water systems, city council members, commissioners, and officers.

The term “system” will be used to refer to any organization or structure that provides drinking water to a group of users. This includes communities, utilities, districts, public entities, and profit or nonprofit corporations and associations.

This Rural Water System Training Guide is written for water system decision-makers as a general introduction to the subject of small water system operation and maintenance. It is in no way intended to replace or supplement local, state, or federal regulations. Also, it is not meant to substitute for any manufacturer’s or consultant’s products or services.

Chapter 1

Governing Bodies and System Operation

Generally, Board Members have three board responsibilities. Each member of a water system governing body should:

1. learn about the operation of the system;
2. learn about the administration of the system; and,
3. participate in decision-making in good faith at Board meetings.

The Focus of This Water System Training Guide

This training guide will focus on the first responsibility, that of system operation. It will review the basics of water system operation and maintenance. It will also identify some of the things that Board Members need to know to participate effectively in decision-making as it applies to water system operation and maintenance.

This guide may also be used by administrators, operators, and other employees. It will help them to understand the role of the small water system Board Member and how their jobs are affected by good Board action and policy.

Finally, this training guide will assist the Board Member in recognizing principles which have best served the system and the governing body in the past. Knowing what has worked before, enables Board Members to participate better in making long-range policy.

The Governing Body

The governing body of a water system works to insure that a safe, sufficient supply of water is provided to the system at a reasonable cost.

“The governing body of a small water system works to insure that a sufficient, safe supply of water is provided to the community at a reasonable cost.”

Meeting this challenge involves:

- gathering information for decision-making about the operation and maintenance of the system;
- setting policy for the short-term and long-term operation and maintenance of the system;
- communicating policy and decisions to the public; and,
- insuring that decisions are carried out.

Importance to Public Good

Board Members may be asked a wide variety of questions regarding the safety and quality of water and the operation of their water system. These may include questions as:

"Is the drinking water supply tested regularly?"

"What will the system do in case of emergency?"

"Does the drinking water have lead or radon in it?"

"How will the system pay for expansion or repair?"

Even though Board Members may not have the technical expertise to answer these questions, they are ultimately responsible for the answers.

The essential difference between public and individual water systems is the strict testing and control that regulates public water supply. A public water supply that meets state requirements implies good water quality. State health agencies enforce these regulations.

Each state has specific ordinances that cover virtually every aspect of water system operation, from the protection of the raw water source, to the quality of the water at the customer's tap. It is up to Board Members to insure that the system's employees are aware of all relevant regulations and that the system operates within the law.

The Safe Drinking Water Act

The public drinking water supply must meet strict standards. Board Members may be asked why these standards are needed. The answer lies in the fact that water is continually recycled through the atmosphere by nature. This on-going process is known as the hydrologic cycle.

Water evaporates from oceans and lakes, forms clouds, condenses as snow or rain, and falls back to the earth. Through this process water may come in contact with natural or man-made contaminants. For the protection of all consumers of publically supplied drinking water, standards were set regarding the quality of water provided.

Perhaps the most important legislation concerning drinking water is the *Safe Drinking Water Act (SDWA).* The SDWA is something that affects all water system Board Members and the operation of every water system. This federal law was enacted in 1974 as a response to a need for national standards for drinking water.

In 1986, amendments to the SDWA were passed. These amendments required additional monitoring and testing for additional contaminants. The law also stipulates that there be public notification by

the water system when standards for drinking water are not being met.

Another aspect of this law requires that all water systems notify their users of the potential hazard of lead in drinking water, regardless of whether any trace of lead has been detected. The state regulatory agency or water associations can provide additional information on the SDWA.

Mandatory Testing

The Safe Drinking Water Act requires the U.S. Environmental Protection Agency to establish maximum contaminant levels (MCL) for various substances that may have an adverse effect on public health if consumed in drinking water. The SDWA requires all public water systems to test their drinking water supply at regular intervals.

The tests that are performed on drinking water may be divided into four classifications of substances:

- physical;
- chemical;
- biological; and
- radiological.

The frequency and number of samples needed for analysis depends on the size of the system and the supply source.

State Laws

Board Members should become familiar with state laws, which affect the system and its operation. State laws that regulate drinking water are at least as stringent as federal laws, and are often more strict. Because regulations and laws governing water systems are constantly changing, study of water system laws should be on going among members of the governing body.

Board Member Responsibility

It is also advisable that Board Members be informed about the operation, responsibility, and authority of the state agency charged with enforcing drinking water laws. *Board Members have the ultimate responsibility to insure that their system follows the state's laws and cooperate with their state regulatory agency.*

Chapter 2

The Board Member's Role

Who is a "typical" water system Board Member? It is impossible to say. A Board Member may have any occupation or live and work in any part of the system. Board Members have a great variety of backgrounds, skills, and talents. Ideally, however, all Board Members share a common desire to help the system provide safe and economical drinking water.

Skills and Training

Does a new Board member have to know everything there is about water system operation when elected or appointed?

No!

The first test of genuine ability, however, is whether the newly elected person has a willingness to learn.

Does a new Board Member need training?

Yes

Training may begin with a review of a number of documents important to the individual system. New Board Members should begin by reading the bylaws or charter of the system, plus any other documents that relate to the organization of their system. This may be followed by reading state statues that govern such systems. The new Board Member should become familiar with policies and operating procedures as they apply to the functioning of the system. Finally, Board Members can learn a great deal about the operation and maintenance of the system by reviewing the minutes of past meetings.

Continuing Education

Board Members (even seasoned veterans) may learn more about water systems by taking advantage of continuing education opportunities. There are a number of books, trade journals, and newsletters that report on a wide variety of water system news and trends. In most states, schools, agencies and associations regularly provide training or technical sessions on a variety of small water system topics. Contact water associations or the state health department for more information.

Board Member Privileges

To participate effectively in decision-making, the Board Member should have certain privileges. One of the most important of these is the open access to information about the system. This includes all system records, reports, and mail including correspondence with customers and regulatory agencies. It is up to the Board to decide upon the means of this access.

The Board Member also has the right to expect to be promptly notified about certain actions by an operator or by other Board Members. This usually does not include the routine aspects of daily operation. The right of notification refers to any unusual or significant aspect of system operation, such as special meetings, an employee automobile accident, or a violation of health standards. It is up to the Board to set these notification guidelines.

Board Member Obligations

Just as there are specific privileges due the small water system Board Member, there are also specific obligations.

The Board Member's first obligation is to be a part of a decision-making team. No single Board Member makes decisions in the name of the water system. If, however, individual Board Members familiarize themselves with all areas of operation, they are in a good position to participate in-group decision-making in the best interest of the short-term and long-term operation of the system.

The scope of what contributes to good leadership is certainly not limited to monthly or weekly meeting attendance. It is not, however, necessary to carry this to an extreme. Typically, Board Members do not need to develop a "hands-on" knowledge of water system operation. This should be the responsibility of the professionals hired to do that job. (It is recognized that on some small systems Board Members assume active roles in the operation and maintenance of their system. This practice is not recommended, and state regulations should be consulted in this regard.)

Board Members and the Public

Most progress will require action on the part of Board Members, and many times this action does not please each person in the system. Board Members may be targets of criticism. It is good to remember that Board Members are far more likely to be criticized for NOT taking action. By taking action after careful consideration, Board Members are often able to prevent crises.

Obligation to the Future

Often it is said that "water is becoming more and more of an issue." Because water is an "issue," every governing body and each Board Member has an obligation to participate in long-range goal setting for the operation of the system that extends beyond their project tenure in office.

The future of the system is dependent in large part upon the planning that Board Members do regarding the operation and maintenance of the system. It is important that each decision – even one which appears to deal with a "short-term" issue – be considered in terms of how it might affect the system in the coming months or years. In the following pages, the reader will learn about some of the elements that make up the typical water system and some of the issues that Board Members might face.

Chapter 3

Key Jobs and Personnel

It is important that Board Members become familiar with all phases of water system operation in a general sense. This gives Board Members the ability to ask questions, read reports, understand technical data, and participate effectively in decision-making about operation and maintenance issues. This chapter presents an overview of the tasks, personnel, and procedures that are necessary to the operation of a small water system.

There are three broad categories of work that must be performed in the functioning of a small water system: operation and maintenance; system management; and office management.

Operation and Maintenance

The operator is responsible for the technical functioning of the water system. Typically, this person has the authority to work on the system or to direct the work of contracted labor and services. In most states, operator certification is required.

The choice of system operator (or operator/manager as discussed below) is one of the most important decisions that Board Members make. The system operator should be viewed as a professional who provides a vital service to the system by insuring its smooth functioning. The operator should be given the support and flexibility needed to perform the job well.

Improper operation can seriously damage a facility and result in excessive repairs, higher operating costs, or health hazards. The operator helps to insure that these things do not happen. In most cases, however, the Board Members are responsible for the actions of the operator.

The operator performs another important job in serving as chief advisor to the Board Members. When Board Members plan, make policy, or change current practice relative to the operation of the system, the operator is usually the main source of information.

"The choice of system operator is one of the most important decisions that Board Members make."

It is important that the operator have a basic mechanical aptitude and the ability to

understand and direct all phases of operation and maintenance of the water system. The operator's basic knowledge, skills and training might include the following.

- sufficient training to protect the public health;
- knowledge of all aspects of the distribution system (including maintenance);
- knowledge of the water supply (including pump operation);
- skill to maintain water quality (including water treatment where necessary plus state and federally required sampling routines);
- knowledge and understanding of energy sources;
- understanding of emergency procedures;
- knowledge of state and federal regulations;
- record keeping skills; and additionally,
- a willingness to participate in continuing education programs.

System Management

When possible, Board Members delegate responsibilities and authority to a system manager. In some systems, the operator is designated as the "manager" or "operator/manager." In this case, one person performs both the day-to-day operation and maintenance jobs on the system (as described above) as well as routine management tasks.

The system manager has the authority to make some decisions for the system. It must be stressed, however, that this authority comes from the Board Members. All decision-making in the form of system procedures and policies continues to be the responsibility of Board Members.

The system manager may do the following:

- enforce the objectives and policies of the Board Members;
- keep the Board Members informed about expansions, operations and other activities;
- keep the Board members informed about any finances under the manager's control;
- coordinate and oversee all operation and maintenance work and all office activity;
- act as the official decision-maker for the system concerning any problems or complaints about routine operation;
- represent the system in official district or community affairs.
- Stay current with new developments in the area of water system operation and maintenance, including all laws and regulations; and,
- Be prepared to perform any task that is essential to the daily operation of the system.

Office Management

Most systems designate someone to perform the duties of office management. This may be a town recorder, an office

bookkeeper, a city clerk, or a town clerk. For the purposes of this training guide, this person will be referred to as the "office manager."

The office manager serves the small water system in several ways. For instance, the office manager may coordinate the financial management of the system. The office manager may also perform secretarial duties for Board meetings. These roles will be reviewed in other guides. For this guide, the discussion of the job of the office manager will be limited to the routine system operation.

The specific responsibilities of the office manager vary greatly from system to system. In some cases, many of the duties described below are part of the system manager's job and not the office manager's. It is the responsibility of the decision-makers for each system to create job descriptions and delegate authority in a scheme that works best for their situation.

The small water system office manager performs a wide variety of jobs that affect system operation. One of the most important of these is in the area of public relations.

Public Relations

The office manager is likely to be the first and perhaps only – contact person in all routine water system communications. This person greets office visitors and answers most telephone calls. The office manager coordinates the start or re-connection of water service. The office manager answers any questions customers might have, and explains system policy and procedure.

Complaints

One of the most difficult tasks the office manager faces is talking to customers with complaints. It's the office manager's job to determine the nature of the complaint and work with the customer to find a way to solve the problem that is acceptable to both. If this is not possible, the office manager then acts as a liaison to transfer the complaint to the operator or manager. (If Board Members are contacted about complaints first, it is important to know what the system policy is for responding.)

Correspondence

Most business correspondence is coordinated by the office manager. In some cases, the office manager is the person who actually writes the letters that go out in the system's name. Board Members may be interested in the type of correspondence that is sent and the general image of the system that is projected.

Finance

The office manager coordinates and maintains the financial business of the system. This includes billing, collections (non-delinquent), and bookkeeping. The office manager balances the cash drawer at the end of the day and secures all financial documents.

The responsibilities of an office manager may include supervision or performing other routine tasks. This includes maintaining regular office hours, purchasing office supplies, running errands to banks and the post office and coordinating routine office housekeeping.

Chapter 4

Procedures and Equipment

It is important that Board Members have a general understanding of all procedures and equipment used by the water system. This is vital to wise planning and policy creation for long-term needs. This knowledge also enables Board Members to better understand the advice of the operator, manager, or any special consultants the system might hire. As a result, Board Members are better able to approve the spending of funds for upgrading the system and for general maintenance.

The operational aspects of a water system can be divided into three parts:

- the source;
- the water plant; and,
- storage and distribution.

The following sections present an overview of these parts.

The Source of Water

The Board Member who wants a better understanding of the operation of a system may begin with the system's source of water. Unprocessed or "raw" water that might be available for use as a drinking water supply typically comes from one of two sources: *"ground water" or surface water."*

Systems that depend on ground water usually get water from wells that tap into underground aquifers (natural underground layers or porous, water-bearing materials). Board Members are cautioned to insure that the wells that serve the system are not neglected. Wells require routine inspection and maintenance just as any other part of the water system.

The other source of water is surface water. Surface water may come from streams, open ponds, lakes, open reservoirs, or springs. (In some situations, springs are classified as ground water.)

"The Board Member who wants a better understanding of the operation of a system may begin with the system's source of water."

Surface water is water that has been collected from rain or runoff (such as from melting snow or rain in other areas). Systems that depend on surface water for supply normally operate a more elaborate treatment plant than those that use ground water.

In some instances, Board Members are faced with the responsibility of seeking new or alternative sources of water. Hopefully, long-range planning will enable a system to access new sources (for instance, develop new wells) so routine service is not disrupted.

If a system does not have access to a usable supply of ground water or surface water, Board Members may explore the alternatives of supplying the system with water produced by other systems. This water may be obtained by tapping into the distribution system of neighboring systems or transporting water by truck or rail from more remote sources. It will be up to the Board Members to approve negotiations with a proposed supplier.

The Water Plant

Board members should be familiar with the quality of water being supplied to the system and whether treatment is necessary. In many cases, the quality of the untreated (raw) water and the system demand is such that water must be processed in a water plant for distribution.

Water treatment involves a broad range of issues for Board consideration, including compliance with state and federal regulations and long-range planning and policy setting. If water is treated, then Board Members must also consider the cost of water plant operation. From power costs to chemicals to labor, the water plant can be one of the most expensive parts of the small water system.

If it is decided that it is necessary to process water to insure its safety and quality, raw water is channeled into a water treatment plant where it may be processed in a variety of ways. The size and complexity of a water plant depends on several factors:

- the source of the raw water;
- the impurities in the raw water;
- water quality regulations and standards;
- the demand for water by the population served; and,
- cost

Disinfection

Water treatment is typically associated with contaminant removal. One of the most important treatments is disinfection. Disinfection can destroy bacteria and other dangerous pathogens in water.

Disinfection by chlorine compounds (as a solid, liquid, or gas) is the most common method. There are, however, some problems associated with the use of chlorine. For instance, chlorine gas is highly toxic. An accident with a chlorine gas tank can create a serious hazard to the system. Board Members are advised to investigate state public notification regulations about the storage of chlorine gas.

There are alternative methods for disinfection, such as the use of iodine, ozone, or ultraviolet treatment, to name a few. As with chlorine compounds, each has its advantages and disadvantages. The best method for any system is determined by the quality of the raw water and the demand on the system.

Other treatments

There are other common treatment techniques that remove contaminants. One is filtration. This is the process of removing suspended matter from water by passing it through porous material that traps some contaminants.

Water may be treated for reasons other than to correct potential health hazards. Treatment may improve water appearance, taste, or odor even in cases where the water is safe to drink.

For instance, some systems treat water to remove iron and/or manganese, which may stain fixtures. Other systems condition hard water or fluoridate it to improve dental health. Some systems treat highly corrosive water, which may cause long-term pipe damage. The type of treatment required depends on the needs of individual system.

Distribution

Board Members are often concerned with the water distribution system. Board Members set all policy for system expansion, negotiate easements, determine minimum standards, authorize the purchase of equipment, and approve financing. When making such decisions, Board members should consider all sources of information including employees, consultants, and water associations.

Below is a general overview of the elements of a distribution system and the type of service, equipment, and processes Board Members must consider when preparing budgets and in long-range planning.

Types of Service

Board Members define or approve the various types of services available to customers. These services must be consistent with the provisions of the system's rules and regulations or operating policies.

There are several types of service that can be offered to the customer. In addition to providing water to homes and small business, service can be extended to include bulk sales, industrial use, agricultural use, street cleaning, and fire protection (see below).

Parts of the Distribution System

A typical distribution system includes:

- pumps;
- water mains and service lines;
- valves; and
- meters.

Maps. There are other devices and attachments used in a distribution system that are far too numerous to mention. One key tool, however, used in the operation and maintenance of the distribution system that should not be neglected is maps.

Maps are vital in the planning of system expansion, in routine maintenance (for instance, for valve location), in leak location, and in emergency situations. One set of accurate maps should be kept in a safe. If maps have been lost or destroyed, they should be drawn again or reproduced from copies held by engineering firms or state agencies. Drawings held by engineering firms are generally considered to be the property of the system.

Pumps

Few water systems have a local geography that permits the movement of water from the source to the customer by gravity. For this reason, pumps must be used in some parts of the system.

There are other uses for pumps. Pumps are often used in the chemical treatment of water, the backwashing filters, the disposal of sludge and the movement of finished water to storage.

Because pumps are so important to the operation of the system, operation and maintenance manuals for each pump should be stored in a safe but easily accessible place. In case of emergency, a technician not familiar with a particular model will have a complete reference source.

Generally speaking there are two types of pumps in use on small water systems. One is the positive displacement pump, which operates by forcing (or "displacing") water through a pumping mechanism. The other type is the centrifugal pump. It is used in almost any situation requiring transport of water.

Water Mains and Lines

The most important considerations in the selection of pipe for a distribution system are cost, size, strength, durability, corrosion resistance, and safety. Other considerations include the ease with which the pipe can be handled, the availability of a variety of sizes to handle the anticipated flow, and the ease of tapping the line.

A wide variety of materials have been used in pipe construction. Two commonly used materials for pipes for small water systems are *ductile iron and PVC (Polyvinyl chloride).*

Valves

Valves are essential in a distribution system for one main reason: they control the flow. Special types of valves perform specialized functions. For instance, a valve can fully stop or start the flow of water. Valves can provide air and vacuum relief. Valves can prevent backflow or keep a storage tank from overflowing.

Several types of valves are in normal use in a distribution system. These include the gate valve, the butterfly valve, the globe valve, and the ball and plug valve.

It is important that the maps of the distribution system show the exact location of each valve. This is for two reasons. First, valves are of no use – especially in an emergency – if they cannot be found. Second, valves are of no use if they do not work properly. Maps help the operator to find each valve so it can be exercised (fully opened and closed) regularly to insure its proper operation.

Hydrants

Valves are also used to regulate the flow of water to hydrants. Hydrants permit the flow of water to fight fires and flush pipelines.

A hydrant usually includes four main parts: an inlet pipe connection from the supply main, a main valve, a barrel, and a head. It is advisable to keep emergency repair parts for hydrants in case of damage.

Meters

A meter is a device that measures and registers the amount of water that flows through a pipe. Meters can be classified as

small-flow meters, large-flow meters, and "combination" or "compound" meters. Compound meters are used in metering both small and large flows.

Meters should be placed at each source (the Master Meter) and at every point of use, including parks, cemeteries, schools, public buildings, and any other point of use that may have been previously unmetered. The information from meters can show how efficiently the system is operating, and give the operator invaluable help in distribution system control.

Meters are of extreme importance to a water system and to Board Members' planning sessions because of the valuable information they provide. Meters are, in effect, the "cash register" for the system. By measuring all water taken from the source, and metering all water at each point of use, the fair cost of water can be determined and billed for the full amount due.

If meters are not accurate, the system is the loser. Household meters are usually accurate, but some types may under-register. Some large master meters may over-register if improperly installed or maintained. While the loss of revenues because of a single under-registering meter may not be large, losses can be significant system-wide. In some states, there are regulations for periodic meter inspection.

A meter may be faulty if average readings begin to decline or if there is an unexplained change in usage from month to month. It is important that all meters be read each billing period. Systems, which use self-billing methods, should read all meters at least annually. In this way, meter reading errors can be found.

Another benefit of metering is that it can indicate water loss. (Water loss is discussed in Chapter 5, "Operational Issues.") In some cases, there may be an unreasonable difference between the amount of water measured flowing into a system and the amount flowing out of a system. This can be a signal to the operator to search for the reasons for this "unaccounted for" water.

Finally, some systems must mix water from more than one source to get the desired quality. If this is the case, meters can provide an accurate measure of the flow from each source.

Storage Tanks

Water storage tanks are a key element in the distribution system. The foremost reason is that they insure an adequate, protected supply of drinking water.

Functions

Tanks help equalize the daily demands on the system, and provide needed flow during high demand.

"Meters are, in effect, the 'cash register' for the system. By measuring all water taken from the source, and metering all water at each point of use, the fair cost of water can be determined and billed for the full amount due."

Depending upon the type of tank and its elevation, the water in storage tanks can help to provide pressure to the lines in the system.

Tanks used in outlying areas can reduce pumping costs because they can be filled during off-peak hours of electrical demand.

Finally, tanks can serve as public relations tools for the system. Tanks that are neatly maintained and have good paint coatings reflect well on the community or district they serve.

Basic Types

There are four basic types of storage tanks. *Ground storage tanks* are built with the storage body located at ground level. *Standpipes* are also located at ground level, but are narrower and taller than ground tanks. *Elevated tanks* have all storage above ground to provide water at pressure and permit flow by gravity feed.

Hydropneumatic tanks, or pressure tanks, are used occasionally by smaller systems to serve the extreme ends or low-pressure areas of a distribution system.

Life Span

The life span of a storage tank depends in part on the maintenance it receives. Systems invest a large sum of money in a storage tank. *If it is not properly maintained, the value of the tank goes down.* For this reason, tanks should be inspected at least every three years. Depending upon the type of tank and its construction, periodic repairs, painting or coating, and cleaning may be necessary.

Chapter 5

Operational Issues

The best possible water system is one that is both equipped and operated properly. Board Members need to be assured that routine maintenance is performed and that problems are corrected in a timely manner. The elements of routine operation and maintenance are reviewed below, along with some of the major operational issues that Board Members might face.

Routine System Operation and Maintenance

The following is a review of some of the elements of routine system operation:

Maintenance. The operator must perform day-to-day maintenance and preventive maintenance. Board Members are cautioned to insure that this aspect of system management is not neglected. Planning and budgeting must provide for periodic maintenance for all parts of the system.

Installation of New Service. This includes setting new meters, constructing short extensions for new users, and reinstalling meters that have been taken out.

Enforcement of System Rules and Regulations. Enforcement involves turning off service because of unpaid bills, finding and disconnecting illegal taps, and reporting multiple users on meters.

Correction of Potential Health Risks. The operator must respond to any problem that might result in the delivery of unsafe water to users. This includes positive bacteria samples, malfunctioning treatment facilities, and possible cross-connections.

Re-connection of Disrupted Service or Correction of Low Pressure Problems. This can result from broken water lines, and interruption in the flow from the water source, or a malfunctioning of a booster pump.

Correction of Unwanted Water Discharge. This includes broken water lines, overflowing storage tanks, and malfunctioning treatment facilities.

Repair or Replacement of Non-working Meters. This can be caused by mechanical defects, sand or other foreign material inside the metering mechanism, or worn-out meter parts.

Participation in Continuing Education. Key personnel in the operation of the system should participate in continuing education. This includes studying plans and maps, attending training sessions, and reading instructional materials.

Practice of Good Public Relations. All employees should strive to do a consistently good job and project a positive image of the system.

Water Loss

The sale of water is the principle source of income for a water system. Sometimes, system operators or managers report that the system is experiencing a "water loss" problem. This means that there is no record of use of a significant percentage of the water that is pumped into the distribution system. Lost water results in lost revenue to the system. Board members should do everything possible to insure that their water system has as low a percentage of water loss as possible.

Indicators of Water Loss

There are two commonly used indicators of water loss. The first uses the daily pumping record (or a record of water purchased). Operators should enter readings of their master meters in a daily record and compare that amount to the readings of the previous day. If the master meter records indicate water usage above ten percent over the previous day, the manager should suspect a problem. If usage increases beyond twenty-five percent and there has been no obvious explanation for the demand, then the warning is clear. The water system may have one or more serious leaks or a malfunction of a facility (such as a tank control failure).

The Water Loss Formula
P-B/P = L
P = Gallons Pumped or Purchased
B = Gallons Billed
L = Percent of "Unaccounted For" Water

Another indicator of water loss can be a comparison of the pumping record with billings. A monthly comparison of the amount of water pumped or purchased against the amount billed is one of the most important clues to leaks. From that comparison of the amount of water pumped or purchased against the amount billed is one of the most important clues to leaks. From that comparison, the loss rate can be determined. (See box at left.)

Virtually all systems have some unaccounted for water. If it is decided that a system is experiencing a water loss problem that should be corrected, then a systematic loss detection program should be initiated. The steps are outlined below:

Check the Obvious

Check the obvious causes for any water loss problem. Inspect for possible leaks along the pipeline. Sometimes, visual inspections may reveal leaks. Double-check the accuracy of all computations. In some instances, the water loss problem is only "on paper." Inspect tanks for overflowing. Check abandoned connections for leakage. Look for signs of theft.

Identify Unmetered Uses

If some users are not metered, estimate the usage and recalculate the water loss percentage. If three still seems to be a water loss problem, then initiate a leak detection program with the following step.

Verify Meter Accuracy

If faulty meters are found, repair should be considered. In some cases, repair may not be cost-effective. For example, if water is charged at only $0.75 per thousand gallons, the return on repairing a meter under-registering by four percent would be only $3.00 for every 100,000 gallons. Estimating an average household use of 5,000 gallons per month, the monthly income loss to the system would be only $0.15 cents. It may not be cost-effective to repair or replace meters with small percentages of loss when water is inexpensive.

If, however, water is billed at $1.25 per thousand and the meter is under-registering by 20 percent there is greater concern for meter repair. For every 100,000 gallons of water through the meter, the system would lose $25.00. In this case, a meter check and maintenance program would be cost-effective.

The use of the correct size of water meter can play a major role in the reduction of unaccounted for water. If the meter is too large or too small for the desired minimum and maximum flow rates, the system may be losing revenues because of improper registering.

If faulty meters are discovered and repaired, or if the amount of metering error can be estimated, the water loss formula can be recalculated using new figures. If there still seems to be a water loss problem, go to the next step.

Obtain Accurate System Maps

Obtain an accurate map of the entire distribution system. As mentioned in the section above concerning distribution, maps are essential in the operation of the system, especially in leak detection. It would not, for example, be possible to systematically close portions of the system to listen for leaks if the location of all lines and valves were not known.

Inspect Connections

Check all appurtenances, including valves, hydrants, air relief valves, and backflow prevention devices for proper functioning.

Search for leaks

The search for leaks may require the inspection of the system in zones. This can involve the use of metal detectors to find buried pipe, the closing of certain valves, and the use of listening devices to detect spraying water under-ground.

Leaks are commonly associated with:

- faucets and taps;
- main breaks;
- meter box leaks;
- service line;
- street settlement;
- river crossings; and,
- tank and reservoir overflow.

Fire Protection

Some small and rural water systems are constructed to provide drinking water supply only. Providing fire protection requires much planning. Board Members should be aware of the problems, responsibilities, and liabilities that are associated with providing fire protection to a system.

Fire protection cannot be an assumed advantage because many small rural water systems are not prepared to provide adequate fire protection. In most cases, the rural water system's lines are not large enough to produce the quantity of water needed to provide fire protection.

Hydrants are often placed on small water systems for the general purpose of flushing the distribution system rather than fire fighting. Although these hydrants may be able to permit certain flows of water, their limitations should be recognized.

For instance, in some cases the use of hydrants for fire fighting could result in the collapse of the pipeline and loss of pressure.

If a system is not constructed for fire protection, the Board Members should establish a fire hydrant policy for the protection of the water system from liability. Liability can be incurred because of the false assumption of the availability of fire protection. The policy should state that the system is not a fire protection system and that is was designed and constructed to provide potable water to its customers for domestic use only. Further statements should be made as a disclaimer of any warranty or liability for damages to persons or property resulting from the use of hydrants to fight fires.

Cross-Connection Control

An issue of ever-increasing importance is that of cross-connection control. A cross-connection is a link between a supply of potable water and a potential source of contamination. Board Members should determine the state regulations in this regard and discuss whether special public relations efforts are needed to inform users of a possible health hazard.

Backflow

One of the most common cross-connections is one that results from "backflow." In the past, backflow has caused more waterborne disease outbreaks than any other reported factor.

Backflow can result from "backsiphonage" or "back pressure." Backsiphonage can happen when a negative pressure occurs in a water supply line. If there is a physical connection between the system and a contaminant (for instance, a hose connecting an open faucet with a container of pesticide) then the contaminant can be drawn into the distribution system.

Back Pressure

Back pressure can also create a cross-connection. For instance, if a water system customer also has a private well, the pump on the private well can create enough back pressure to force well water to backflow into the distribution system. This is classified as a cross-connection because the public water supply is mixed with water of unknown quality.

Maintaining Records and Reports

It is important that water system personnel maintain various reports and records for planning and proper management of the system operation. In some states, the storage and maintenance of certain records is a matter of law. It is equally important that Board Members know the significance of each report and record because, ultimately, the Board is responsible for them.

Technical reports and records are generally viewed as those dealing with the physical operation and maintenance of the water system's facilities. These reports, like financial reports, can be valuable tools for good decision-making and good day-to-day management. A Board Member can use these tools as a gauge to help determine the financial integrity and condition of the system.

Good records also allow Board Members to react to potential problems and plan for future expansion. Accurate historical data allows Board Members to make more informed decisions regarding projections for system improvements. This data can also be an invaluable asset in helping to recognize areas of preventative action. The following reports or records should be used by systems:

Daily Operating Report

This report lists such things as the amount of water purchased or produced, meter readings, and the amount of chemicals used in the treatment process. The report is completed on a daily basis. It is advisable to maintain these records in the files for ten years.

Water Loss Report

The term "water loss' is generally defined as the difference between the amount of water produced or purchased and the amount of water sold to the customers (as described above).

Operation and Maintenance Records

It is essential to know when equipment was installed or repaired, the number of hours operated or other maintenance performed. Operation and maintenance records cover all the physical facilities of the water system including storage tanks, meters, pumps, vehicles, fire hydrants, valves, etc. Operation and maintenance manuals should be available for all appurtenances.

Emergency Response

Emergency planning is an important responsibility for governing bodies of water systems. Board Members should make sure that the water system has contingency plans to handle emergency situations.

Good emergency planning includes guidelines to help the system initiate preventive measures directed toward potential emergencies. Several areas in which Board Members should plan for emergency response and prevention include the following:

- Emergency and standby systems including supply options for contamination, main breaks, drought, flood, or other disasters.

- Board members should have access to all federal and state disaster emergency service numbers in the event of an emergency.
- Emergency conservation plans.
- Plans for emergency staffing.

“Local preparedness, Board action and cooperation are the keys to coping with water shortage. Board members should monitor local conditions, organize their system, and take necessary action.”

Although federal and state governments can generally provide limited assistance during an emergency, water shortages can only be addressed at the local level. The role of local officials and the local system cannot be overemphasized. Local preparedness, Board action and cooperation are the keys to coping with water shortage. Board Members should monitor local conditions, organize their system and take necessary action.

During emergency situations, Board Members may ask for help from community leaders to make recommendations. This group can provide essential support to the water system’s governing body in times of impending crisis.

In planning for emergencies the options for supplementing the water supply should be evaluated (such as assistance agreements with neighboring systems), as well as plans for reducing water usage (such as rationing or watering bans). Comprehensive leak detection and water loss programs should also be initiated if not already in place.

The action a governing body takes will depend on the degree of severity. There are four stages of severity, matched to specific conservation activities:

1. **Advisory phase:** During this phase, the system should issue a water shortage advisory bulletin, set conservation goals, prepare for decreasing supply, inform the public of the potential problem, and request voluntary conservation.
2. **Alert phase:** If the water shortage problems continue, a water shortage alert should be issued and increased conservation goals may be set. All nonessential uses of water should be banned. Voluntary conservation for all water use may be requested, compliance with the ban on nonessential use should be monitored, and conservation requests may be enforced as necessary.
3. **Emergency phase:** When the water shortage reaches an emergency level the system should issue a water shortage emergency declaration. Increased conservation goals should be set.

Ban all nonessential water use and monitor all conservation activities (particularly compliance with the bans).

4. **Rationing phase:** During this phase, mandatory allocation of water is ordered. The system should also request usage reductions at specific levels and establish new conservation goals. Monitor all water shortage related activities, especially compliance with the allocation program.

Some states have guidelines for emergency response. Board Members may contact water associations or the state health agency for more information.

Alternative Energy Sources

Nearly every water system is dependent to some degree on electricity as the energy source to operate water treatment plants, pumping stations and office facilities. Plans for emergency response should always include provisions for auxiliary generators or other motorized power sources at the water treatment plant or wells and essential pumping stations. Board Members should recognize which of their facilities are critical for continued water service in case of power failure. Local conditions should dictate the priority the system will place on those needs.

Chapter 6

Board Member Tips

The job of a small and rural water system Board Member is always challenging. In accepting a position on the Board, an individual agrees to insure that the system is operated and maintained in a businesslike manner to meet long and short term needs. In return, the system gives Board Members the authority, responsibility, and privilege to act on its behalf.

Listed below are some final thoughts and suggestions regarding the Board Member's role in the operation and maintenance of a small water system:

Board Members Do Not:

1. Interfere with the day-by-day routine of administration and supervision.

2. Refuse to support worthwhile officials in the programs because of personal reasons.

3. Show favoritism.

4. Make promises and commitments about system operation before the questions are fully discussed in the Board meetings.

5. Indulge in petty criticism of the operation of the system.

6. Assume authority in operational matters when the Board is not in session.

Board Members Do:

1. Recognize that it is their responsibility to set policy and not participate in daily operation and maintenance of the system.

2. Work through the properly appointed employee according to the organization as planned.

3. Function as a part of a policy forming and controlling Board rather than as part of an administrative Board.

4. Refer, as far as possible, all complaints and requests to the operator, system manager, or office manager.

5. Become familiar in a broad and non-technical manner with the problems of system operation and maintenance.

6. Voice opinions frankly in Board meetings and vote for what seems best for the short-term and long-term welfare of the operation and maintenance of the system.

7. Recognize fully that the operator, system manager, or office manager is entirely responsible for carrying out a particular policy in accordance with laws and regulations.

8. Help to frame policies and plans only after considering the recommendations of the operator, manager or office manager, together with the reasons for making such recommendations.

9. Require oral and written reports for the purpose of keeping the Board properly informed on operational matters, and insure that these reports are adequately reflected in the minutes from Board meetings.

10. Give authority in keeping with responsibilities.

11. Establish criteria for evaluating the efficiency of employees under the direct supervision of the Board.

12. Present personal criticism only to the appropriate person.

13. Support and protect employees and other Board Members in the performance of their duties.

14. Give friendly counsel and advice to employees.

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