INDIANA DRINKING WATER OPERATOR TRAINING

Transmission and Distribution Manual

First Publication January 2025

Contents

Introduction

This manual provides a basic overview of water distribution. It was compiled using multiple resources. No manual, regardless of how comprehensive, can take the place of experience and institutional knowledge.

It is impossible to account for conditions in each water system. While the manual includes best practices, some system operations may differ from the material included. Always refer to your system's internal documentation and standard operating procedures.

Special thanks to the Environmental Protection Agency, Missouri DNR, Pennsylvania Bureau of Safe Drinking Water, National Weather Service, and United States Geological Survey for use of their images.

Thanks also to fellow IDEM employees and water system operators for their contributions and feedback. If you're reading this and breathing a sigh of relief that you weren't mentioned by name, this "thanks" is for you.

Chapter 1 – Source Water and Regulation

Learning Objectives

- List the components of the Hydrological (Water) Cycle
- Identify federal regulatory bodies and explain federal drinking water legislation
- Identify state regulatory bodies and explain state drinking water regulations
- Explain the different system classifications and recognize the duties for each classification
- List requirements and tiers of public notification and demonstrate knowledge of when each tier should be used
- Identify the requirements in the Consumer Confidence Report

Hydrological Cycle (Water Cycle)

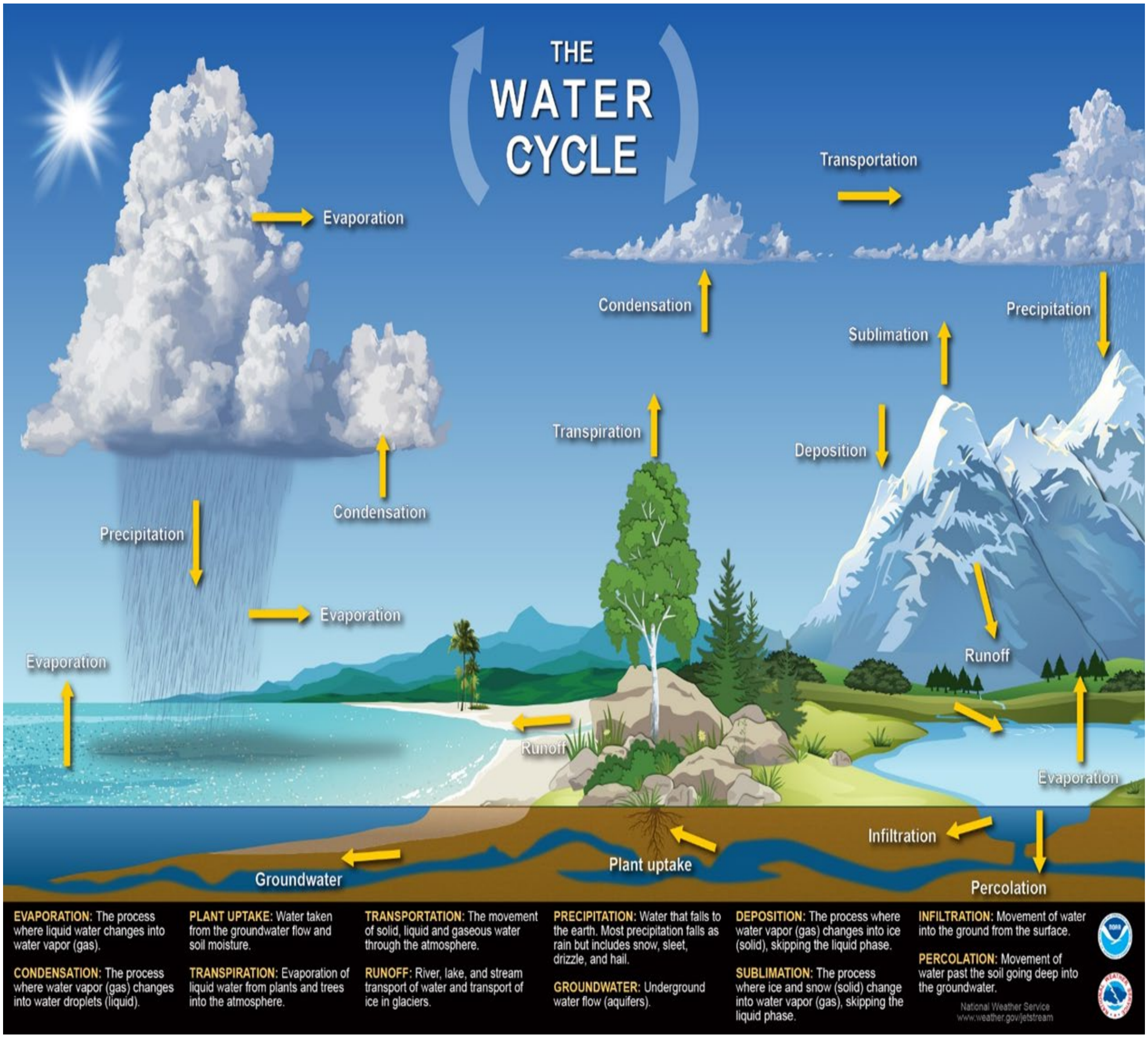
Water is a chemical compound made of two Hydrogen atoms and one Oxygen atom (H_2O). All lifeforms on Earth require water to survive. Drinking water professionals provide an essential service, by ensuring safe, clean water is available to their customers.

Water exists on earth one of three states of matter: solid, liquid, or gas. Water in gaseous form is commonly referred to as water vapor. Most chemicals and compounds become denser, or contract, as they move from gas or liquid state to a solid state. Water is one of the few that is less dense as a solid than it is as a liquid. Water reaches its maximum density at 4° C, or 39.2° F, and becomes less dense, or expands, as it freezes. Ice is roughly 9%, or 1/9, less dense than liquid water. This is why ice floats in water.

The hydrological cycle covers the "continuous exchange" of water between the earth and the atmosphere. The hydrological cycle, also known as the water cycle, shows the movement of water through those phases as it travels through the land, sky, and bodies of surface water, like oceans and lakes.

Figure 1.1 illustrates the movement of water through the hydrological cycle. Table 1.1 lists each component, or phase, of the water cycle.

Figure 1.1 – The Water Cycle



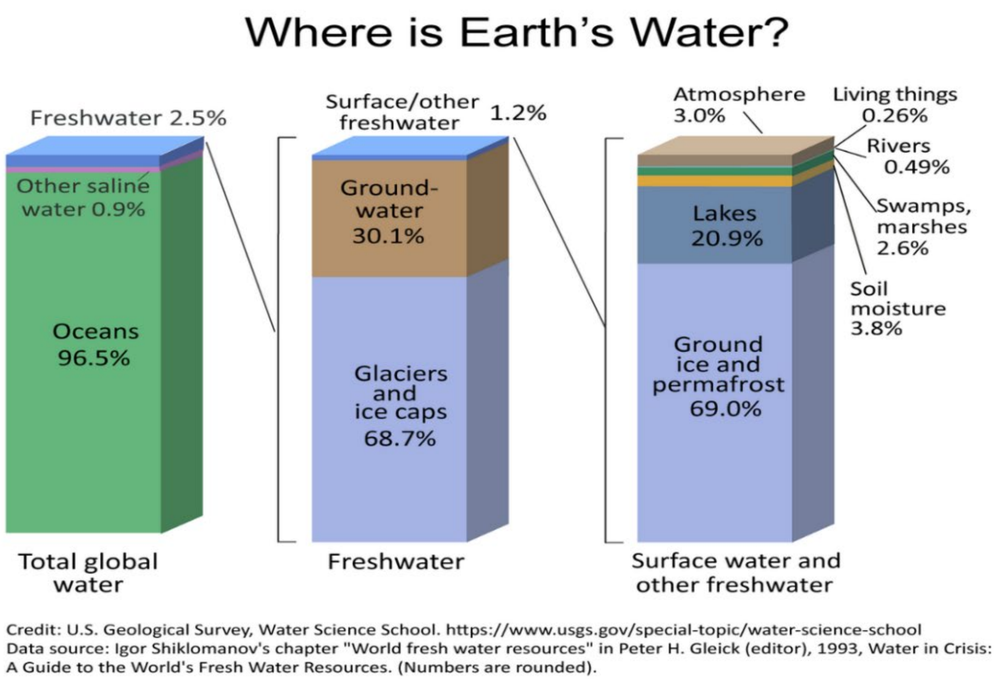
Courtesy of the National Weather Service

Table 1.1 – Phases of the Hydrological Cycle

Phase	**Process**
Condensation	The process of water vapor in the air becoming liquid water.
Deposition	The process where water vapor changes from a gas to a solid, skipping the liquid phase.
Evaporation	The conversion of water from a liquid to a gas.
Evapotranspiration	Liquid water evaporates from land and soil into the atmosphere.
Precipitation	Water that falls to the earth in liquid form as rain, snow, sleet, and hail.
Percolation	The slow seepage of water through the ground, or the slow passage of water through filter media.
Sublimation	The process of solid water (snow or ice) changing to gaseous water (water vapor), skipping the liquid phase.
Transpiration	The process of liquid water evaporating from plants and trees into the environment.

Because of the water cycle, the amount of water on earth has remained mostly constant. Roughly 70% of the Earth's surface is made of water. Of the available water on Earth, only around 2.5% is fresh water, and only a percentage of that is available for consumption. Because of this, it is important to conserve water. Figure 1.2 shows the composition of the Earth's water.

Figure 1.2 – Where is Earth's Water



Federal Regulations

United States Environmental Protection Agency (U.S. EPA, USEPA, or EPA)

https://www.epa.gov/

The United States Congress is responsible for creating federal laws and regulations. Due to environmental disasters like the fire on the Cuyahoga River and publications detailing the hazards of chemicals released into the environment, President Nixon signed the National Environmental Policy Act (NEPA) on January 1, 1970. The Environmental Protection Agency (EPA) was established in December of 1970.

The mission of the EPA is "To protect human health and the environment". It does so by enforcing the rules and regulations enacted by Congress. In 1972 the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act, was passed. It was enacted to restore and maintain water quality in the U.S. through pollution control and assistance in wastewater treatment.

The Clean Water Act has undergone multiple revisions but has maintained its core functions from the original 1972 legislation:

- Established structure for regulating pollutant discharges into U.S. waterways.
- Granted authority to the EPA to create pollution control programs and set wastewater standards for industry.
- Maintained existing water quality standards for surface water contaminants.
- Outlawed pollution discharges into navigable waters, unless granted a provisional permit.
- Funded grant program for sewage treatment plant construction.
- Recognized the need to address critical problems caused by nonpoint source pollution.

The Safe Drinking Water Act (SDWA)

https://www.epa.gov/sdwa

The Safe Drinking Water Act (SDWA) was originally adopted, or passed, in 1974, with amendments passed in 1986 and 1996 to protect public health by regulating the drinking water supply. It authorizes the EPA to set national health standards for drinking water to protect consumers from naturally occurring and man-made contaminants. Table 1.2 defines the EPA SDWA health standards. A full list of regulated contaminants and their allowable amounts is available on the EPA's SDWA website.

Table 1.2 – SDWA Standards

Contaminant Class	What it Means	Enforceable?
Maximum Contaminant Level Goal (MCLG)	The level of contamination below which there is no known or expected health risk.	No
Maximum Contaminant Level (MCL)	The highest level of contamination allowed in drinking water. It is set as close to MCLG as possible, using the best and most cost-effective technology available.	Yes
Secondary Maximum Contaminant Level (SMCL)	Non-mandatory levels for systems to manage taste, color and odor.	No

The SDWA defines a public water system (PWS) as having at least 15 service connections or serving 25 or more people per year, at least 60 days out of the year. Community systems serve the same residents, while non-community systems serve non-residents and have either transient (moves) or non-transient (does not move) populations. Table 1.3 explains the types of public water systems.

Table 1.3 – Public Drinking Water Systems

Type of System	Characteristics	Examples
Community	Serves the same population of 25 or more year-round.	Municipal Utility, Mobile Home Parks, Neighborhoods
Non-transient non-community	Serves the same population of 25 or more for at least 6 months, but not the entire year.	Factories, Schools, Daycare Centers
Transient non-community	Provides water to 25 or more people for at least 60 days/year, but not the same people on a regular basis.	Gas stations, Campgrounds, Rest Areas, Churches

The 1996 SDWA Amendment enhanced the existing legislation, which focused on treatment as a means of providing safe drinking water, to include the following additional methods:

- Consumer Confidence Reports – requires all community water systems to prepare and distribute an annual report providing detailed information on water quality, potential contaminants, and their impact on human health.
- **Cost-Benefit Analysis** – requires a thorough cost-benefit analysis of any proposed new water system to ensure the benefit of creating the system will justify the cost.
- **Drinking Water State Revolving Funds** – established for states to assist water systems with improvements and source water protection.
- **Microbial Contaminants and Disinfection Byproducts** – strengthened protection for microbial contaminants like Cryptosporidium while also adding protections to control the byproducts from chemical disinfection. Includes the Stage 1 Disinfectants and Disinfection Byproducts Rule and the Interim Enhanced Surface Water Treatment Rule.
- **Operator Certification** – requires water system operators to be certified to ensure safe operation. The operator certification guidelines were issued in February of 1999 and outline the minimum standards for certification and recertification.

- **Public Information and Consultation** – Emphasizes consumers' right to know about what is in their drinking water. The EPA distributes public information, holds public meetings, and works with states, tribes, water systems and environmental groups to accomplish this.
- **Source Water Assessment Programs** – Requires states to conduct testing on drinking water sources like lakes, rivers, streams, reservoirs and groundwater wells. The goal is to find out how susceptible to pollution these sources are and to identify potential sources of contamination.

The SDWA allows the EPA to grant primacy to states. This gives the state authority to enforce the federal regulation. The state must adopt standards at least as stringent, or strict, as the standards included in the federal legislation. The EPA divides the states into regions and has offices throughout the country. Indiana is in EPA region 5, which also includes Illinois, Michigan, Ohio, Wisconsin, and 35 Tribes.

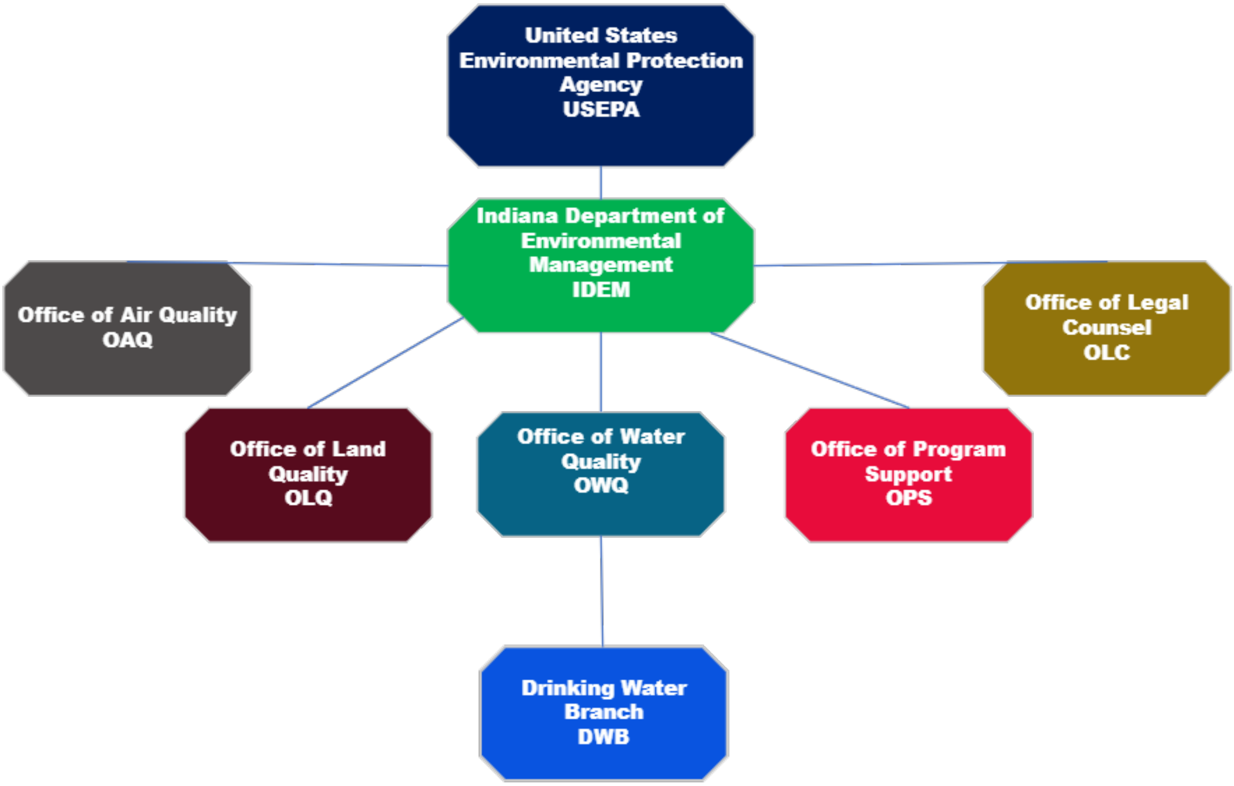
State Regulations

Indiana Department of Environmental Management (IDEM)

https://www.in.gov/idem/

The Indiana Department of Environmental Management (IDEM) is the agency responsible for enforcing environmental laws in Indiana. It applied for and was granted primacy by the EPA. Figure 1.3 shows the hierarchy of the EPA and the different IDEM offices.

Figure 1.3 – Federal and State Environmental Hierarchies



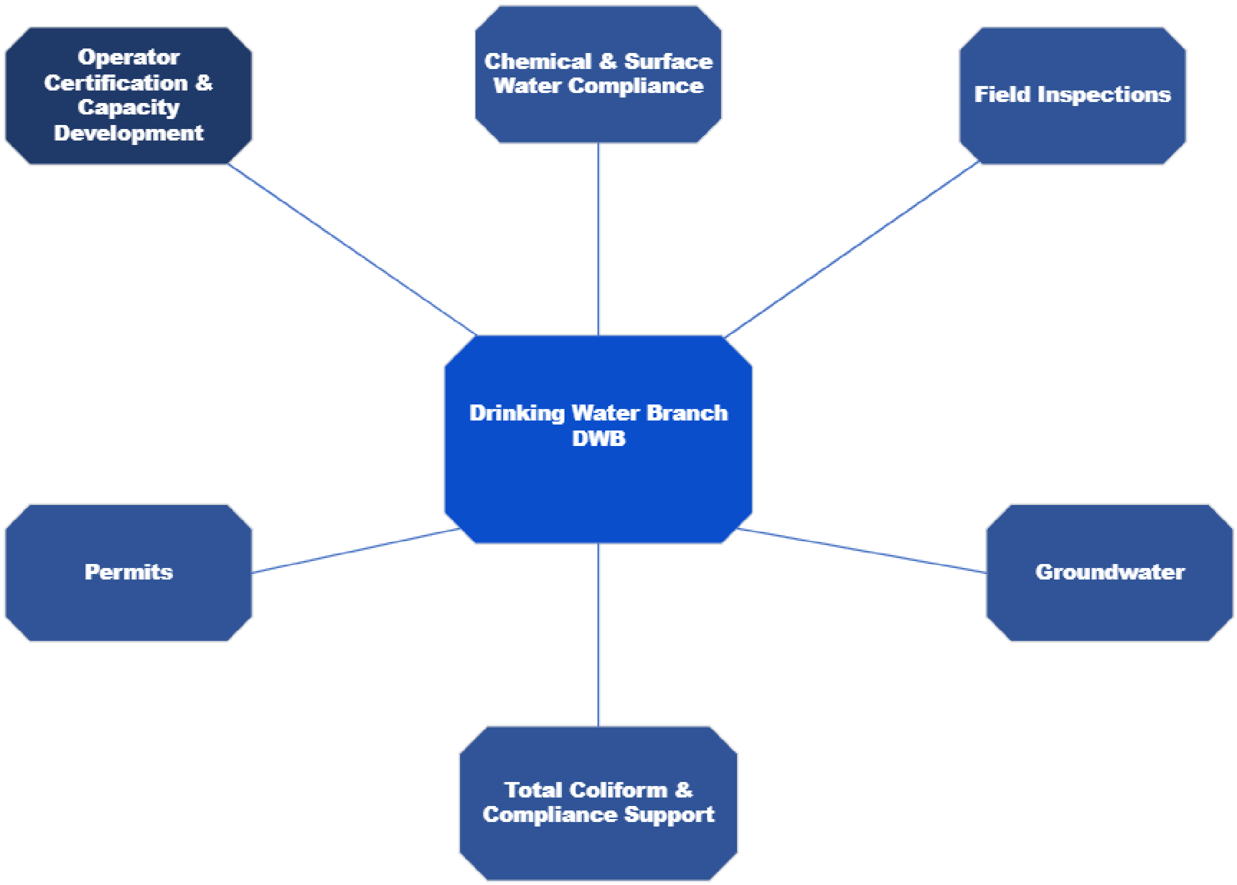
Each office of IDEM is responsible for protecting different parts of the environment. The Office of Water Quality (OWQ) works to ensure that Indiana waterways, wetlands and aquifers are protected from contamination. There are many branches in OWQ, but the Drinking Water Branch oversees program areas that regulate the drinking water supply.

Drinking Water Branch (DWB)

https://www.in.gov/idem/cleanwater/drinking-water/

The Drinking Water Branch is part of the Office of Water Quality and works to ensure Hoosiers have water that is safe for drinking and other consumption. Figure 1.4 shows the six sections in the DWB.

Figure 1.4 - Drinking Water Branch Sections



The six sections in the DWB work together to monitor contaminants, protect source water, inspect treatment facilities for compliance, review and approve system plans for new and existing treatment facilities and distribution mains, and administer an operator certification program.

Indiana Administrative Code (IAC)

Indiana Administrative Code (IAC) are the administrative rules or laws passed by the Indiana State Legislature. The rules that pertain to the OWQ are contained in Title 327. Rule 12 of Article 8 in Title 327 regulates public water supplies, or systems. Refer to Table 2 on page 4 for the definitions of public water supplies.

System Classifications and Operator Responsibilities

System Classifications

327 IAC 8-12-2 separates public water systems into two categories: Treatment and Distribution. Treatment plants will fall into one of six categories based on population size and technology. Distribution systems will fall into one of three categories, based on population size, storage, and pressure and flow management. Tables 1.4 and 1.5 provide details on these different classifications.

Table 1.4 – Water Treatment and Distribution Operator Classifications

Operator Class	Characteristics

WT1	• Serve a population less than or equal to five hundred (500) people
	• Acquire water from one (1) of the following:
	    ○ Ground water
	    ○ Purchase
	• Have one (1) of the following:
	    ○ Ion exchange softening process for cation removal
	    ○ Inline filtration device with no chemical treatment

WT2	• Acquire water from one (1) of the following:
	    ○ Ground water
	    ○ Purchase
	• Utilize chemical feed to achieve one (1) of the following:
	    ○ Disinfection
	    ○ Fluoride standardization
	    ○ Water stabilization

WT3	• Acquire water from one (1) of the following:
	    o Ground water
	    o Purchase
	• Utilize chemical feed
	• Have one (1) of the following:
	    o Pressure or gravity filtration
	    o Ion exchange processes if the population served is five hundred one (501) or greater
	    o Lime soda softening
	    o Reverse osmosis

WT4	• Serve a population less than or equal to ten thousand (10,000) people
	• Acquire water from one (1) of the following:
	    o Surface water
	    o Ground water under the direct influence of surface water

WT5	• Serve a population of ten thousand one (10,001) or more people
	• Acquire water from one (1) of the following:
	    o Surface water
	    o Ground water under the direct influence of surface water

WT6	• Utilizes newly emerging treatment technology not commonly in use for drinking water treatment in Indiana, as determined by the Commissioner of IDEM.

Table 1.5 -Distribution System Operator Classifications

Operator Class	**Characteristics**

DSS (Distribution System Small)	• Serve a population of less than three thousand three hundred one (3,301)
	• Have no components other than:
	  ○ pressure tanks; or
	  ○ storage tanks

DSM (Distribution System Medium)	Meet one (1) of the following:
	• Serve a population greater than or equal to three thousand
	• three hundred one (3,301) but less than or equal to ten thousand (10,000) people and have no mechanical means of movement of water other than one (1) of the following:
	  ○ Pressure tanks
	  ○ Storage tanks
	• Consist of the following:
	  ○ Pump
	  ○ Storage tanks
	  ○ Booster pumps to storage tanks

DSL (Distribution System Large)	• Serve a population greater than or equal to ten thousand one (10,001) people, or more
	• Consist of the following:
	  ○ Storage tanks
	  ○ Booster pumps to the distribution system
	  ○ Mechanical devices for the movement of water beyond storage

Treatment classes WT1, WT2 and WT3 cover systems that acquire water supply from either purchase or groundwater. Treatment classes, WT4 and WT5 both acquire water from surface water or groundwater under the direct influence of surface water (GWUDI), but the population served determines their classification.

Ensuring your system is classified correctly is important, as each classification may have different regulatory requirements. Your facility may need reclassification if any of the following situations occur:

- The system uses special equipment or emerging technology.
- Features of design require a change in operation.
- A change is required by law.
- IDEM Commissioner determines a new classification requirement.
- Change in source water.

Some non-community non-transient, and community systems serving 100 or fewer people may qualify for Facility Specific Operator (FSO) certifications. If you have questions regarding your system classification, please contact IDEM.

Operator Responsibilities

An operator is responsible for drinking water quality from the treatment facility to the customer's tap. The customer's tap describes the connection from the utility's main to the customer's service line, NOT an interior faucet. The primary goal of an operator is to protect human health and safety by providing potable water. It is also important to provide aesthetically pleasing finished water, without any foul colors, tastes, or odors.

IDEM requires all PWS to have a designated operator who is the Certified Operator in Responsible Charge (CORC). The CORC is designated by the owner or governing body and is responsible for the operations of the treatment or distribution facility. They make decisions regarding daily operations which impact water supply and quality. A facility may have multiple operators, but there is only one CORC. Table 1.6 details CORC requirements for each facility grade.

Table 1.6 – CORC Requirements

Operator Grade	**CORC Requirements**

All Grades	• The certified operator will be able to provide adequate supervision to all units involved.
	• Before undertaking multiple operator positions of responsible charge, a letter signed by the certified operator is submitted to the owner or governing body of each water treatment plant and water distribution system to be under the responsible charge of the certified operator providing the following information:
	  ○ The name and location of each water treatment plant and water distribution system to be under the responsible charge of the certified operator.
	  ○ The number of hours per week the certified operator shall work at each water treatment plant and water distribution system.

DSS	• Be monitored daily by a dependable person or automated system.
	• Meet the following conditions based on system size and type:
	  ○ A community water system must have a certified operator on site for a minimum of two (2) daily visits every week.
	  ○ A non-transient noncommunity water system serving greater than five hundred (500) individuals must have a certified operator on site for a minimum of one (1) daily visit every week.
	  ○ A non-transient noncommunity water system serving five hundred (500) or fewer individuals must have a certified operator on site for a minimum of one (1) daily site visit every two (2) weeks.

DSM	• Be monitored daily by a dependable person or automated system. • Have a certified operator on site for a minimum of three (3) daily visits every week.
DSL	• Be monitored daily by a dependable person or automated system. • Have a certified operator on site for a minimum of five (5) daily visits every week.

WT1	• Be monitored daily by a dependable person or automated system. • Have a certified operator on site for a minimum of three (3) daily visits every week.
WT2	• Be monitored daily by a dependable person or automated system. • Have a certified operator on site for a minimum of five (5) daily visits every week.
WT3	• Be monitored daily by a dependable person or automated system. • Have a certified operator on site for a minimum of five (5) daily visits every week.
WT4	• Must have a certified operator on site during water treatment plant operation unless the plant is equipped with an automated system approved by the commissioner.
WT5	• Must have a certified operator on site during water treatment plant operation unless the plant is equipped with an automated system approved by the commissioner.

Required Qualifications

Many different skills are required to successfully operate a treatment or distribution facility, as outlined in 327 IAC 8-12-3. Operators of all grades must possess the following skills and qualifications:

- Understanding of basic scientific principles.
- Understanding basic sanitation principles.
- Ability to read and write in English for the purpose of interpreting service manuals, reading work orders and creating written reports.
- Ability to make simple and complex calculations.
    - Multiplication and division
    - Decimals, fractions and percentages
    - Converting units of measurement
    - Calculating volume of pipes and storage structures
    - Calculating appropriate dosages for various chemicals
    - Reading a linear scale
- Strong organizational skills for record keeping and maintaining necessary supplies.
- **High School Diploma or its equivalent.**

An operator must also pass a certification examination unless otherwise exempted by statute or rule. A score of 70% or more is required to pass a certification examination.

Table 1.7 details the experience and education requirements for each operator grade and the continuing education requirements to renew certification. Renewal for all operator grades requires Continuing Education Unit (CEU) hours. 70% of the CEUs must be technical for renewal. Figure 1.5 is the form for submitting CEU hours.

Figure 1.5 – Continuing Education Credit Report

PUBLIC WATER SUPPLY DRINKING WATER OPERATOR/VALIDATOR CONTINUING EDUCATION CREDIT REPORT
State Form 45674 (R4 / 1-22)
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
DRINKING WATER BRANCH

**The information in this document is confidential according to 327 IAC 8-12-7.6*

To ensure proper credit, the Indiana Drinking Water approval number MUST be submitted on this form.

Indiana Drinking Water Approval Number	*PWS________________"
Maximum Credit Hours	

Mail to:	Indiana Department of Environmental Management OWQ Drinking Water Branch - Mail Code 66-34 100 N. Senate Avenue Indianapolis, IN 46204-2251

INSTRUCTIONS: To ensure proper credit, print legibly

This form must be completed in order for the attendee to get credit. Be sure to record the certification number and class/grade for each certification for which you are requesting credit.

Mail the original form to IDEM at the above address. The Training Provider must retain a copy of the completed form for their records in accordance with 327 IAC 8-12-7.6.

Since this is a form of attendance verification, it is requested that this form be distributed during the latter portion of the training session. No credit will be considered when original signatures are not shown.

Name of certified operator/validator	Mailing address *(number and street)*:		
City:	State:	ZIP code:	Work telephone number: ( )
☐ **Check here if this is a change of address.**			Home telephone number: ( )
Title of training course:			
Name of organization offering the course:			
Number of contact hours approved for the course:			

CREDIT APPLIED TO DRINKING WATER:

Operator certification number:	Class/Grade:	Expiration Date:
Operator certification number:	Class/Grade:	Expiration Date:
Operator certification number:	Class/Grade:	Expiration Date:
Operator certification number:	Class/Grade:	Expiration Date:
Operator certification number:	Class/Grade:	Expiration Date:
Operator certification number:	Class/Grade:	Expiration Date:
Operator certification number:	Class/Grade:	Expiration Date:
Certified validator number:	Number:	Expiration Date:
Date Attended: **(Required)**	Location attended:	
Number of contact hours attended and verified: **(Required)**		
Signature of instructor or training provider: **(Required)**		
Signature of drinking water operator/validator: **(Required)**		

https://www.in.gov/idem/forms/idem-agency-forms/#owq_cert_education

Table 1.7 – Qualifications, experience, and renewal requirements

Operator Grade	Work Experience and Qualifications	Renewal Requirements
Operator in Training (OIT)	• Current employment at a WT3, WT4, or WT5 treatment system or a DSL distribution system.	Not eligible for renewal.
WT1	• Minimum of 1 year experience. • The ability to maintain inventories. • Ability to order supplies and equipment. • Ability to interpret chemical and bacteriological sample reports.	10 CEU hours
WT2	• Maintain inventories. • Order supplies and equipment. • Interpret chemical and bacteriological sample reports. • Attain one (1) of the following acceptable work experience requirements: ○ One (1) year in the operation of a Class WT 2 water treatment plant. ○ Two (2) years in the operation of a Class WT 1 water treatment plant.	15 CEU hours
WT3	• Maintain inventories. • Order supplies and equipment. • Interpret chemical and bacteriological sample reports. • Attain the following acceptable work experience at a minimum: • Two (2) years in the operation of a Class WT3 water treatment plant. ○ Successful completion of educational work at college level in: ▪ Engineering ▪ Chemistry ▪ Science related to water treatment may be substituted for work experience required at the ratio of four (4) semesters or six (6) quarters of schooling for a maximum substitution of one (1) year of experience.	25 CEU hours

WT4	• Maintain inventories.
	• Order supplies and equipment.
	• Interpret chemical and bacteriological sample reports.
	• Attain the following acceptable work experience at a minimum:
	• Two (2) years in the operation of a Class WT4 water treatment plant.
	    ○ Successful completion of educational work at college level in:
	        ▪ Engineering
	        ▪ Chemistry
	        ▪ Science
	related to water treatment may be substituted for work experience at the ratio of four (4) semesters or six (6) quarters of schooling for a maximum substitution of one (1) year of experience.
		30 CEU hours

WT5	• Ability to use conversion factors.
	• Ability to solve simple mathematical equations.
	• Understand the following:
	    ○ Simple chemical laboratory equipment.
	    ○ The bacteriological procedures used in water supply work.
	• Maintain inventories.
	• Order supplies and equipment.
	• Attain the following acceptable work experience at a minimum:
	    ○ One (1) of the following:
	    ○ Three (3) years in the operation of a Class WT5 water treatment plant.
	    ○ Five (5) years in the operation of a Class WT4 water treatment plant.
	    ○ Successful completion of educational work at college level in:
	        ▪ Engineering
	        ▪ Chemistry
	        ▪ Science
	related to water treatment may be substituted for work experience at the ratio of four (4) semesters or six (6) quarters of schooling for one (1) year of experience, up to a maximum of two (2)years of experience.
	    ○ Two (2) years in the operation of a WT 3 water treatment plant may be substituted for one (1) year of experience required, with up to a maximum substitution of two (2) years' experience.
		30 CEU hours

WT6	• Operator qualifications determined by the commissioner on an individual plant basis in response to the specialized nature of the water treatment plant.	30 CEU hours
DSS	• Attain a minimum of one (1) year of acceptable work experience in the operation of a Class DSS water distribution system.	10 CEU hours
DSM	• Attain one (1) of the following acceptable work experience requirements: ○ One (1) year in the operation of a Class DSM water distribution system. ○ Two (2) years in the operation of a Class DSS water distribution system.	15 CEU hours
DSL	• Maintain inventories. • Order supplies and equipment. • Interpret chemical and bacteriological sample reports. • Attain one (1) of the following acceptable work experience requirements: ○ One (1) year in the operation of a Class DSL water distribution system. ○ Three (3) years in the operation of a Class DSM water distribution system. ○ Five (5) years in the operation of a Class DSS water distribution system. ○ An acceptable number of years of experience approved by the commissioner if gained in operation of a combination of the various classifications of water distribution systems.	15 CEU hours

A Certified Operator may operate a facility of a different grade. Below are the allowable facility grade operations for each grade. DSS, WT1 and WT6 can only operate facilities of their respective operator classification.

- DSM can operate a DSS system.
- DSL can operate a DSM or DSS system.
- WT2 can operate a WT1 facility.
- WT3 can operate a WT2 or WT1 facility.
- WT4 can operate a WT1 or WT2 facility.
- WT5 can operate a WT1, WT2, or WT4 facility, a non-transient, non-community DSS system serving 500 or fewer individuals, or a community DSS system serving 100 or fewer individuals.

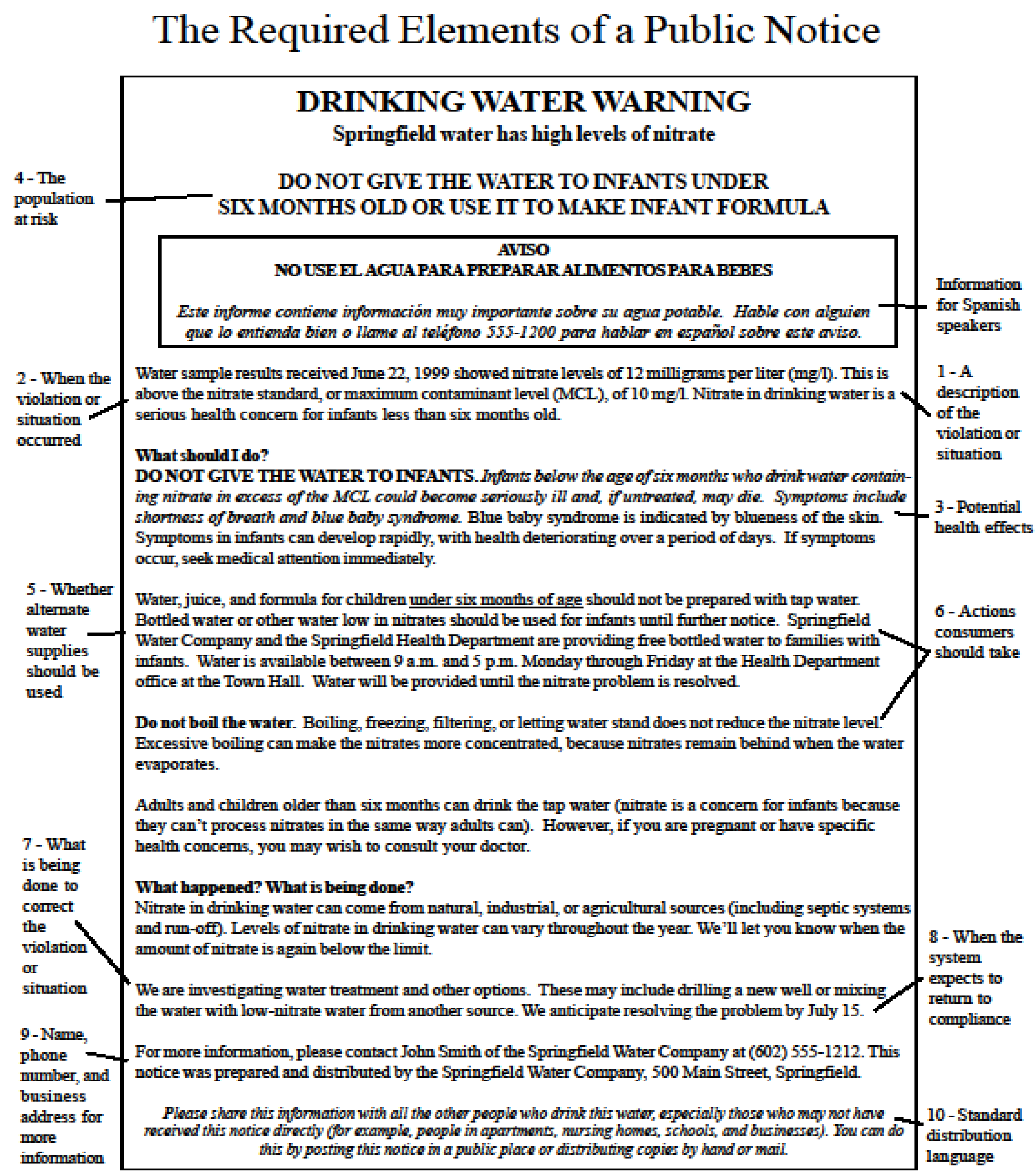
Public Notification

If a public water system violates the EPA or IDEM's drinking water regulations, or if their drinking water poses a health risk, it is required to notify consumers of the violation. This process is called Public Notification. The EPA set strict requirements on the contents of the notification:

- A description of the violation that occurred, including the contaminant(s) of concern, and the contaminant level(s).
- When the violation or situation occurred.
- The potential health effects (including standard required language).
- The at-risk population, including subpopulations who are vulnerable if exposed to the contaminant in their drinking water.
- Whether alternate water supplies need to be used.
- What the water system is doing to correct the problem.
- Actions consumers can take.
- When the system expects a resolution to the problem.
- How to contact the water system for more information.
- Language encouraging broader distribution of the notice.

Figure 1.6 Is an example of a public notification from the SDWA website.

Figure 1.6 – The Required Elements of a Public Notice


The Required Elements of a Public Notice

DRINKING WATER WARNING

Springfield water has high levels of nitrate

DO NOT GIVE THE WATER TO INFANTS UNDER SIX MONTHS OLD OR USE IT TO MAKE INFANT FORMULA

AVISO

NO USE EL AGUA PARA PREPARAR ALIMENTOS PARA BEBES

Este informe contiene información muy importante sobre su agua potable. Hable con alguien que lo entienda bien o llame al teléfono 555-1200 para hablar en español sobre este aviso.

Water sample results received June 22, 1999 showed nitrate levels of 12 milligrams per liter (mg/l). This is above the nitrate standard, or maximum contaminant level (MCL), of 10 mg/l. Nitrate in drinking water is a serious health concern for infants less than six months old.

What should I do?

DO NOT GIVE THE WATER TO INFANTS. *Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome.* Blue baby syndrome is indicated by blueness of the skin. Symptoms in infants can develop rapidly, with health deteriorating over a period of days. If symptoms occur, seek medical attention immediately.

Water, juice, and formula for children under six months of age should not be prepared with tap water. Bottled water or other water low in nitrates should be used for infants until further notice. Springfield Water Company and the Springfield Health Department are providing free bottled water to families with infants. Water is available between 9 a.m. and 5 p.m. Monday through Friday at the Health Department office at the Town Hall. Water will be provided until the nitrate problem is resolved.

Do not boil the water. Boiling, freezing, filtering, or letting water stand does not reduce the nitrate level. Excessive boiling can make the nitrates more concentrated, because nitrates remain behind when the water evaporates.

Adults and children older than six months can drink the tap water (nitrate is a concern for infants because they can't process nitrates in the same way adults can). However, if you are pregnant or have specific health concerns, you may wish to consult your doctor.

What happened? What is being done?

Nitrate in drinking water can come from natural, industrial, or agricultural sources (including septic systems and run-off). Levels of nitrate in drinking water can vary throughout the year. We'll let you know when the amount of nitrate is again below the limit.

We are investigating water treatment and other options. These may include drilling a new well or mixing the water with low-nitrate water from another source. We anticipate resolving the problem by July 15.

For more information, please contact John Smith of the Springfield Water Company at (602) 555-1212. This notice was prepared and distributed by the Springfield Water Company, 500 Main Street, Springfield.

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

https://www.epa.gov/dwreginfo/required-elements-public-notice-public-water-systems

There are three categories of public notification, known as tiers. Table 1.9 explains each tier and its requirements, and examples of violations that could occur.

Table 1.9 - Public notification tier system

Tier	Requirements	Delivery Method	Examples
Tier 1 (Acute Violation, Immediate Notice)	Any situation which has the potential for immediate harm to human health. The water system has 24 hours to notify its consumers.	Media outlets such as television, radio, and newspapers. The notices should also be posted in public places, or personally delivered to customers.	Fecal coliform, nitrate/nitrite, waterborne disease outbreak, failure to collect required samples.
Tier 2 (Notice as soon as possible)	Any situation where contaminant levels are exceeded, or water hasn't been properly treated, but does not pose an immediate health threat. The water system should notify consumers ASAP but must do so within 30 days of the violation.	Media, public posting or through the mail.	MCL violations not considered tier 1 violations, monitoring and testing procedure violations, failure to comply with Violation & Enforcement conditions.
Tier 3 (Annual Notice)	Violations that do not have a direct impact on human health. The system has up to one year to provide notice to customers.	Media, public posting, through the mail, or through the Consumer Confidence Report.	Monitoring and testing procedures not requiring Tier 1 or Tier 2 notice, operation under Violation & Enforcement, exceeding an SMCL.

Consumer Confidence Reports

327 IAC 8-2.1 establishes the purpose and standards for Consumer Confidence Reports (CCR). The federal requirement for CCRs was established in the 1996 amendments to SDWA. All Community water systems must publish an annual CCR.

The CCR should be published no later than July 1st, and must include the following elements:

- The water source(s).
  - Types, such as surface or groundwater.
  - Commonly used name.
  - Location of the body or bodies of water.
- A source of water assessment.
  - Availability of the water.
  - The means to obtain the water.
- Any source of water assessment from the IDEM commissioner.
  - Must include a summary of potential sources of contamination.
  - Must include language provided by the commissioner, or an approved summary written by the operator.
- Definitions for MCL and MCLG.
- Information on any Level 1 or Level 2 assessments.
- Terms and definitions, if applicable, for:
  - Action level
  - Maximum residual disinfectant level (MRDL)
  - Maximum residual disinfectant level goal (MRDLG)
  - Treatment technique
- Regulated contaminants, with data displayed in a table.
- Any MCL violations.
  - Length of the violation
  - Potential health effects
  - Actions taken to address the violation
- Violations for monitoring and compliance data.
- Telephone number of the owner, operator or designee of the CWS as a source of additional information regarding the report.

If 20% or more of the community residents do not speak English, the report must contain information in the language spoken by those residents. A report must prominently display the following language:

"Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons, such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. U.S. Environmental Protection Agency and Centers for Disease Control guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline at (800) 426-4791.".

A copy of the report should be delivered directly to each consumer. A good faith effort must also be made to share the report with consumers who do not get water bills, and can include, but is not limited to, any of the following methods:

- Posting on the internet.
- Mailing to postal patrons in metropolitan areas.
- Advertising the availability of the report in the news media.
- Publication in a local newspaper.
- Posting in public places or buildings.
- Delivering multiple copies for distribution in places such as apartment buildings or large private employers.
- Delivery to community organizations.

Communities serving 100,000 or more persons must post the current year's report to a publicly-accessible site on the Internet. Copies of the CCR must be retained for a minimum of 5 years.

Practice Exam

1) Which of these is NOT a part of the hydrological cycle?
    a. Transpiration
    b. Evaporation
    c. Standardization
    d. Percolation

2) IDEM can set drinking water regulations because it has been granted _________ by the EPA.
    a. Sovereignty
    b. Primacy
    c. Delegation
    d. Funding

3) Which of these is NOT a required qualification to become an operator?
    a. Ability to read and write in English
    b. Ability to perform complex calculations
    c. Strong organizational skills
    d. College coursework

4) Which type of sample is taken at a single point in time?
    a. Grab
    b. Continuous
    c. Composite
    d. All the Above

5) Which system classification filters and treats groundwater?
    a. WT1
    b. WT2
    c. WT3
    d. WT4

6) Which distribution system serves a population of 3,301 or fewer?
    a. DSS
    b. DSM
    c. DSL
    d. DBA

7) The SDWA was passed in what year?
    a. 1969
    b. 1974
    c. 1999
    d. 2004

8) Laws passed by the Indiana State Legislature are called ________.
    a. Indiana Statutory Laws (ISL)
    b. Indiana Foundational Code (IFC)
    c. Indiana Administrative Code (IAC)
    d. Indiana Secret Code (ISC)

9) ALL Operators are required to have _________________.
    a. An engineering license
    b. A high school diploma or its equivalent
    c. Two years of experience with a utility
    d. Coursework in chemistry

10) The Consumer Confidence Report must be submitted by ___________.
    a. April 1st
    b. July 1st
    c. October 30th
    d. December 31st

Chapter 2 – Sampling and Monitoring, Record Keeping, Corrosion Control

Learning Objectives

- List the different types of sampling techniques
- Identify best sampling practices and sampling sites
- Compare types of contaminants sampled and methods of sampling for each contaminant
- Explain the importance of good record keeping
- Give examples of the different types of corrosion control
- Define a pressure vessel and identify which ones should be regulated

Basic Sampling

To ensure water quality, it is important to collect samples from various points in the treatment plant and distribution system. Always wash or sanitize your hands and avoid touching surfaces with the mouth or lid of the sample container. Contact with dirty hands or surfaces can contaminate the sample and lead to false positives for some contaminants.

Before obtaining a sample, remove any of the following:

- Strainers
- Aerators
- Hoses

Table 2.1 lists sampling types and techniques. Additional details on coliform and lead & copper sampling can be found in their respective sections.

Table 2.1 – Sample Types and Techniques

Sample Type	Volume	Procedure	Notes
Coliform	100mL	See RCTR (Revised Total Coliform Rule)	Best performed on an unthreaded faucet. Sodium thiosulfate powder in sample container neutralizes chlorine residuals.
Lead and Copper	1L (1000mL)	See LCR (Lead and Copper Rule)	Fill sample container to the shoulder. Ensure that water has had time (6-8 hours) to stand in the pipes.
Grab Sample	N/A	Taken at a single time. Provides a snapshot of water quality at that point.	Best used to test dissolved gases, coliform, chlorine residuals, Disinfection Byproducts (DBPs) and pH
Composite Sample	N/A	Taken at intervals throughout the day. Shows change over time.	Should be stored under 40° F (4° C), but above freezing temperature. Never appropriate for coliform sampling.
Continuous Sample	N/A	Continuously collected at desired points in the treatment system.	May be used to monitor raw source water or chemical residuals in the distribution system.

Samples should represent the water system. Avoid sampling in the locations listed below.

- Fire hydrants
- Yard hydrants
- Mop sinks
- Drinking fountains
- Hose bibs
- Storage tanks

When sending the sample to a lab for analysis, it is important to include the correct form for the sample type. All lab report forms can be found on IDEM's website on the forms page: https://www.in.gov/idem/forms/idem-agency-forms/#owq_public_water.

The lab should transmit the completed report directly to IDEM. If you do receive a non-compliance letter regarding your reporting requirements, you have 10 days from the end of the monitoring period to send the report to IDEM directly, or have the lab send the report. The operator is ultimately responsible for providing IDEM with any required lab documentation.

Figure 2.1 on the next page is the IDEM Coliform Lab Report Form. It provides an example of the information required on a lab report form.

Figure 2.1 – IDEM Total Coliform/Groundwater Rule Reporting

TOTAL COLIFORM / GROUNDWATER RULE REPORTING
State Form 53297 (R3 / 1-13)
Indiana Department of Environmental Management (IDEM)
Office of Water Quality - Drinking Water Branch - Compliance Section

Lab received: *(mm/dd/yy)* __ / __ / __
Time received: __ : __ ☐ AM ☐ PM
Date reported: *(mm/dd/yy)* __ / __ / __

CERTIFIED LAB NUMBER: M - __ - __

TO BE COMPLETED BY THE PUBLIC WATER SYSTEM

Samples will not be analyzed if this form is not complete. Use black ink.

Laboratory, please send a copy to:

Name: __________

Street: __________

City: __________ IN ZIP: __________

Organization telephone number: ( ) -

PWSID: I N

Collection Date *(mm/dd/yyyy)*: __ / __ / ____ Collection Time: __ : __ ☐ AM ☐ PM

Sample Location Address:

Sample Comments / Remarks (tap, sink, boil water, etc.)

Chlorine Residual at Sample Location:
FREE __ . _ mg/L TOTAL __ . _ mg/L

SAMPLE TYPE *(check appropriate box)*:

TCR: ☐ Routine ☐ Repeat ☐ Special

GWR: ☐ Source triggered (TG) ☐ Source additional (CO)

Well Number / ID:

Date of Original Sample – only if repeat or additional *(mm/dd/yyyy)*: __ / __ / ____

Lab Sample ID of Original Sample:

Additional Comments:

Printed Name and Initials of Sample Collector:

Printed Name and Initials of Certified Operator:

ANALYSIS DATA – *FOR LAB USE ONLY*

Lab Sample ID:

TEST RESULTS: **Total Coliform**

METHOD:
☐ MF ☐ MPN ☐ LST P/A ☐ MM P/A ☐ MM QT

RESULTS:
☐ PRESENT ☐ ABSENT Most probable number:

Analyst: Date: __ / __ / __ Time:

TEST RESULTS: ☐ **Fecal Coliform** ☐ **E Coli**

METHOD:
☐ MF ☐ MPN ☐ LST P/A ☐ MM P/A ☐ MM QT

RESULTS:
☐ PRESENT ☐ ABSENT Most probable number:

Analyst: Date: Time:

HETEROTROPHIC PLATE COUNT:
☐ /1.0mL ☐ /0.1 mL ☐ TMTC (Too many to count)

* If MPN or MMQT is checked, the result is a statistical determination of the most probable number per 100 mL. If MF is checked, the result is in organisms per 100 mL. If P/A is checked, the result is present or absent.

FOLLOW-UP ACTION IS REQUIRED:

☐ SUBMIT REPEAT SAMPLES

☐ SAMPLE WAS REJECTED BECAUSE:

- ☐ Too long in transit (> 30 hours)
- ☐ Invalid or no collection date and/or time
- ☐ High background count
- ☐ Sample broken or leaked in transit (insufficient volume)
- ☐ Residual chlorine present

https://www.in.gov/idem/forms/idem-agency-forms/#owq_public_water

Site Sampling

Samples for contaminants are required under the National Primary Drinking Water Regulations (NPDWRs). Some contaminants that must be sampled under the law include:

- Coliform (bacterial or Bac-T)
- Lead and Copper
- Turbidity
- Nitrates and Nitrites
- Trihalomethanes (THMs)

These contaminants, or chemicals, pose a public health risk, so it is important to submit the legally required samples. Samples should be taken from representative points throughout the distribution system.

Some samples require a raw water sample and samples from specific points in the system. Figure 2.2 shows a basic site sampling plan, with a routine sample tap, or routine sample station, along with upstream and downstream taps.

Figure 2.2 – Simple Site Sampling Plan

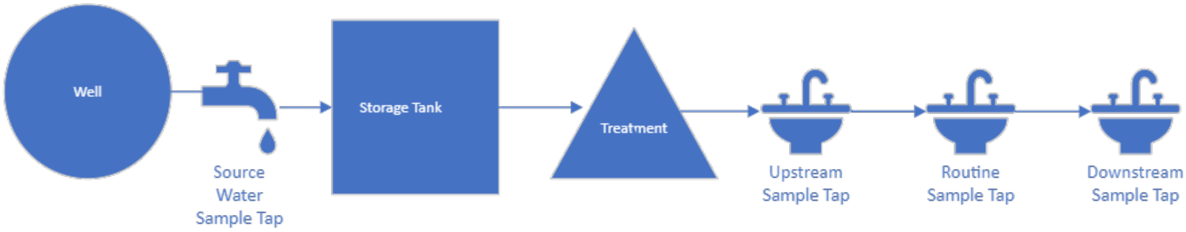
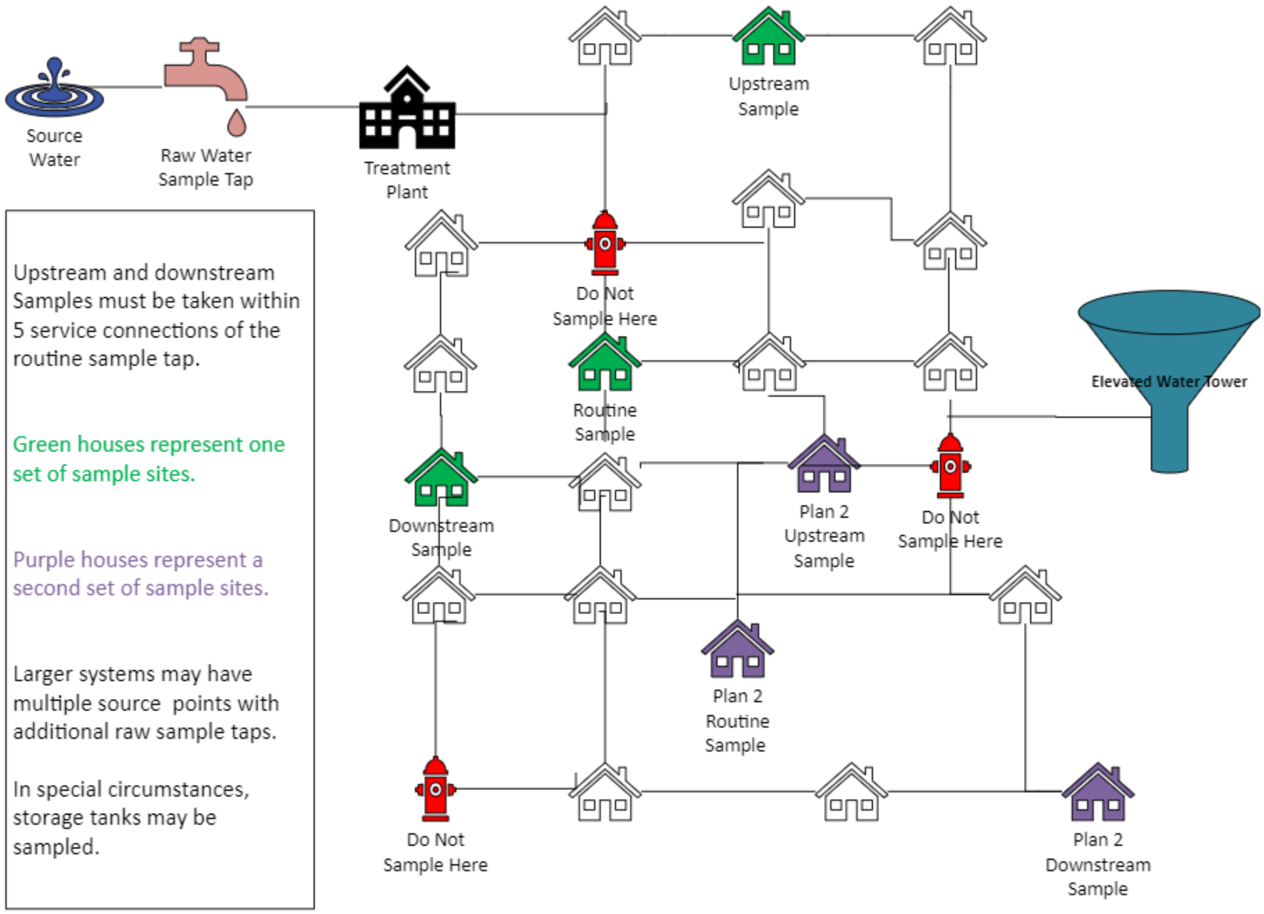


Figure 2.3 shows a site sample plan and an alternate site sample plan. Note that the sample sites are within 5 service connections of the routine sample tap.

Figure 2.3 – Site Sample Plan with Alternate Plan



When creating a site sampling plan, the upstream and downstream samples must be within 5 service connections of the routine sample tap.

Table 2.2 Lists commonly sampled contaminants, proper sample containers, holding temperature, and holding time.

Table 2.2 – Sample Guidelines

Contaminant	Sample Container	Holding Temperature	Holding Time
Biological (Bacteria)	Plastic	4° C – 10° C	30 Hours
Nitrate	Plastic or glass	4° C	48 Hours
Nitrite	Plastic or glass	4° C	48 Hours
Fluoride	Plastic or glass	N/A	1 month
Free Chlorine	Glass	N/A	None, analyze immediately.
Haloacetic Acids (HAA5)	Glass	4° C	14 days
Metals (Lead, Copper, Mercury)	Plastic	N/A	14 days

Samples must be sent to the lab with a chain of custody form, noting the sample type, sampler, and sample location. Some samples require a preservative, such as an acid, to be added, so it is important to transfer the sample to the lab as soon as possible.

To ensure that samples are taken from representative points, submit a site sampling plan to IDEM. IDEM will then either approve the plan, or let you know what corrections need to be made.

The number of samples required depends on system classification, population size, and type of contaminant. Some contaminants may qualify for reduced monitoring, if previous samples show low or no contamination for that chemical or compound.

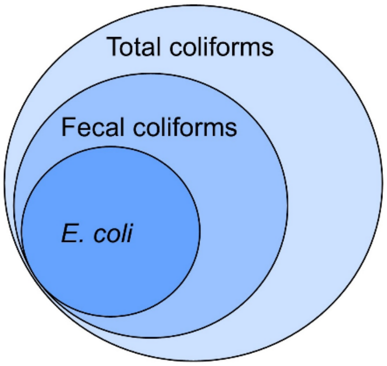
Monitoring

Coliform (RTCR)

The Revised Total Coliform Rule (RTCR) requires testing for total coliforms and *Escherichia coli (E. coli).* Earlier versions of the rule used several different tests. The revision requires a Presence/Absence (P/A) test. If the test is positive for coliform bacteria, additional samples are required. In additional testing, a Heterotrophic Plate Count (HPC) test might be performed.

Total Coliforms may indicate the presence of other harmful bacteria. *E. coli* is a bacterium found in the fecal waste of mammals (i.e. humans, cows, dogs), which can cause acute gastrointestinal illness. Symptoms of gastrointestinal illness include diarrhea, vomiting, and cramps. Figure 2.4 illustrates how *E. coli* and other fecal coliforms relate to total coliforms.

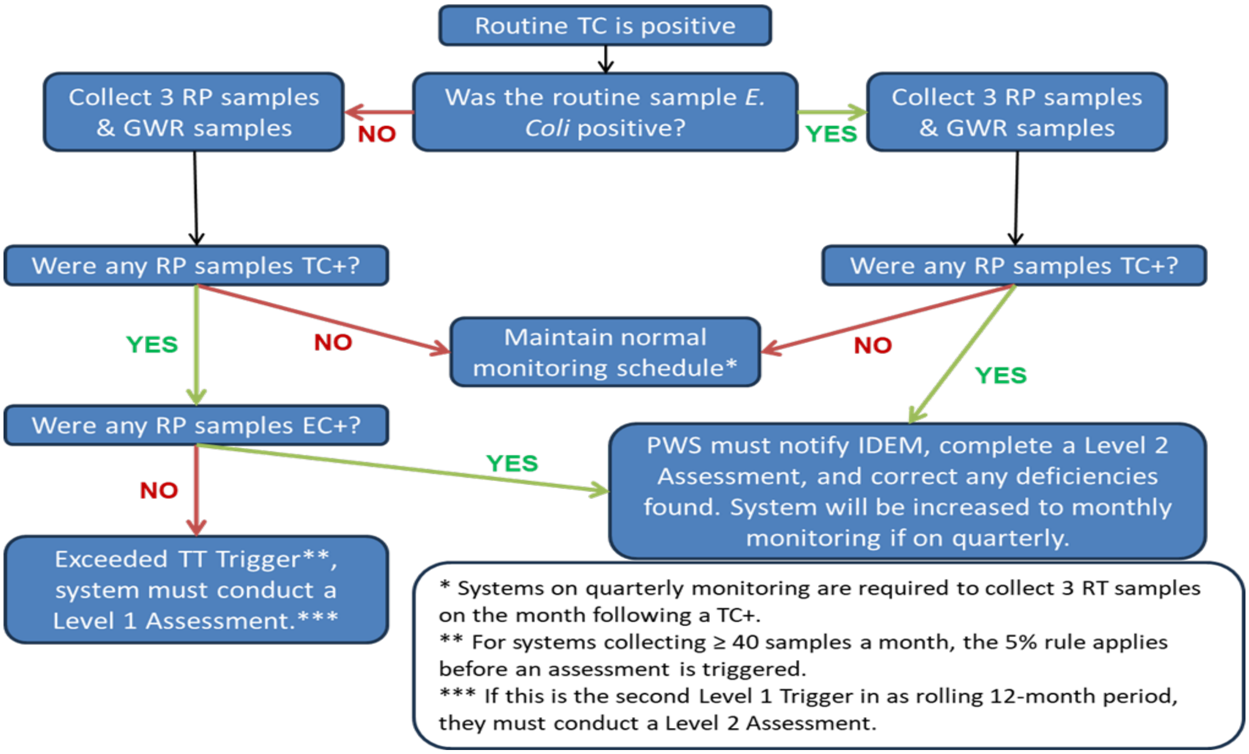
Figure 2.4 – Coliforms



Stock Image

If a sample is positive to total coliform bacteria, then additional testing is needed to determine the presence of *(E. coli)*. Figure 2.5 is a flowchart, showing the actions needed if the presence of coliform is detected in a sample. **If a sample tests positive for Coliform, IDEM must be notified within 24 hours!**

Figure 2.5 – Positive Coliform Sample Flowchart



The population served determines the number of coliform analysis samples required. The proper coliform sampling procedure is listed below.

- Use a clean faucet that has a dedicated hot and cold tap.
- Flush the system thoroughly, disinfect the faucet, flush again, then take the sample.
- Ensure the lid of the container is facing down, is not placed on a counter, and is not touched.
- Fill the container without splashing or rinsing.
- **Following the sample, a system has thirty (30) hours to get the sample to a lab.**
- **The sample should be kept between 4° and 10° Celsius.**

Under the RTCR, if the initial sample tests positive, additional sampling is required. An additional sample must be taken from the routine sampling tap, or routine sampling station. Samples must also be taken from an upstream and downstream location, within 5 connections of the routine tap. In total, 4 repeat samples must be taken (Routine, Upstream, Downstream, Source)

Note: If multiple sources (wells) supply water to a total coliform positive routine site, multiple source samples may be required.

IDEM will send correspondence once we are notified of a positive coliform sample outlining the next steps. Sometimes there are delays between when the lab tests the sample and sends the results to IDEM. If you receive a positive coliform lab report, you should immediately collect repeat samples and not wait for further guidance from IDEM.

If these samples test positive, Level 1 and Level 2 Assessments must be performed. In these assessments, an IDEM approved assessor will evaluate a water system, looking for sources and sites of potential contamination. Triggers for these assessments are outlined below:

- Level 1 Assessment
  - System incurs a positive Total Coliform (TC) sample, followed by a TC positive repeat sample.
  - System takes no repeat samples or an insufficient number of repeat samples following a positive TC sample.
  - An operator can perform a Level 1 Assessment.

- Level 2 Assessment
  - System incurs an *E. Coli* MCL violation (positive sample).
    - An IDEM Representative MUST complete this Level 2 Assessment.
  - The system has a second Level 1 Assessment within a rolling 12-month period.
  - Voluntary Level 2 Assessment.
  - A Level 2 Assessor must be approved by IDEM and certified under the RTCR.

Both Level 1 and Level 2 Assessments must be completed within 30 days of the trigger. Any corrective action noted in the Assessment must also be completed within 30 days.

Nitrate

Nitrates and Nitrites are chemicals formed from Nitrogen found in water. They are caused by runoff from agricultural, specifically fertilizers, along with leaking septic tanks, sewage, and the erosion of natural deposits.

Nitrates have an MCL of 10 mg/L and nitrites have an MCL of 1 mg/L. Nitrates react with chlorine to produce nitrites. These nitrites cause a condition in infants called methemoglobinemia, also known as "blue-baby syndrome". This condition interferes with the oxygen carrying capacity in blood, and causes shortness of breath, blue skin, and possible death. Nitrate or nitrite concentrations above the MCL are considered serious health hazards and require a Tier 1 public notification. Treatment for these compounds is done at the treatment facility, but samples should be taken throughout the distribution system.

Grab samples should be taken from source water, just after treatment, and at representative sites throughout the distribution system. Refer to the basic site sampling plan. Samples should be collected in clean plastic or glass containers, kept between 4° C – 10° C, and preserved with sulfuric acid. Samples should be sent to the lab with the appropriate sample form completed but can be held for up to 28 days.

LCR

The 1986 SDWA amendment banned the use of lead in piping materials. The EPA published its initial regulations on lead and copper in drinking water in 1991. These regulations are known as the Lead and Copper Rule (LCR). It had revisions in 2000, 2004 , 2007, and 2021. Lead and copper service pipes deteriorate due to corrosion, which causes these metals to dissolve into the drinking water. Both lead and copper can cause adverse health effects.

Lead and copper have an "action level" instead of an MCL. The rule requires that lead and copper levels be monitored at the customer's tap. Below are the sampling steps for lead and copper:

- Sample containers are 1000 mL in volume.
- Pull the sample from an unthreaded, cold-water tap.
- Ensure that the system has not been used for at least 6 hours – first-draw or first-flush.
- Samples are required every six months.
    - If a system does not exceed action levels, sample frequency can be reduced to annually.
    - If a system does exceed action levels, it must return to biannual sampling.

If the 90th percentile of samples exceeds action levels, meaning if 10% of samples exceed action levels, the water system MUST take action to lower the lead and copper levels. Table 2.3 provides information on lead and copper action levels and their health hazards.

Table 2.3 – Lead and copper

Contaminant	Action Level	Health Hazards
Lead	0.015 mg/L (15 ppb)	• Impairs cognitive development in children. • Causes memory problems in adults. • Can cause kidney damage, anemia, and increased blood pressure.
Copper	1.3 mg/L (1.3 ppm)	• Stomach upset, cramps, diarrhea, vomiting. • Kidney and liver damage. • People with Wilson's disease are particularly susceptible.

Chemical & Contaminant

SDWA regulates over 90 contaminants, including the ones listed in previous sections. A complete list of regulated contaminants, their MCLs, and their MCLGs can be found at https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations.

Treatment to remove these contaminants is discussed in a separate manual. For a distribution system operator, it is important to draw samples according to the schedule for your system classification. These samples should be drawn from locations representative of the water system's population. Some of the SDWA regulated contaminants include:

- Arsenic
- Synthetic Organic Compounds
- Inorganic Chemicals
- Volatile Organic Compounds
- Radionuclides

For additional sampling guidance, refer to the EPA's *Quick Guide to Drinking Water Sample Collection: https://www.epa.gov/sites/default/files/2015-11/documents/drinking_water_sample_collection.pdf.*

Distribution System Cl

A disinfectant residual must be maintained throughout the distribution system. 327 IAC 8-2-8.6 states that the disinfectant concentration may not be less than 0.2 mg/L for more than four (4) hours. The maximum concentration limit for chlorine and chloramines set by the EPA is 4.0 mg/L. Chlorine dioxide cannot exceed 0.8 mg/L. As with other chemical monitoring, samples should be taken to ensure an adequate disinfectant residual is maintained at representative sites in the system.

The treatment facility is responsible for adding the chemicals to maintain a disinfectant residual throughout the distribution system. In large systems, disinfectants may need to be added at booster stations.

The N,N diethyl -1, 4 p-phenylenediamine sulfate (DPD) color test is the most used test for chlorine, both free and total. DPD is added to the sample, and the color is used to determine how much chlorine is in the sample. If a system's disinfectant is consumed before reaching the end of the distribution system, it could be a sign of contamination.

Records

Good record keeping is very important. These records show compliance with drinking water regulations. Non-compliance could result in penalties, or violations. IDEM requires retention of reports as listed in Table 2.4.

Table 2.4 – Record Retention Requirements

Record Type	How Long to Keep
Bacteriological Analyses	5 Years
Chemical Analyses	10 Years
Actions to Correct Violations	3 Years
Sanitary Survey Reports	10 Years
Variance or Exemption	5 Years
Turbidity Results	5 Years
All Lead/Copper Data	12 Years
Monitoring Plans for RTCR, LCR & DBPRs	As long as subject to rule(s)

EPA - How to Conduct a Sanitary Survey of Drinking Water Systems

Aside from records required by law, it is helpful to keep maintenance records for equipment, lines and structures in your distribution system. If you do not already have a system map, making records during repair and replacement of lines can help with creating a system map.

Keep detailed records for pumps, motors, and engines used as backup power supply. Records from initial installation and routine maintenance are helpful when troubleshooting problems with these devices. Some helpful records include:

- Make, model, and serial number of the device.
- Specifications and capacity.
- Warranty information.
- Date and location of installation.
- Part numbers for parts subject to wear and tear.
- Initial test results from the equipment.
- Manufacturer’s inspection and maintenance schedules.
- Contact information for local service representatives.
- Records of storage tank maintenance, cleaning, and repairs.

Tank location should be recorded and included on any system maps. It is good practice to keep records for contractors who perform repairs and maintenance, as well as customer service contact information from equipment manufacturers or local service representatives.

Records can be kept in files on site or can be stored digitally. Manuals, repair purchase orders, and correspondence from the manufacturer or repair personnel may provide details needed for smooth operation to future operators.

Corrosion Control

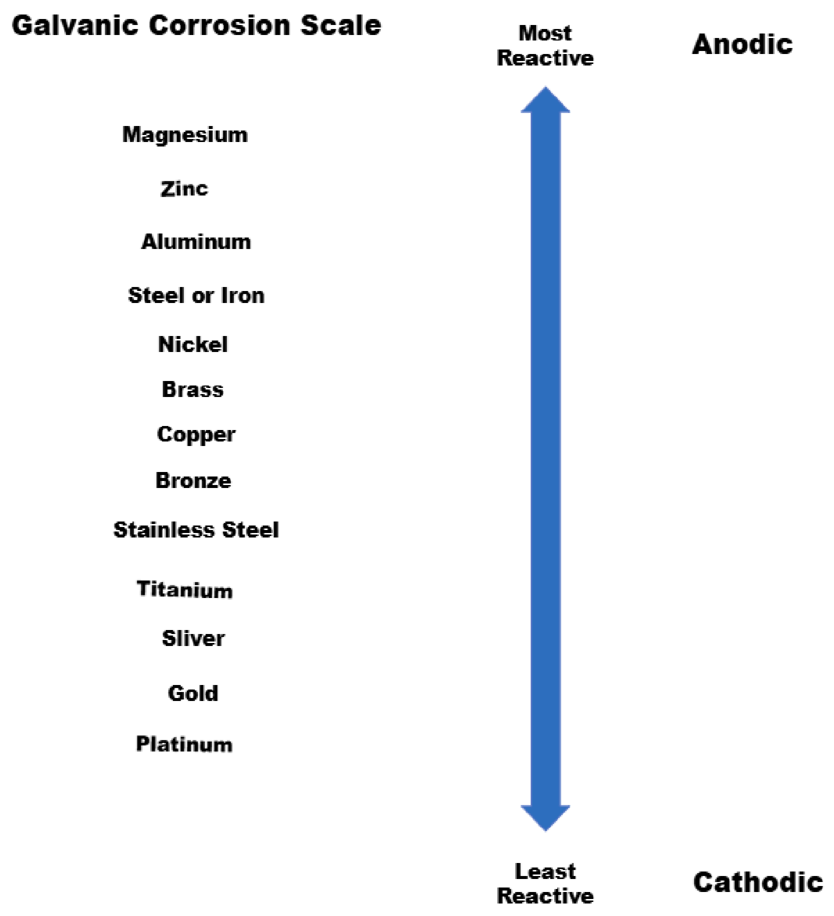
Corrosion describes the gradual breakdown of a substance or material. It can be caused by electrochemical reactions, like oxidation-reduction reactions (redox) and galvanic reactions. Steel tanks, and copper, lead, steel, or cast-iron service lines are particularly susceptible to corrosion. These metals can precipitate from the pipes into the water supply, causing health concerns or customer complaints.

Corrosion promotes the growth of bacteria, slimes, and biofilms by creating tubercules in the pipes. These can lead to customer complaints regarding color, taste, and odor. Tubercules can also harbor harmful bacteria, like coliforms.

The treatment facility is responsible for ensuring non-corrosive, stable water is being sent to the distribution system. A distribution system operator is responsible for controlling corrosion in storage structures and transmission lines.

Chemicals can be added at the treatment facility to inhibit corrosion and stabilize the finished water, however there are also ways to control corrosion throughout the distribution system. One way is pipe selection. Galvanic metals will corrode when placed next to dissimilar metals. Pipe selection is an important part of corrosion control in the distribution system. Figure 2.6 shows the galvanic scale of metals.

Figure 2.6 – Galvanic Corrosion Scale



Another option is to coat the interior or exterior of the pipe or storage tank. Metals coated on the outside with zinc are referred to as galvanized. Because zinc is a more reactive metal, it will corrode before the metal underneath does.

Interior surfaces must also be protected. Paint, epoxies, resins, tar or other bituminous materials are used to coat the inside of tanks and pipes. These coatings must be regularly inspected for holes or wear.

Cathodic protection is the process of running an electrical current through water or soil in contact with metal. This will concentrate the corrosion on sacrificial anodic parts, which will corrode before the metal does.

Pressure Vessels

Some types of pressurized water tanks, softeners, boilers, and specialized treatment plant equipment are classified as pressure vessels by the Indiana Department of Homeland Security (IDHS). Because these devices can create a safety risk to the public, some may require a permit from IDHS.

Pressure vessels requiring a permit include those in locations intended for public assembly. If a treatment facility is located within a school, church, or prison, for example, its pressure vessels would be subject to the IDHS permitting requirements. https://www.in.gov/dhs/files/675-IAC-30-Indiana-Boiler-and-Pressure-Vessel-Rules.pdf.

Any questions regarding pressure vessels can be directed to IDHS at (317) 232-2222. You can view more information on their website: https://www.in.gov/dhs/fire-and-building-safety/boilers-and-pressure-vessels/.

Practice Exam

1) Coliform samples should be 100mL and be taken as a _________.
    a. Composite sample
    b. Continuous sample
    c. Grab sample
    d. All the Above

2) Which of these locations is best for pulling required samples?
    a. Mop sink
    b. Storage tank
    c. Fire hydrant
    d. Dedicated sample station

3) A system has _____ days from the end of the monitoring period to report lab results to IDEM.
    a. 10
    b. 15
    c. 20
    d. 30

4) Sample sites should be within ___ service connections of the routine sample tap.
    a. 2
    b. 5
    c. 10
    d. 15

5) Biological or bacteria samples have a hold time of _____ hours.
    a. 6
    b. 12
    c. 24
    d. 30

6) What material should be used to contain heavy metal samples, like lead and copper?
    a. Plastic
    b. Glass
    c. Metal
    d. Polypropylene

7) Sanitary Survey Reports must be kept for ______ years.
   a. 5
   b. 10
   c. 15
   d. 20

8) Which of these are NOT a record that should be kept to enhance future operations?
   a. Warranty information on equipment
   b. Specifications and capacity for equipment
   c. Expired chemicals
   d. Contact information for local service representatives

9) Which of these is NOT a method of corrosion control?
   a. Galvanic protection of pipes
   b. Water stabilization
   c. Increasing dissolved oxygen
   d. Cathodic protection

10) Which agency regulates pressure vessels?
   a. IDHS
   b. IDEM
   c. IDOH
   d. DNR

Chapter 3 – Hydraulics and Transmission

Learning Objectives

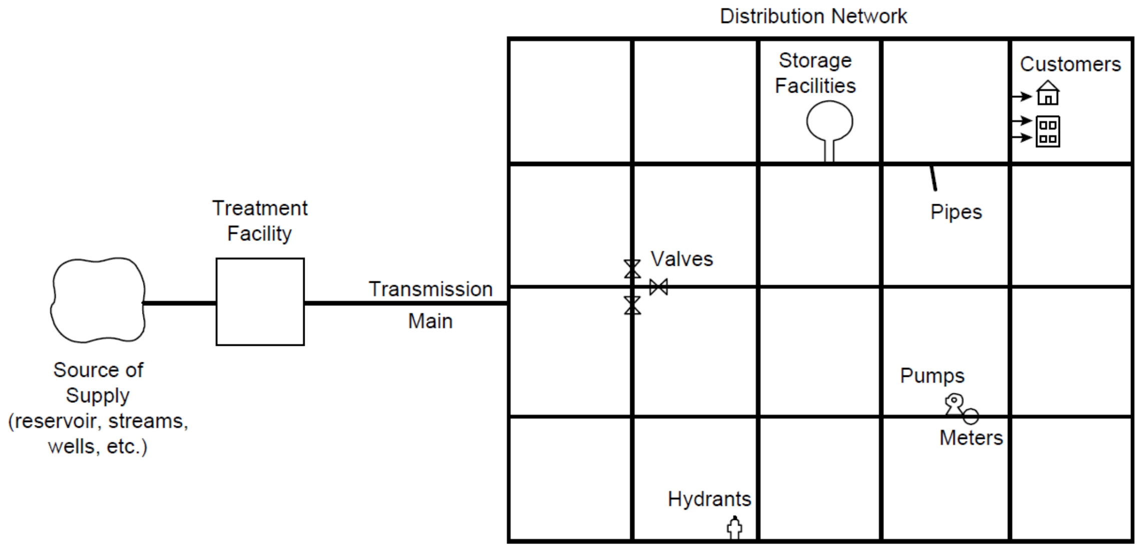
- Apply the basic principles of hydraulics
- Distinguish between the different distribution system configurations
- Identify pipe material and select appropriate pipe for replacement or expansion within the system
- Compare different valve types and recognize appropriate use for each type
- Describe types of appurtenances used throughout the system and their function
- Differentiate between types of meters used to measure flow
- Identify permit requirements for water main replacement and extensions

Transmission

Transmission describes the movement of water from the treatment facility to the customers' taps. The finished water is pumped from the treatment facility and moves through a series of connected pipes to each service connection. The flow rate and pressure are controlled through valves, elevated storage tanks, and booster pumps.

Transmission systems consist of pipes to move the finished water from the treatment facility to the customers' taps and pressure or storage tanks. Hydrants, valves and meters are also components of the system. Booster stations or pumps beyond the treatment facility are components of larger systems. Figure 3.1 is a basic example of a distribution network.

Figure 3.1 – Distribution Network



Courtesy of the Pennsylvania Bureau of Safe Drinking Water

Hydraulics

Hydraulics is the study of fluid movement or fluid under pressure. It is important to understand how water will move though the distribution system.

- Pressure is the amount of force exerted per unit of area.
    - It is usually expressed as pounds per square inch (psi) but may sometimes be expressed in kilopascals (kPa).
        - 1 psi = 2.31 ft.
        - 1 psi = 6.895 kPa
        - Pressure is measured with a gauge.
            - Referred to as gauge pressure – pounds per square inch gauge (psig)
            - Gauges can be calibrated in feet of head.
            - 1 psig = 2.31 ft head
- Static pressure describes the pressure of water that is not moving.
- Dynamic pressure is the expression of moving water as energy.
- The pressure is directly related to the height or depth of the water.
    - 8ft. of water in a narrow standpipe will exert the same amount of pressure as 8ft. of water in a tank with a 50ft. diameter.

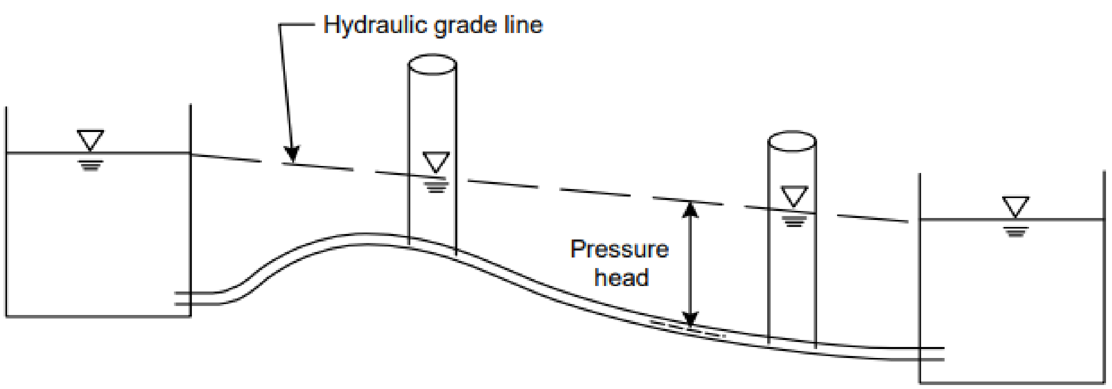
- Hydrostatic Pressure is a specific type of static pressure that is solely affected by the weight of a fluid.
- Absolute Pressure = Gauge Pressure + Atmospheric Pressure.

- Head is the measure of the energy of water at a specific point in the system.
    - Expressed in feet or meters.
    - Total
    - Pressure Head is the vertical distance from the surface of water to a point below the surface.
        - It is expressed in units of feet of water.
        - Pressure, psi = Pressure Head, ft/2.31
- Velocity (V) is the measure of speed of movement.
    - $V = \frac{Q}{A}$ Where Q is quantity of water and A is area of the pipe.
- Total Dynamic Head (TDH) measures the work done by a pump, per unit weight, per unit of fluid volume.
    - TDH = Static Lift + Pressure Head + Velocity Head + Friction Loss.

The difference between Head and Pressure Head: Head is a measure of energy, while Pressure Head is a measure of force applied against a surface.

Water will always move from an area of higher pressure to an area of lower pressure. Figure 3.2 shows the Hydraulic Grade Line.

Figure 3.2 – Hydraulic Grade Line



Courtesy of the Pennsylvania Bureau of Safe Drinking Water

Distribution Pipes

Service pipes carry the finished water from the treatment facility to the customers. In most cases, a distribution system will follow one of three layouts:

- Arterial Loop System – Surrounds the distribution system with mains, providing supply from multiple directions.
- Grid System – Mains are interconnected, allowing water to flow from several directions.
- Tree System – A primary main provides water to different branches in the system.
    - Smaller mains in this type of system are prone to dead ends.
        - Dead ends allow water to stagnate, since it only moves in a single direction.
        - They can lose pressure during firefighting events.
        - Repair work on mains to dead ends disrupts service to all customers on that main.

If the system does not have a map of mains, lines, storage tanks, valves, and services, one should be created. If a system map does exist, it should be updated to reflect repairs, replacements, current and projected consumption, and any planned additions to the system. Knowing what components are in the system, where they are located, and what material they're made of will allow for better selection of repair and expansion materials.

Water Mains

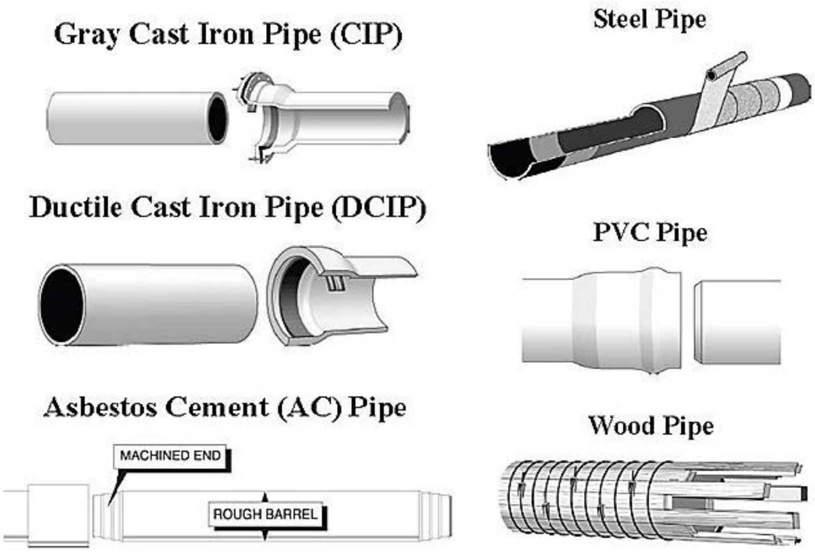
Water mains carry large volumes of water from the treatment plant to the smaller service lines in the system. In older systems, they may be made of cast iron, asbestos cement, or wood. Table 3.1 lists the current pipe materials in use and their AWWA standard.

Table 3.1 – Water Main Pipe Materials

Pipe Material	**AWWA Standard(s)**
Ductile Iron (DIP)	AWWA C151
Steel – Cement-mortar lined steel	AWWA C200, C205, C207, C208
Polyvinyl Chloride (PVC)	AWWA C900, C905
Reinforced Concrete Pressure Pipe (RCPP) – Steel cylinder, Noncylinder, Pretensioned	AWWA C300, C301, C302, C303
High-density Polyethylene (HDPE)	AWWA C906

Identifying the material of mains in the system will assist with selecting repair and replacement materials and help to identify proper corrosion control. Figure 3.3 shows a cross-section of several water main materials.

Figure 3.3 – Water Main Materials



Courtesy of the EPA

When choosing pipe materials, there are many factors to consider:

- Interior pressure requirements.
- Exterior pressure requirements.
- Federal, state, and local regulations.
- Soil composition.
- Local weather conditions.
- Seismic activity.
- Material of pipes currently in the system.
- Cost of material, transportation and storage.

The interior surface of the pipe is particularly important in maintaining pressure throughout the distribution system and controlling corrosion. Pipes are assigned a C Value or C Factor that indicates the smoothness of the interior of the pipe. The higher the C Value or C Factor, the smoother the interior surface of the pipe is.

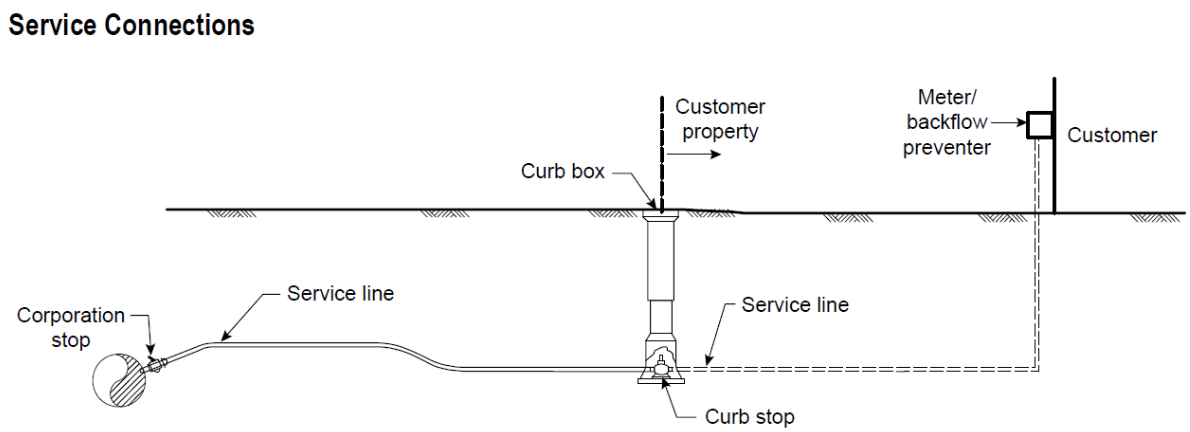
Service Lines

Service lines extend from the mains to the structures served. They are much smaller than mains. They can be made of the same materials that water mains are composed of, but may also be made of brass, copper, or lead, especially in older systems.

Resistance to internal and external corrosion is the primary concern when replacing service lines. Lead was banned for use in the 1986 SDWA amendments. Any lead service lines should be inventoried and replaced, since corrosion of these pipes causes adverse health effects. Corrosion of copper pipes can also be a health concern. More details on the regulations for lead and copper pipes can be found in the LCR section in Chapter 2.

Service lines are often connected to the larger transmission lines using a corporation stop or shut-off valve. An additional shut-off valve called a curb stop is usually located close to the customer's property line. A meter for customer billing is located downstream of the curb stop. Meters are often located indoors, or in a box or pit. Additional information on meters is available later in the chapter. Figure 3.4 depicts a typical transition from the main lines to the service lines.

Figure 3.4 – Service Connections



Courtesy of the Pennsylvania Bureau of Safe Drinking Water

Pipe Installation

The specific installation instructions for each type of pipe are provided by the manufacturer. They can be found online, or by contacting the manufacturer directly. It is important to inspect all pipe deliveries for damage, and to ensure proper storage. Each type of pipe will require special handling for loading and unloading. For large diameter or heavy pipes, special equipment may be needed.

Before installing the pipes, a trench must be excavated. Trenches should be one to two feet wider than the diameter of the pipe and should be deep enough that the pipe is below the frost line when covered with backfill. The material excavated, known as spoil, should be placed four to five feet from the trench, depending on pipe size, and should be placed on one side only. This can help prevent damage to the pipes and injury to the workers. The minimum spoil setback, set by the Occupational Safety and Health Administration (OSHA), is two feet.

Shoring is the process of bracing the trenches to keep soil from collapsing into the trench. Trenches are considered confined spaces. Laws and codes for shoring are strictly enforced, since the collapse of a trench can lead to injury or death. The material used for shoring will depend on soil composition and the location of the trench. Types of shores include:

- Hydraulic
- Screw jacks
- Air
- Solid sheeting

In some cases, sloping the trench will provide adequate safety. For information on shoring laws, or to find an approved course in trench safety, refer to OSHA.

Whether replacing a main or a service line, it is important to communicate with other utilities and identify other utility lines in or around water line. Sewer lines located too close to potable water lines increase the risk of contamination.

Once the pipe is installed, it will need to be partially backfilled, and pressure tested. Leaks are easier to detect when backfill is not complete. If the pressure test fails, the source of the leak must be detected.

Main Disinfection

After the line passes the pressure test, the line will need to be flushed and disinfected before bringing it online. Pipes that undergo repairs must also be disinfected before being brought back into service.

Lines are usually disinfected with chlorine. Chlorine comes in three forms:

- Gas (Cl_2) – 100% available chlorine
- Liquid (Sodium Hypochlorite) – 5% to 15% available chlorine
- Solid (Calcium Hypochlorite) – approximately 65% available chlorine

Solid and liquid chlorine forms are used when disinfecting lines. Liquid, or chlorine solution is used in the continuous-feed method. Flush the pipe first with a minimum of 5 ft/sec flow. Then inject the pipe with a chlorine solution of at least 25 mg/L. The residual (remaining) chlorine after 24 hours should be 10 mg/L or higher.

Chlorine tables can be used for lines measuring under 24 inches in diameter and shorter than a few hundred feet, if the pipes are kept clean and dry. Tablets are secured to the top of each pipe, and the line is slowly filled with water. The chlorinated water sits in the pipe for 24 hours. If the chlorine residual does not go below 25 mg/L, the disinfection was successful.

The slug method uses calcium hypochlorite tablets or granules. It is appropriate for long, larger diameter mains. Quantities based on the size of the main are placed inside it during construction. Then fill the main completely, ensuring there are no air pockets, and flush. Next use the continuous-feed method to generate a slug, or large column of water, with a concentration of 100 mg/L that moves through the main, exposing it to the highly concentrated chlorine. The concentration of the slug should not drop below 50 mg/L. If the concentration does drop below 50 mg/L, increase the chlorine dosage. The target contact time for the slug is 3 hours. Flush the main once the slug has passed through, then perform bacteriological tests. The tests must be negative for coliform bacteria prior to putting the main back in use.

Valves

Valves are used to control the flow of water. They are used throughout the distribution system to control treatment processes, and with pumps and other operating equipment. Some functions of valves include:

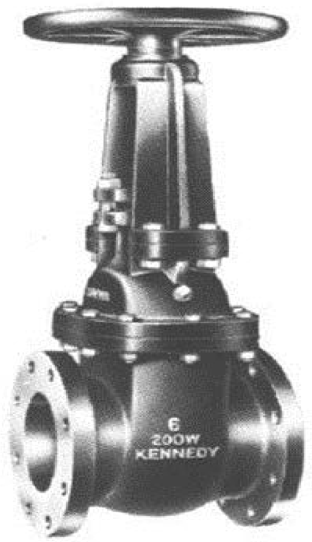
- Starting or stopping water flow.
- Regulating pressure or flow speed.
- Backflow prevention.
- Pressure relief.
- Isolating sections of pipe for repair.

Most valves move in one of two ways: rotary or linear stroke. In a rotary valve, the stem turns the internal mechanism 90° to open or close the valve. In a linear stroke valve, many turns of the stem are required to move the internal mechanism up or down.

One of the most common valves found in the distribution system is the gate valve. It is a linear stroke valve used to start or stop the flow of water, and for isolating sections of pipe for repair. They work by raising and lowering a disk inside of the valve with a wheel or screw on the outside of the valve. They are available in multiple sizes and configurations.

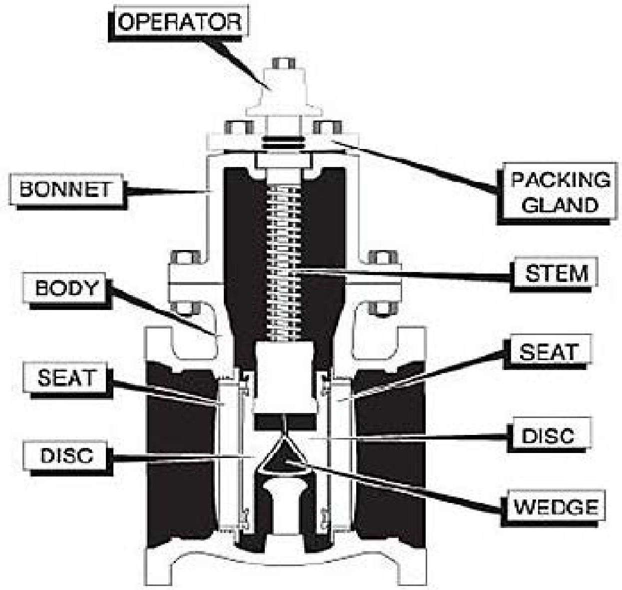
They are not appropriate for throttling water flow, as the gate, or disk, can be damaged by the water flow if it is not fully raised. Gate valves take time to open and close properly, so they are not well suited for frequent use. Figure 3.5 shows a gate valve. Figure 3.6 is a cross section of a gate valve.

Figure 3.4 – Gate Valve



Courtesy of the EPA

Figure 3.5 - Gate Valve Cross Section

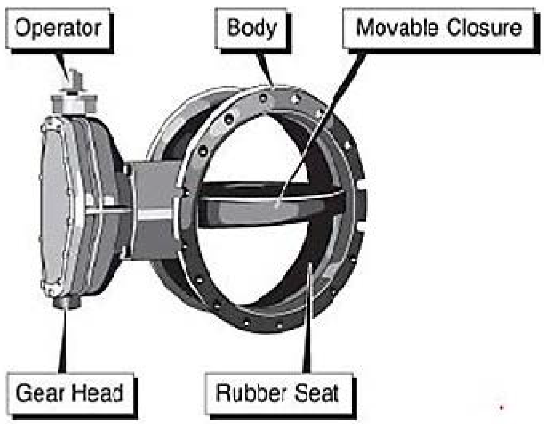


Courtesy of the EPA

Because of the difficulty opening and closing a gate valve, especially the larger ones, bypass valves are often used to bypass gate valves. Bypass valves are smaller in diameter and can reduce the pressure generated on the disk of a larger gate valve. They also allow for a lower volume flow without having to operate the main valve.

Butterfly valves are a rotary valve with a disk that rotates to open and close the valve. They are best used for isolation and automatic control functions. They are easy to install and operate, and less expensive than other types of valves. Head loss is higher with butterfly valves than with gate valves. Figure 3.6 shows a butterfly valve.

Figure 3.6 – Butterfly Valve

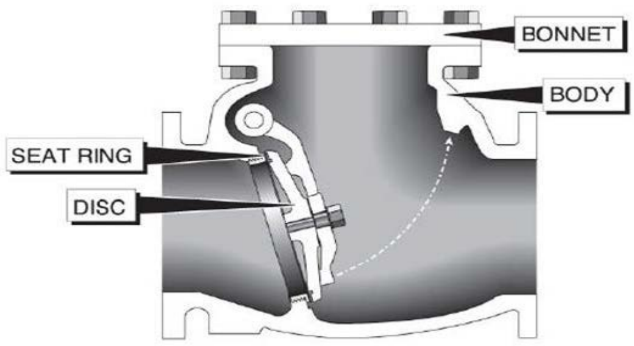


Courtesy of the EPA

Gate and butterfly valves are two examples of valves used to control the flow of water. Other valves are used to control or regulate pressure. Along with backflow prevention valves, which are covered in the next section, these are considered special-purpose valves.

A check valve keeps water flowing in one direction. When water is going in the right direction, a flap opens to allow water to pass. When pressure comes from the wrong direction, it pushes the flap closed, keeping water from flowing in the wrong direction. Figure 3.7 shows a swing check valve.

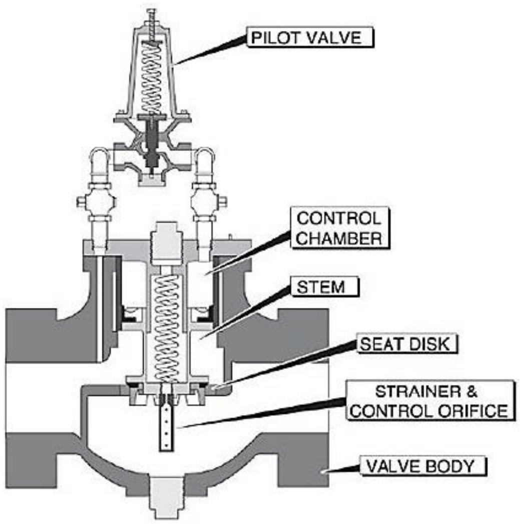
Figure 3.7 – Swing check valve



Courtesy of the EPA

Pressure relief valves are used to relieve pressure in water lines. Reducing pressure, when necessary, helps a system avoid damage to pipes and appurtenances. When the pressure reaches a certain limit, spring loaded stems release disks, venting the excess pressure. Figure 3.8 shows a pressure relief valve assembly.

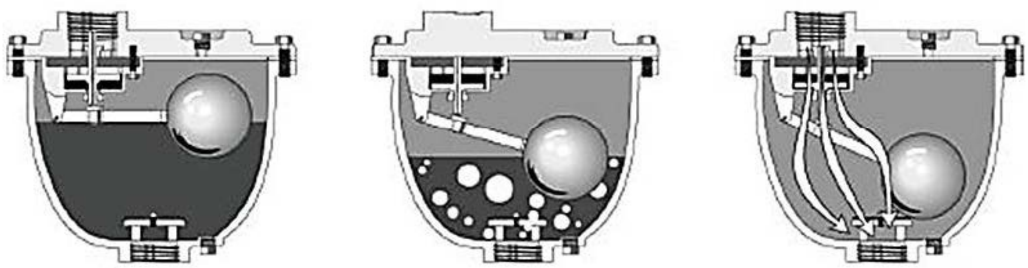
Figure 3.8 – Pressure Relief Valve



Courtesy of the EPA

An air release valve allows air bubbles trapped in a pipeline to escape. They're installed at high points in the system and use a ball float device to open and close the valve. As air enters the system, water is displaced, causing the ball to sink and the valve to open, releasing the trapped air. Figure 3.9 shows an air release valve and how it functions.

Figure 3.9 – Air release valve



Courtesy of the EPA

These are just a few of the valves used in the distribution system. Table 3.2 lists other valves commonly used, their application, advantages, and drawbacks.

Table 3.2 – Valves – Uses and Drawbacks

Valve	**Type**	**Application**	**Advantages**	**Drawbacks**
Globe	Linear stroke	Flow and pressure regulation	High sealing capacity Resistant to wear	High friction loss Heavy Expensive in larger sizes
Piston	Linear stroke	Flow control	On/Off operations Some flow control	High head loss Sediment can get trapped, causing excessive wear
Needle	Linear stroke	Precise flow throttling Appropriate for use on hydraulic lines to valve actuators	Precise flow control	Small and limited in their application

Plug	Rotary	Flow Control Appropriate for use where slurries, solids, or grit will flow through the valve	Low friction loss Slow shutoff minimizes surges	Heavy Expensive
Cone	Rotary	Flow control Appropriate for high velocities, like pump discharge	Low flow resistance Good flow control	Large and heavy Expensive Difficult and expensive to maintain
Ball	Rotary	Flow control and pressure throttling Appropriate for use at customer connections and curb stops and in pump discharge	Low flow resistance High pressure capability Multiple types of actuators can be used	High initial cost Large sizes are heavy and difficult to install More susceptible to water hammer
Altitude	Special Purpose	Flow control Used mostly in storage tanks to stop water influx once the tank is full	N/A	N/A

For more comprehensive information on valves, refer to the American Water Works Association (AWWA) *Manual of Water Supply Practices M44 - Distribution Valves: Selection, Installation, Field Testing, and Maintenance.*

Appurtenances

Joints and Fittings

Joints and fittings are used to connect pipes. The type of joint or fitting should be based on the material of the pipes being connected, installation conditions, and the necessary change in alignment the joint needs to provide. To ensure a proper fit, it is important to clean the joints and fittings of any debris before installing them.

Types of joints include:

- Mechanical
- Push-on
- Compression and Victaulic couplings
- Flanged (Not appropriate for buried pipes)
- Restrained
- Flexible
- Coupling (used for asbestos cement and ductile-iron piping)

Thrust Blocks

Thrust forces are caused by water changing direction in the pipeline, or when the pipeline changes size. To prevent damage caused by these forces, thrust blocks are used. They provide support to fittings and prevent leaking in pipe joints. They should be made of material that does not deteriorate, such as concrete. Places in the distribution system where thrust blocks should be used include:

- Valves
- Hydrants
- Tees
- Bends
- Caps
- Plugs

The size of the thrust block will depend on the water pressure, size of the pipeline, soil composition, and type of fitting it is protecting. They should contact only the fitting they support, and not the pipe itself. Once installed, they require at least five days to settle before the line can be pressure tested.

Hydrants

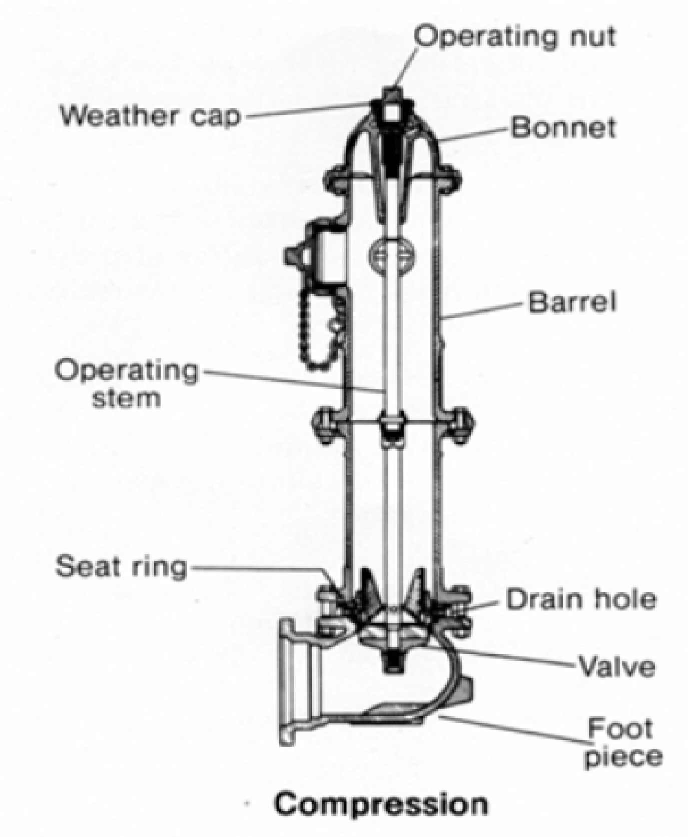
Hydrants provide high pressure and volume water for firefighting events. They provide an outlet for flushing mains and service lines throughout the distribution system. Hydrants may also be used to fill street cleaning equipment or to temporarily provide water for construction sites. Table 3.3 describes the different types of hydrants.

Table 3.3 – Fire Hydrants

Type of Hydrant	Features
Dry-barrel • Wet-Top • Dry-Top	Have a main valve and drain at the base. Will only flow when the main valve is open. Will not flow if broken. Best for areas where freezing occurs.
Wet-barrel	Does not contain a valve and is always filled with water. Not appropriate for areas where freezing occurs. Water will continuously flow from this type of hydrant if it is broken.
Warm-climate	Has a two-part barrel, with the main valve located at the ground line and a lower barrel that is always full of water under pressure. Does not have a drain.
Flush	The head and standpipe are underground. Access is gained from a closed box at ground level. Used in locations where an above ground hydrant is not suitable.

Indiana uses dry-barrel hydrants. It is important to ensure that they are fully drained after each use. Water left in the barrel can cause damage, especially if it freezes. Figure 3.10 shows a cross section of a dry-barrel hydrant.

Figure 3.10 – Dry-barrel hydrant



Courtesy of the Pennsylvania Bureau of Safe Drinking Water

The depth of bury for the underground part of the hydrant should be 4 ½ - 5 ½ feet below ground level, depending on the frost line. The breakaway flange should be 2 inches from the ground surface when properly installed.

Hydrants should be installed vertically, and a level should be used to ensure they are at a 90° angle to the ground. The footing should be concrete, or another material that will not degrade. Gravel, or another porous material should be used at the base, so that water from the barrel can slowly drain after the hydrant is shut off.

Hydrants should be set back from the curb by at least 2 feet. They should be installed near intersections and be spaced between 350 – 600 feet apart. They should have an auxiliary valve located between the hydrant and the water main.

Hydrants should be inspected regularly and maintained to ensure operability during a firefighting event. Due to the pressure and volume of water that travels through pipes when hydrants are in use, sediment in the lines may be loosened, which could cause cloudy water and customer complaints.

It is important to avoid opening and closing hydrant valves too quickly, since this can cause water hammer. A system must maintain a pressure of 20 psi or higher during a firefighting event. Low pressure from hydrant usage can cause back-siphonage, leading to contamination of the potable water supply.

Meter Selection

Meters are used in both treatment facilities and throughout the distribution system to measure the flow of water in specific areas. Some common uses for meters include:

- Meters at customer connections to bill for water usage.
- Meters at the water source to measure production.
- Meters in transmission lines to measure pressure.
- Meters in treatment facilities to ensure proper blending from different sources.

Measuring production and usage flows helps water systems anticipate demand. It can also alert them to water loss in the system. There are several types of meters. Displacement, or positive displacement, meters are appropriate for low flows. Velocity, or current, meters are best for high flows. Compound meters can measure both low and high flows. Table 3.4 lists the different types of meters, how they work, best uses, and drawbacks.

Table 3.4 – Meters

Meter (Type)	How it Works	Best Use/Benefits	Drawbacks
Nutating-disk (Displacement)	• A small disk inside a chamber moves specific volume of water out per cycle. • Movement is transmitted to a register. • Sizes range from 0.6 inches to 2 inches.	• Residential and small commercial customers. • Sensitive to small flows and accurate over a wide range of flows.	• Will under register with excessive wear. • Not designed for continuous use. • Designed to run at half of their maximum operating capacity.
Piston (Displacement)	• Water displaces piston inside a chamber. • Motion is transmitted to a register.	• Residential and small commercial	• Head loss is a little higher than nutating-disk meter.
Turbine (Velocity)	• Has a propeller or rotor that turns when water flows through. • Speed of the propeller is proportional to the flow of water. • Movement is transmitted to a register.	• Large, continuous flows, like mains. • Can be installed within a pipe section or saddle mounted. • Low friction/head loss.	• Low flows will not register. • Not designed for stop-and-go flows.

Venturi (Velocity)	• Constriction in the pipeline called a venturi tube. • Pressure through the throat, or constriction, is measured. • Pressure on the other side of the throat is measured, then compared to the throat pressure. • Proportional calculation of the change is made and recorded.	• Larger pipelines. • Little friction loss. • Very low maintenance.	• Not designed for low flows. • More expensive than other types. • Requires large area for installation. • Not easy to install.
Magnetic, or Mag (Velocity)	• Water flows through a small magnetic field. • Flow generates a small current that is proportional to water flow. • Current is measured and mathematically converted to measure of flow.	• Large lines where water needs to flow unrestricted. • They don't cause head loss. • Highly accurate.	• Not as accurate near areas where water velocity is distorted, like bends or valves. • Will not measure fluids that don't conduct electricity. • Can be expensive and complicated to install and maintain.

Proportional (Velocity)	• A proportion of the total flow is diverted through a bypass meter. • Bypass meter measures water. • Gears in the bypass meter are adjusted to record total flow.	• Accurate for measuring high flows. • Commonly used to meter lines used for firefighting.	• Not accurate for low flows.
Compound (Both)	• Made of three combined parts. • Displacement meter, turbine meter, and automatic valves. • Automatic valves send water through the appropriate meter based on flow.	• Can measure both high and low flows. • Best used in schools, hospitals, and hotels, where flow and demand frequently change.	• May have inaccuracies in the change between high and low flow. • Expensive to install and maintain.

When selecting meters, some important questions to ask are:

- Will it measure high flow or low flow?
- Will the meter result in unnecessary head loss?
- What is the lifespan of the meter vs. the cost?
- How easy will it be to install and maintain?
- How accurate does it need to be?

Permitting

A public water system must obtain an individual construction permit IDEM prior to the construction of a new or existing public water system. A permit is required for the construction, installation, or modification of sources, facilities, equipment, or devices of a public water system including water distribution systems. Construction may not begin until the commissioner has issued a valid permit. Permit Section personnel review permit applications to ensure that the system is properly designed, that adequate water is available, and to verify that the system or equipment complies with all applicable standards and regulations prior to the issuance of the permit.

Public water system construction is governed by the Indiana Administrative Code (IAC) and the Indiana Code. Public water system construction rules can be found at 327 IAC 8-3. The governing statute can be found at IC 13-18-16.

Plans and specifications for the construction, installation, or modification of sources, facilities, equipment, or devices of a public water system must be submitted to the commissioner with a permit application. The plans and specifications must be complete and of sufficient detail to show all proposed construction, changes, or modifications that may affect the sanitary quality, chemical quality, or adequacy of the public water system involved. The applicant shall supply any additional data or material considered appropriate by the commissioner for a review of the plans and specifications.

Plans, specification and related material is to be submitted electronically to the Drinking Water Branch, Permits Section at dwpermits@idem.in.gov. An automatic response will be generated letting the applicant know the application was received. A preliminary review of the application will check for completeness. If determined to be initially complete the applicant will be notified, and the application will be assigned to a review engineer. The public notice of application receipt will be issued at this time. Time frames for reviewing a complete application are 60 days for wells and mains and 120 days for applications related to treatment.

Water main extensions may also be permitted under the general construction permit rules through a notice of intent (NOI) to construct. NOI means a written notification indicating a responsible person has elected to comply with the terms of the general construction permit rule instead of applying for an individual construction permit. The general permit rule applies only to main extensions that meet the requirements of the rule found at 327 IAC 8-3.5. A complete NOI application including fee is to be submitted electronically to dwnoi@idem.in.gov. Plans and specifications are not to be submitted with the NOI application but must be available on site for review by IDEM. The applicant will receive an automated response. If accepted the project may begin 30 days after submitting the application. Any issue with the application will be brought to the attention of the applicant. If those issues can be resolved the NOI will be accepted and construction may begin 30 days later.

IC 13-18-16-1Submission of plans and specifications; issuance of permit; determination

Sec. 1. (a) A permit is required for the construction, installation, or modification of:

(1) sources;

(2) facilities;

(3) equipment; or

(4) devices;

of a public water system, including water distribution systems.

(b) Plans and specifications for the construction, installation, or modification of sources, facilities, equipment, or devices of a public water system must be submitted to the commissioner with a permit application. The plans and specifications must be complete and of sufficient detail to show all proposed construction, changes, or modifications that may affect the sanitary quality, chemical quality, or adequacy of the public water system involved. The applicant shall supply any additional data or material considered appropriate by the commissioner to a review of the plans and specifications.

(c) Unless otherwise provided in rules adopted under section 8(b) of this chapter, plans and specifications must be submitted to the commissioner with the permit application for water distribution systems.

(d) Construction, installation, or modification of a public water system may not begin until the commissioner has issued a permit under subsection (a).

(e) In determining whether to issue a permit under this section, the commissioner shall proceed under IC 13-15.

Practice Exam

1) Hydrostatic pressure describes ________.
    a. Electrical movement
    b. The pressure of moving water
    c. The pressure created by the weight of water
    d. The force of movement of water

2) Which of these is NOT a distribution system layout?
    a. Arterial Loop
    b. Grid
    c. Tree
    d. Cartesian

3) Which of these materials is NOT currently used in water mains?
    a. Asbestos cement
    b. Ductile iron
    c. PVC
    d. RCPP

4) Water mains are often connected to service lines with a __________________ .
    a. Meter
    b. Thrust block
    c. Corporation stop
    d. Check valve

5) Which of these service pipe materials was banned for use?
    a. Lead
    b. Ductile iron
    c. PVC
    d. HDPE

6) Which of these is NOT a method of shoring trenches?
    a. Air
    b. Hydraulic
    c. Solid sheeting
    d. Pylon

7) Which of these valves is best for precise flow throttling?
   a. Gate
   b. Butterfly
   c. Needle
   d. Check

8) Which of these valves is used to control flow in storage tanks?
   a. Gate
   b. Globe
   c. Ball
   d. Altitude

9) Which of these meters is best to measure low flows?
   a. Venturi
   b. Turbine
   c. Proportional
   d. Nutating-disk

10) How many days after an NOI Permit application is accepted may a system begin construction?
   a. 10
   b. 20
   c. 30
   d. 40

Chapter 4 – Storage and System Maintenance

Learning Objectives

- Describe the different types of water storage structures
- List the factors that determine storage selection
- Identify the best storage tank(s) for a water system based on storage criteria and pressure considerations
- Compare a routine tank inspection with detailed tank inspection
- Explain the importance of good routine maintenance
- Identify the parts of the system that require routine inspection and exercise, and how frequently it is needed

Tanks

Tanks are used to maintain pressure or supply throughout the distribution system. They offer increased detention times and decreased power and pump usage. They provide water during power failures and increased demand from fire protection services. Below are the important considerations for tank selection:

- Maximum daily use.
- Maximum hourly use.
- Emergency flow requirements – fire protection.
- Pressure requirements throughout the system.
- Terrain of the distribution system.

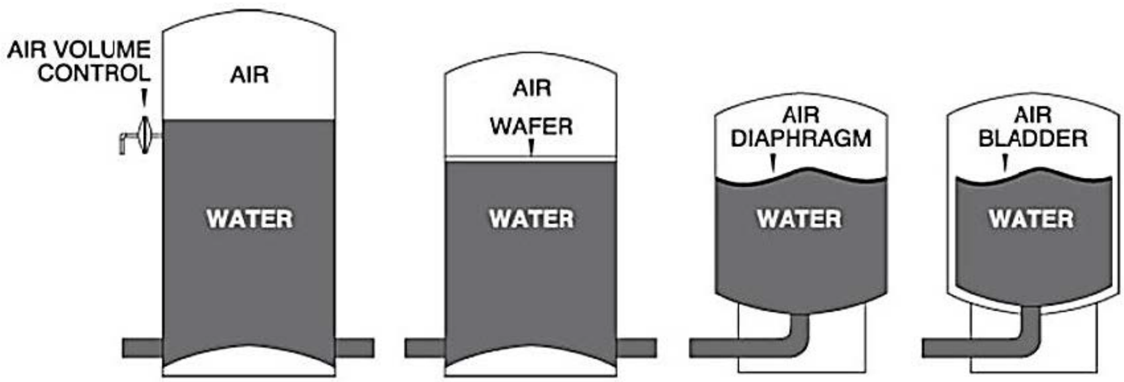
A PWS should maintain a minimum pressure of 35 psi throughout the distribution system. During firefighting events or other emergency flows, a pressure of 20 psi must be maintained throughout the system, otherwise, a boil water advisory must be issued. Normal working pressure should be roughly 60 to 80 psi. Systems with static pressure higher than 100 psi must use pressure reducing devices.

Pressure Tanks

Hydropneumatic pressure tanks are used to maintain pressure in small distribution systems, especially in areas of high elevation. Compressed air within the tank provides the needed pressure. Some have diaphragms or bladders that separate the air from the stored water.

Hydropneumatic tanks provide additional storage for systems without the funds for ground level or elevated tanks. This reduces pump run times. They may become waterlogged when the air in the tank is dissolved into the water. Adding compressed air to the tank will fix this issue. Figure 4.1 shows a cross section of four types of Hydropneumatic tanks.

Figure 4.1 – Hydropneumatic Tanks



Courtesy of the EPA

Storage Tanks

Finished water is pumped from the treatment facility into storage tanks during low demand times. Storage tanks ensure supply during peak demand times and emergency situations. Tanks may be located underground, at ground level, or be elevated. Concrete and steel are the most common materials of storage tank construction.

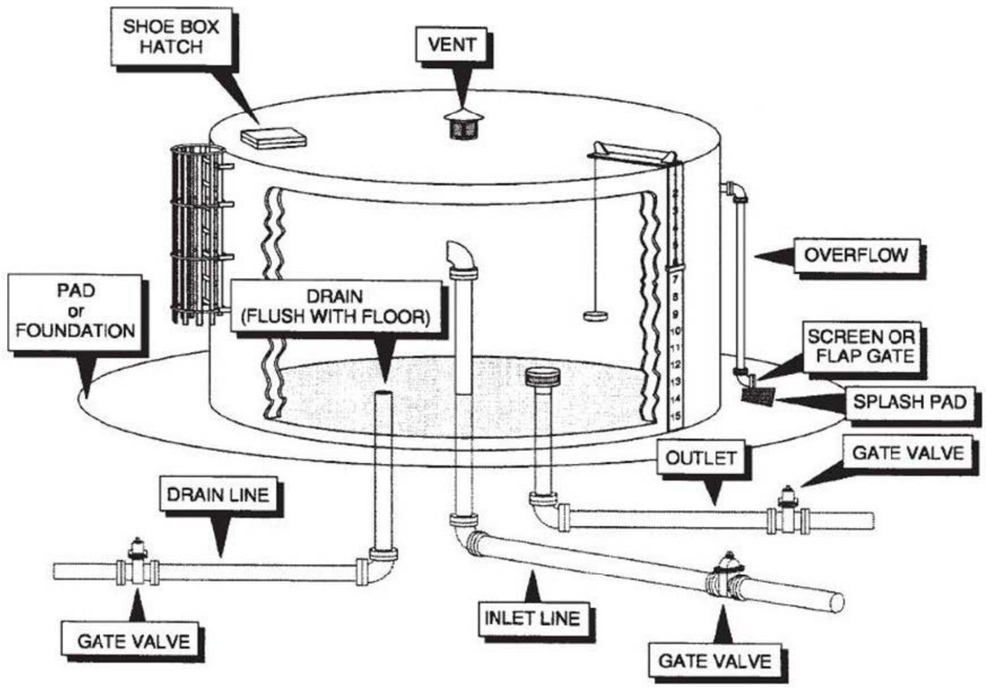
It is important to cycle the water in and out of storage tanks. Water left standing in a tank for too long may become stale, take on foul tastes and odors, or grow harmful bacteria. Tanks should be equipped with vents and overflow piping. All openings to storage tanks should be screened to keep debris and wildlife out of the tank.

Ground Level Storage Tanks

Gound level tanks provide storage in areas where elevated tanks are not suitable, due to topography or community objection. A large area of land is required for a ground level tank. They are usually constructed of steel and have a ladder to access the top of the tank. Figure 4.2 is an example of a ground level storage tank. Figure 4.3 is a diagram showing the components of a ground level storage tank.

Figure 4.2 – Ground Level Storage Tank

Figure 4.3 – Ground Level Storage Tank Diagram

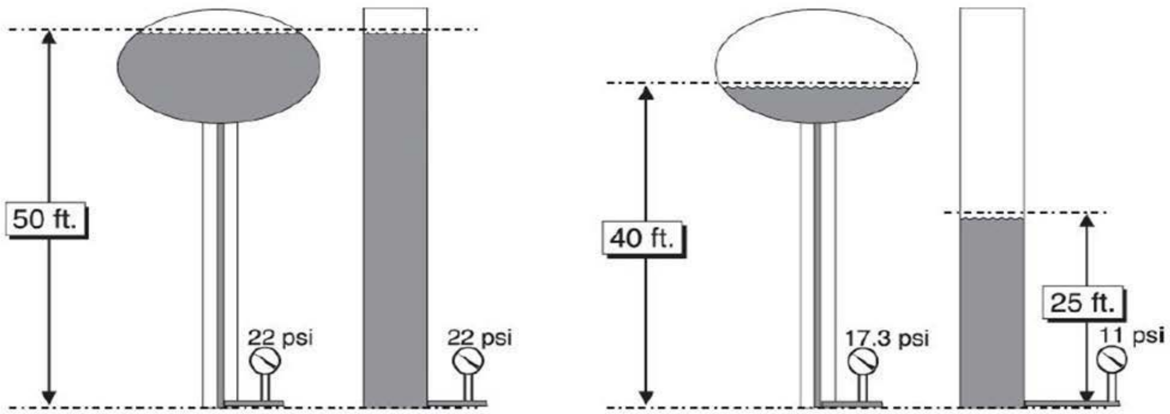


Courtesy of the EPA

Elevated Storage Tanks

Elevated storage tanks provide storage for peak demand and emergencies while allowing the system to maintain pressure. All elevated storage tanks have a riser that moves water from ground level to the tank at the top. Figure 4.4 shows the pressure differences between large, elevated tanks and tanks with a narrow diameter. Table 4.1 describes the types of elevated tanks in more detail. Figures 4.5, 4.6, and 4.7 provide schematic drawings of the three most common elevated tank types.

Figure 4.4 – Large vs. Narrow Diameter Storage Tanks



Courtesy of the EPA

Table 4.1 – Elevated Storage Tanks with Images

Tank Type	Image	Features
Multi-legged steel tank		• Welded steel container supported by multiple legs. • Cost-effective in most cases. • Appropriate for areas with high wind or seismic activity. • Most feature an external balcony for easier inspection and maintenance.

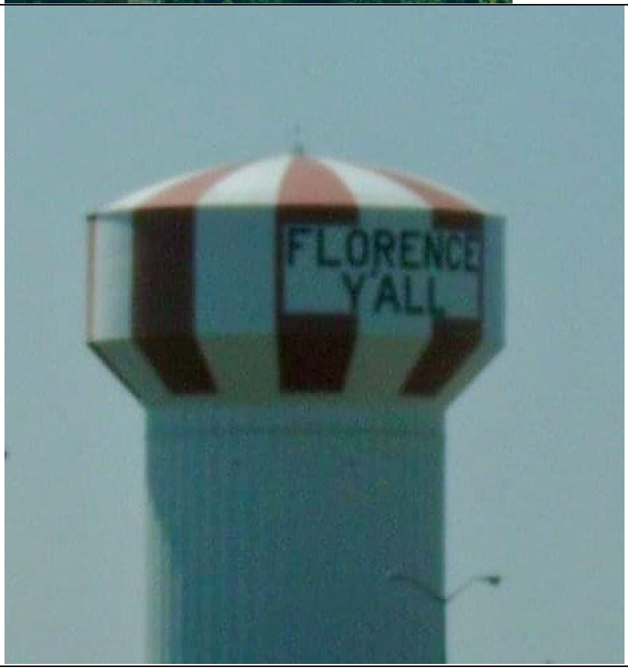
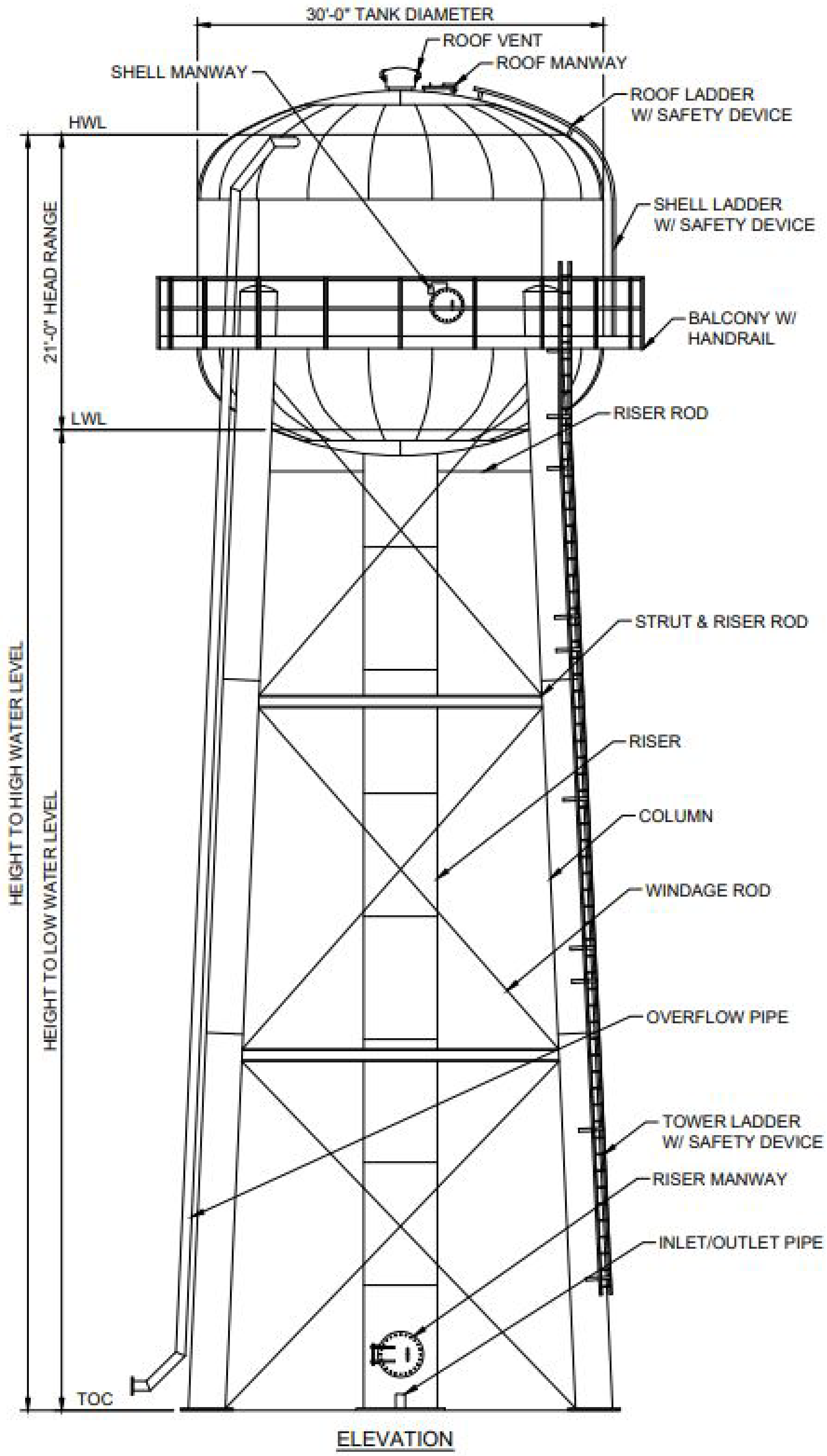
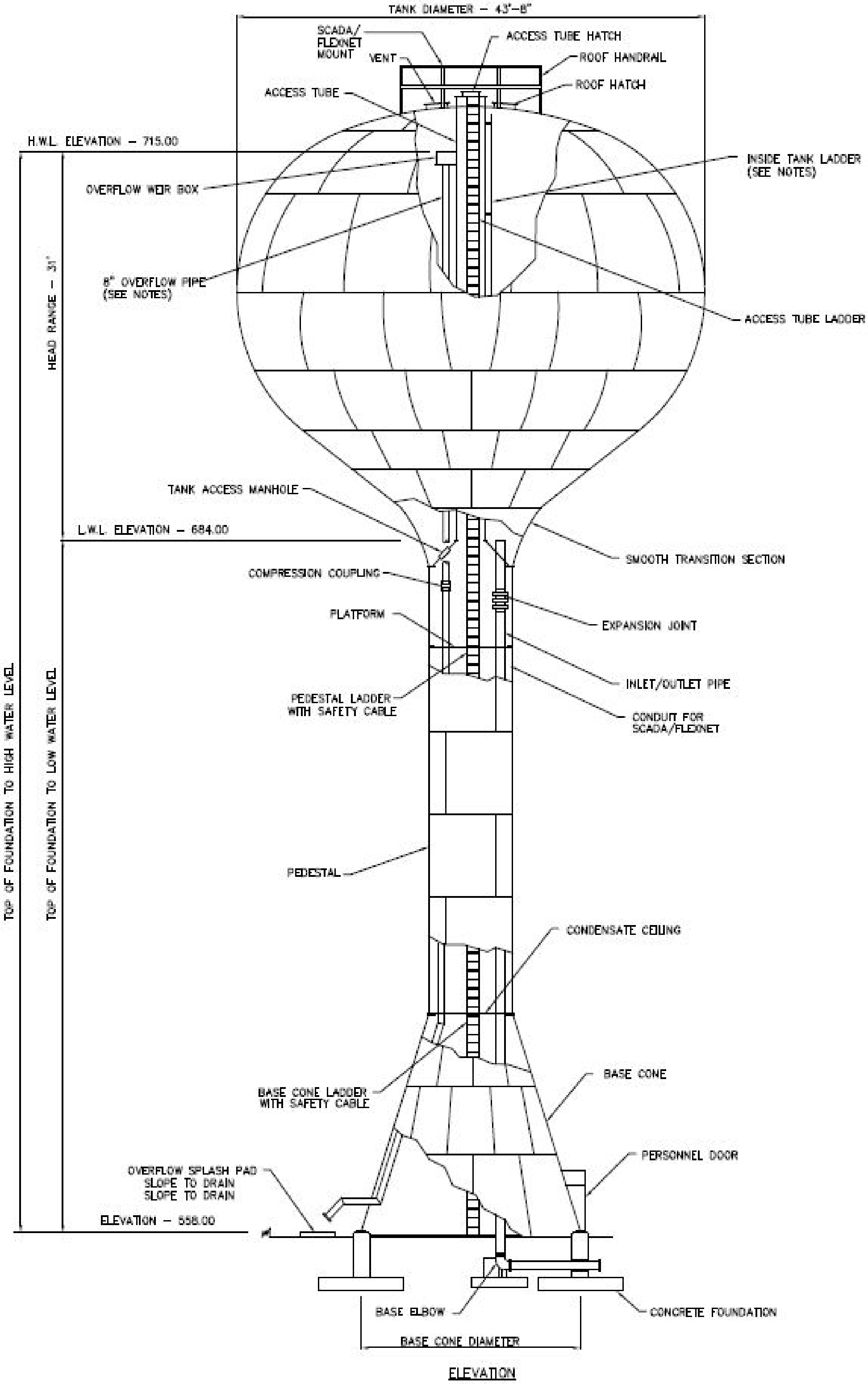
Pedestal Tank		• Looks like a golf ball on a tee. • Single welded steel pedestal supporting a welded steel container. • Smaller construction footprint offers less surface area to maintain. • Interior ladder system reduces the risk of unauthorized access.
Fluted Column Tank		• Welded steel tank supported by a single concrete pedestal. • Concrete pedestal requires minimal maintenance. • Larger base creates space for other uses.

Figure 4.5 - Multi-legged Steel Tank Schematic



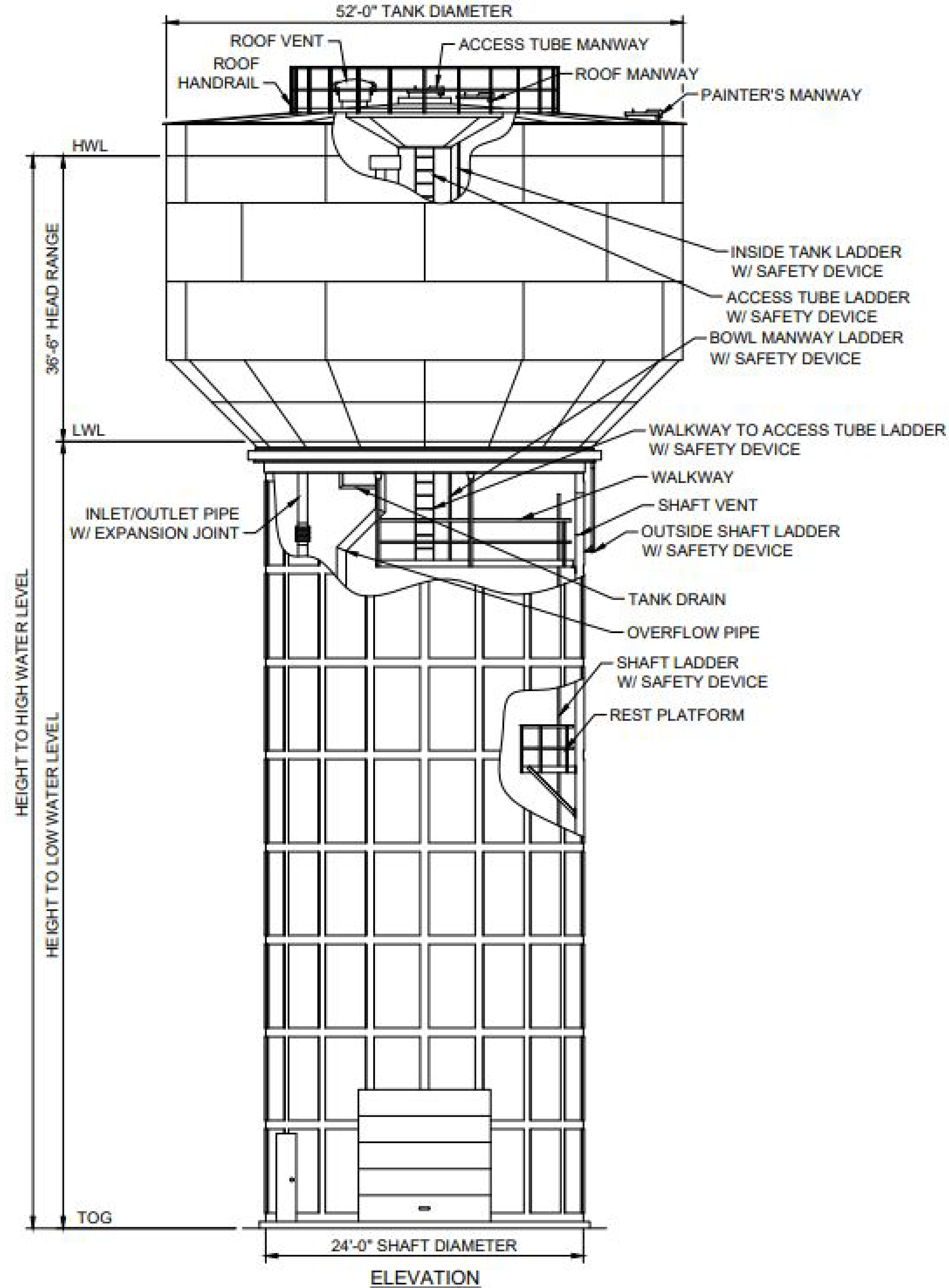
Courtesy of Phoenix Fabricators and Erectors, LLC

Figure 4.6 – Pedestal Tank Schematic



Courtesy of Phoenix Fabricators and Erectors, LLC

Figure 4.7 – Composite Fluted Column Tank Schematic



Courtesy of Phoenix Fabricators and Erectors, LLC

Clear Wells

Clear wells store finished water at the treatment facility. They are typically used to provide contact time for chemical treatment and to ensure a persistent disinfectant residual throughout the distribution system. They can be located above or below ground.

Tank Maintenance

Storage tanks should be inspected regularly. When working around tanks, check the exterior condition, look for leaks, and ensure vent screens are cleared of debris.

Every 3 - 5 years, the tank should receive a comprehensive inspection. All access hatches, vents, pumps, and pipes should be carefully inspected for damage or wear. Corrosion control measures should also be inspected. Internal tank inspections are often done by professional divers, to avoid draining and taking the tank offline.

If a tank is taken offline for repair, it should be disinfected before returning to service. The process is like the main disinfection process. A chlorine residual of 50 mg/L should be maintained for a minimum of 6 hours, but preferably 24 hours.

The exterior of the tank should be cleaned. If corrosion is found, the tank should be repainted after cleaning. When hiring companies for tank cleaning and maintenance it is important to verify their credentials and ensure that they are properly licensed and insured.

System Maintenance

Routine maintenance is important to avoid future problems or failures in the system. A routine maintenance plan should be developed to ensure repairs can be made before a failure occurs.

Water mains and service pipes are difficult to monitor because they are underground. If work needs to be done, it is good practice to inspect surrounding pipes for damage and tuberculation. If a line is tapped, the coupon from the line can be inspected for potential pipe damage.

Directional flushing is used to clean lines. This is a process where water at a high pressure is released from the system using hydrants. It is a good practice because it clears debris and sediment from lines and exercises hydrants and valves. Directional flushing should be carefully planned and should start near the source and work outward through the distribution system.

Another method of cleaning lines is pigging. When a line is pigged, a small device is inserted into the line and pushed through to another opening. This clears the pipe of debris and other fouling material. The line should be flushed after pigging is complete.

Valves should be exercised regularly. When valves are not used, they can get stuck in one position. Hydrants should also be exercised and flushed regularly. Like other valves in the system, they can lose function. If the fire department hooks up to a hydrant that doesn't work, they must unhook and find another hydrant, costing critical time.

Large meters should be tested every 1-4 years. Small meters should be tested every 5-10 years. Meters can be recalibrated if they are reading incorrectly but will eventually have to be replaced. The lifespan of the meter depends on the size and type. Meters that read incorrectly can lead to inaccurate customer billing or apparent water loss.

Any maintenance performed should be documented. Refer to the section on record keeping for more information on what should be recorded.

Practice Exam

1) Which of these is NOT a consideration when selecting storage tanks?
   a. Maximum daily use
   b. Source water
   c. Emergency flow requirements
   d. Terrain of the distribution system

2) What is the minimum pressure required throughout the distribution system?
   a. 10 psi
   b. 25 psi
   c. 35 psi
   d. 60 psi

3) What provides the pressure in a Hydropneumatic tank?
   a. Carbon dioxide
   b. Helium
   c. Nitrogen
   d. Compressed air

4) Which of these is a common material used to make storage tanks?
   a. PVC
   b. Copper
   c. Steel
   d. Asbestos cement

5) Which of these is NOT a type of elevated storage tank?
   a. Hydropneumatic
   b. Multi-legged
   c. Pedestal
   d. Fluted column

6) Which of these is a reason for a system to add an elevated storage tank?
   a. To enhance the city skyline
   b. To maintain system pressure
   c. To fill swimming pools in the summer
   d. To provide teenagers with a way to publicly express their love

7) What is the main purpose of a clear well?
    a. To maintain system pressure
    b. To provide contact time for chemical treatment
    c. To measure turbidity
    d. To allow sedimentation before filtration

8) How often should a storage tank receive a comprehensive inspection?
    a. Annually
    b. Every 1-2 years
    c. Every 2-3 years
    d. Every 3-5 years

9) What is the best way to keep valves functioning properly?
    a. Regularly exercise them
    b. Lubricate them with animal grease
    c. Use them as little as possible
    d. Replace them annually

10) How often should small meters be tested?
    a. Annually
    b. Every 1-4 years
    c. Every 5-10 years
    d. Every 15-20 years

Chapter 5 – System Protection and Instrumentation

Learning Objectives

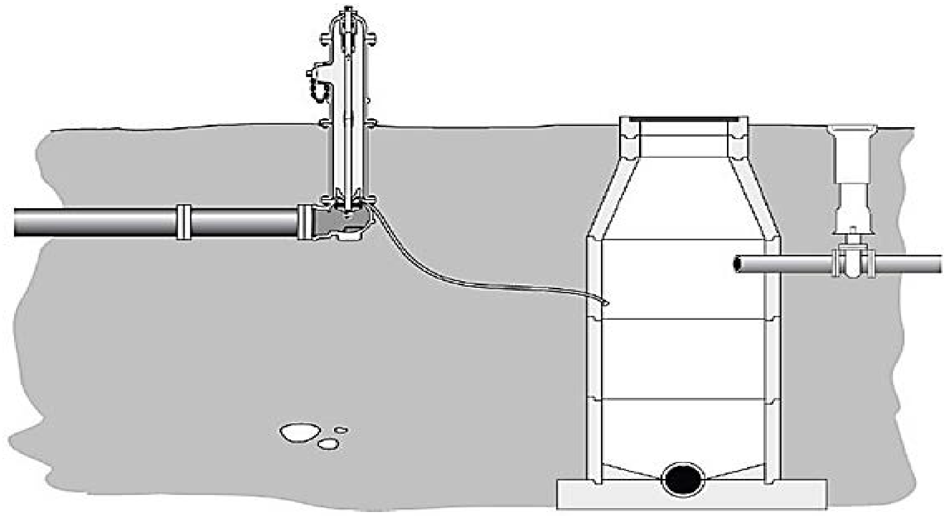
- Define a cross-connection, and differentiate backflow from backpressure
- List the devices used for backflow prevention, and discuss the level of protection provided by each
- Explain the different types of instruments used for system monitoring
- Describe telemetry and the way data moves from sensors to monitoring devices
- Summarize the function and features of a SCADA system
- Explain the importance of system security
- List examples of physical security
- Recognize common types of cyberattacks, and identify cybersecurity best practices
- Identify safety hazards in the workplace and describe proper precautions for those hazards
- Define a confined space and list some of the additional safety measures they require

Cross Connection Control

A cross-connection is an unprotected connection, or potential connection, between the distribution or treatment system and a water source of unknown quality. Cross-connections have the potential to open the PWS to contamination through backflow.

Cross-connections can exist from a variety of sources: Other water systems, sewers, septic tanks, private wells, irrigation systems, fire hydrants, factories, and hospitals. They can occur from either pipe-to-pipe, or pipe-to-water connections. Figure 5.1 illustrates a direct cross-connection.

Figure 5.1 – Direct Cross-connection

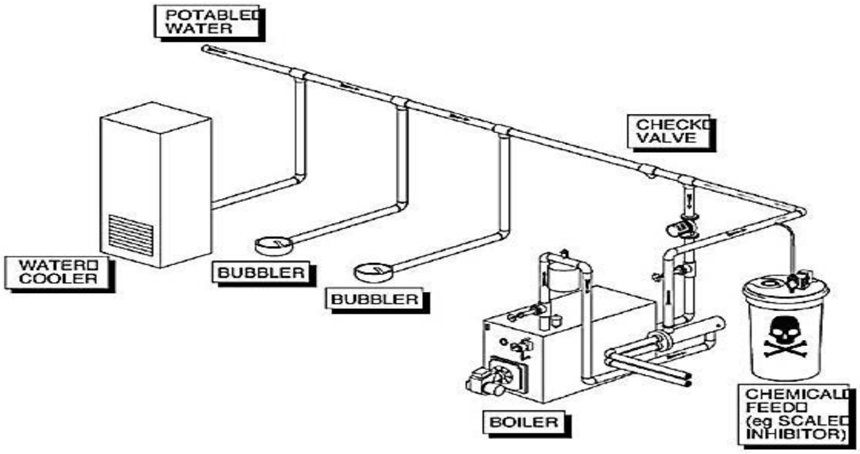


EPA - How to Conduct a Sanitary Survey of Drinking Water Systems

A distribution system operator must monitor the distribution system for cross-connection hazards and ensure they are considered with any new service installation or system repair or upgrade. It is important to understand potential cross-connections in your system and use appropriate backflow prevention devices.

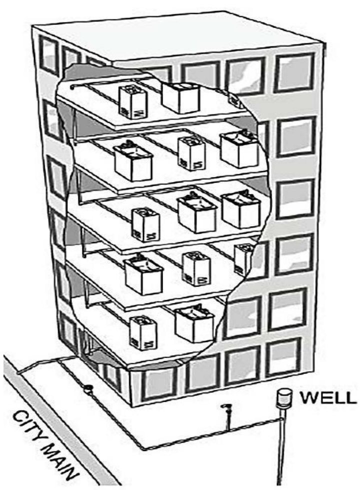
Contamination in the potable water system can occur through either backpressure or backsiphonage. Backpressure is when the non-potable water source is at a higher pressure than the potable water source. The pressure from the non-potable source pushes the contaminated water into the distribution system, like blowing through a straw. Figures 5.2 and 5.3 illustrate backflow from backpressure and hydraulic head, respectively.

Figure 5.2– Backflow from Back-pressure



Courtesy of the EPA

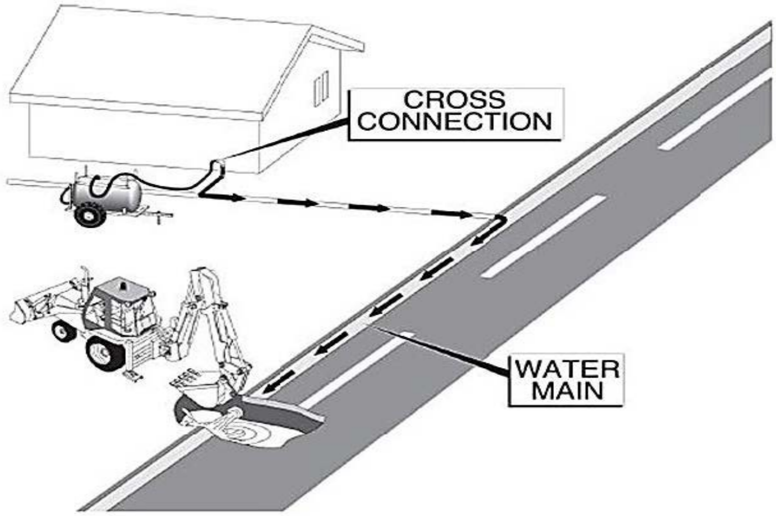
Figure 5.3 – Backflow from Hydraulic Head



Courtesy of the EPA

Backsiphonage can occur when there is a vacuum condition (negative pressure) in the distribution system. The distribution system will pull the non-potable water in, like sucking through a straw. Figure 5.4 shows backsiphonage from a direct cross-connection.

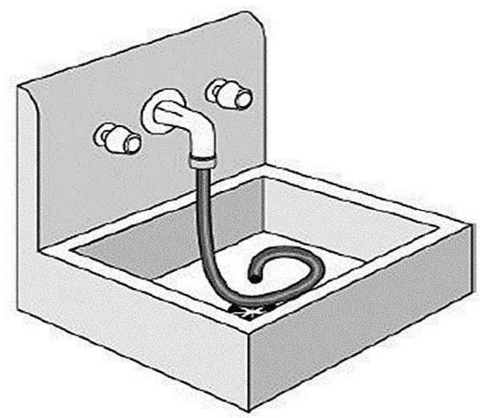
Figure 5.4 – Backflow from Backsiphonage



Courtesy of the EPA

An indirect cross-connection can also cause backsiphonage, especially during a fire-fighting event, which requires high volume and pressure. Figure 5.5 shows a hose connected to a utility sink. If the hose were submerged in a chemical, such as floor degreaser, a vacuum condition in the distribution system would cause that chemical to be sucked into the distribution system.

Figure 5.5 – Indirect Cross-connection From Utility Sink



Courtesy of the EPA

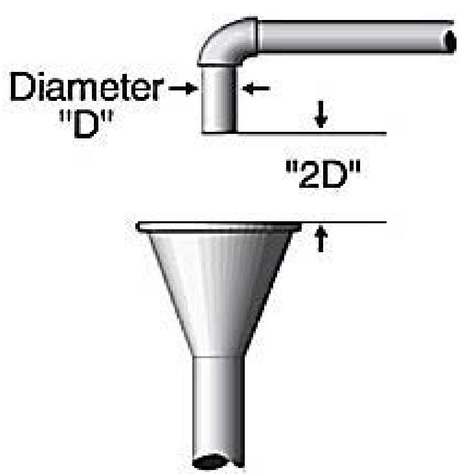
Backflow Prevention

While not all cross-connections will result in contamination of a PWS, they should all be treated as if they will. Backflow prevention devices are used to prevent system contamination from a cross-connection.

Choosing the correct backflow prevention device depends on the degree of hazard posed by the cross-connection. Those with a high degree of hazard require a high degree of protection from a backflow prevention device. An approved backflow prevention device has a shutoff valve, test cock, and can be tested inline.

An air gap is the best method of backflow prevention; however, they can be easily eliminated and must be maintained. An approved air gap must be at least one inch, or twice the diameter of the pipe it's protecting. An air gap provides low and high hazard protection against backsiphonage and backpressure. Figure 5.6 is an illustration of an air gap.

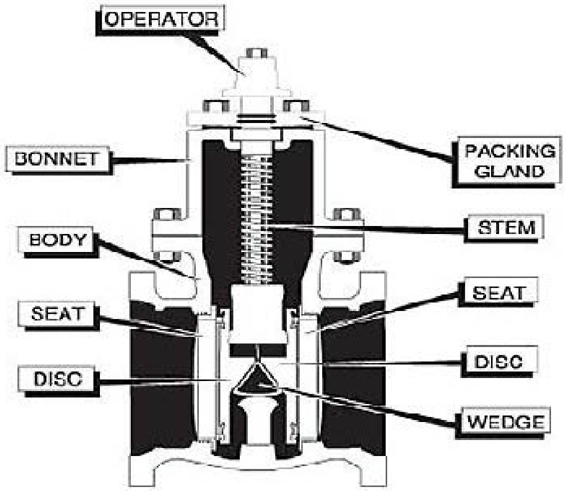
Figure 5.6 – Air Gap



Courtesy of the EPA

Because air gaps can be compromised, other devices and assemblies are used to prevent backflow. An atmospheric vacuum breaker (AVB) is a device that provides low and high hazard protection backsiphonage. An air inlet valve and a check seat cause the device to open when water flows through. When pressure falls below atmospheric pressure, the air-inlet port breaks the vacuum. Figure 5.7 diagrams an AVB.

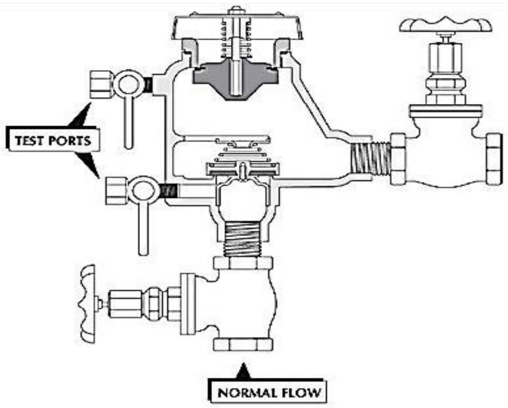
Figure 5.7 – Atmospheric Vacuum Breaker



Courtesy of the EPA

A pressure vacuum breaker assembly (PVB) contains an internally loaded check valve and an independently operated, loaded air-inlet valve on the discharge side of the check valve. In low pressure conditions, the check valve will close to break the vacuum. If the valve does not seal, the air-inlet engages, breaking the vacuum. It prevents backsiphonage in low and high hazard conditions. Figure 5.8 diagrams a PVB. Figure 5.9 is a photo of a PVB.

Figure 5.8 – Pressure Vacuum Breaker Diagram



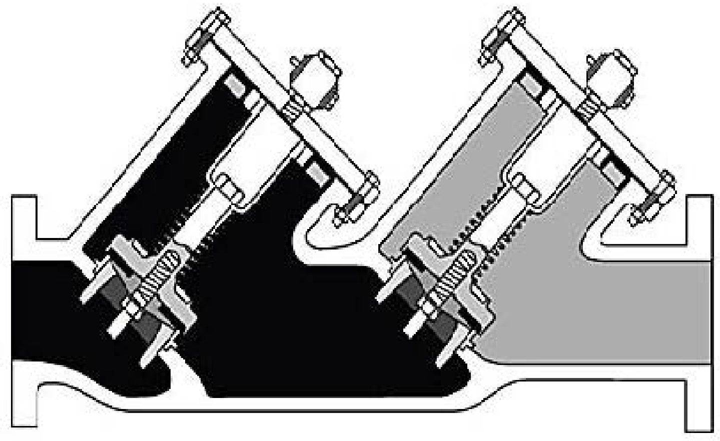
Courtesy of the EPA

Figure 5.9 – PVB Photo

Courtesy of the EPA

A double check valve backflow prevention assembly (DC) consists of two internally loaded, independently functioning check valves, two shutoff valves, and four test cocks. During backpressure conditions, one of the check valves will close, preventing the backflow. If that valve fails, the first check valve will close. DCs are appropriate for low hazard backpressure and backsiphonage. Figure 5.10 shows a double check valve assembly.

Figure 5.10 – Double Check Valve Assembly

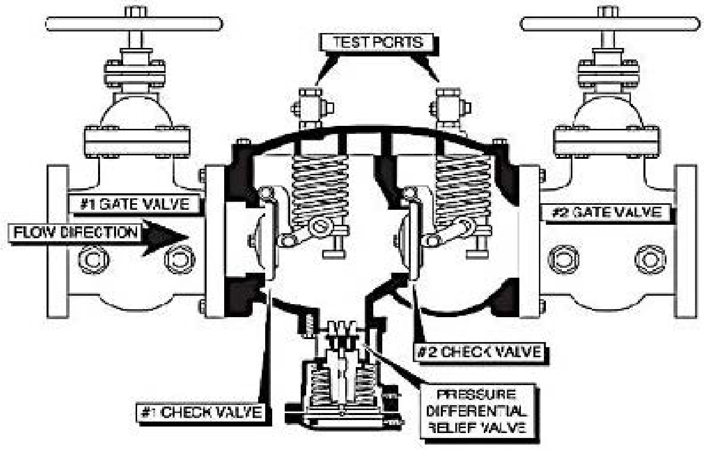


Courtesy of the EPA

A reduced-pressure principle backflow prevention assembly has two internally loaded check valves that act independently, a mechanically independent pressure relief valve located between the check valves and below the first check valve. It also contains two resilient-seated shutoff valves and for resilient-seated test cocks. It is appropriate for both low and high hazard backpressure and backsiphonage. Of the devices and assemblies listed, it provides the highest level of protection. It should never be installed below ground level.

During normal flow, both check valves will be open. In the event of backpressure, both check valves will close, and the second check valve will stop the pressure from traveling between the two checks. In the event of backsiphonage, the inlet pressure is reduced, and the first check valve will cause the relief valve to open and discharge water. Figure 5.11 shows a diagram of an RP assembly and figure 5.12 is a photo of an RP assembly.

Figure 5.11 – Reduced Pressure Principle Assembly Diagram



Courtesy of the EPA

Figure 5.12 – Reduced Pressure Principle Assembly Photo

Courtesy of the EPA

Backflow prevention devices and assemblies must be approved by independent organizations that have developed design and performance standards, such as the American National Standards Institute (ANSI) and the American Society of Mechanical Engineers (ASME). They must be installed properly and cannot be modified. They must be tested annually, and records of test performance should be kept for three years. For more information on backflow prevention, refer to the AWWA *Manual of Water Supply Practices M14: Backflow Prevention and Cross-Connection Control, Recommended Practices.*

Instrumentation

Instrumentation refers to the devices used to monitor and control the system. Meters are an example of an instrument used to read water volume. Other examples of instrumentation include:

- Gauges
- Electronic pipe finders
- Electrical sensors
- Process analyzers
- Pitot meters

Instruments can be broken down into three main categories: Primary instruments, secondary instruments, and control systems.

Primary instruments measure things. They measure pressure, flow, water levels, temperature, etc.

Table 5.1 lists commonly used primary instruments in the distribution system, their function, and examples.

Table 5.1 – Instruments

Instrument	**Function**	**Examples**
Flowmeter	Used to measure water flow and flowing water volumes.	Averaging pitot meter Venturi meter Vortex Turbine or Propeller Weirs
Pressure gauges and sensors	Used to measure water pressure	Bourdon C-tube Bellows Diaphragm Variable capacitance

Level sensors	Used to measure water level in storage or chemical tanks. *Pressure sensors can be used as level sensors, if they are placed at the bottom of the tank.	Float-operated level sensor Bubbler Admittance probe Variable resistance level sensor
Temperature sensors	Used to measure temperature for chemical treatment, monitoring pumps, or detecting system abnormalities.	Resistant temperature devices (RTDs) Thermocouples
Electric power sensors	Used to measure current and voltage to motors and other electrically powered equipment.	Motor current sensor
Equipment status sensors	Used to monitor the status of equipment such as pumps, motors, blowers, etc.	Vibration sensors Position transmitters Discrete sensors

Secondary instruments respond to and display information from the primary instruments. Usually, they are panel mounted. They transmit signals from the primary instruments either electrically or pneumatically. Most modern secondary instruments use electronic transmission. Pneumatic might be used in high hazard or temperature areas.

Pneumatic transmission has limited range, and requires pipes and a supply of clean, dry air to transmit signals. They are low maintenance, resistant to electromagnetic fields (EMF), and safe in hazardous locations. They do not perform well in low temperatures.

Electronic transmission is basically unlimited in range, but it relies on electricity, so any electrical failure would take the instrument offline. It is also subject to EMF interference and requires corrosion protection. Electronic transmission is much faster than pneumatic and has a lower cost of installation.

Control instruments are used to control components in the system, like pumps and valves. The secondary instruments transmit the signals from primary instruments to a control panel. From the control panel, processes can be automatically or manually controlled.

Automatic control processes use either feedforward or feedback control. Feedforward control measures certain input values and uses them to calculate other input values. For example, a feedforward chlorinator would use the flow and the desired chlorine residual to calculate chlorine dosage.

Feedback controls measure the output of multiple processes and uses them to adjust the inputs. This process is reactive, and only responds to errors. Using the chlorinator as an example again, the free chlorine in a tank would be measured. If the concentration goes below 2 mg/L, the feedback control would increase the chlorine dosage to maintain the desired residual.

Telemetry

Telemetry describes the process of transmitting information over long distances. All telemetry systems consist of a transmitter, a channel, and a receiver. The transmitter is the device that collects and sends information. The channel is the pathway used to send information. The receiver is the device that receives information.

Information from the transmitter to the receiver is either analog or digital. In analog systems, the sensor on the transmission side sends mechanical signals, like a pulse, which travel through the delivery channel and are interpreted by the receiver.

Digital transmission uses binary 0/1, or on/off, electrical signals to send data from the transmitter to the receiver. As with analog transmission, a receiver interprets these signals.

Transmission channels may be wired, like copper wiring, telephone lines, or fiber optic cables. They can also be wireless, like radio waves or satellite systems. The proper transmission channel will depend on each system and the sensors and equipment used.

Supervisory Control and Data Acquisition (SCADA)

Supervisory Control and Data Acquisition (SCADA) systems provide monitoring and control for a water system. An operator can monitor and control things like storage tank levels, system pressure, and valves from a computer or handheld electronic device. SCADA systems are also used to monitor and control treatment processes.

SCADA systems work digitally but can receive analog input for things like pressure level, flow, and temperature. The digital control system has the following components:

- Process instrumentation and control devices
- Input/output (I/O) interface
- A central processing unit (CPU)
- Communication interfaces
- Human machine interface (HMI)

Process instrumentation and control devices consist of the sensors and mechanisms in the system. Pressure sensors, valves, and meters are examples.

The I/O interface sends and receives data between the process instruments and the control devices.

The CPU holds programming instructions for the control system. It can gather the data and react based on what instructions it has been programmed with.

The communication interface allows the computer control system to send data to and from outside computers, business systems, process control systems, and equipment.

The HMI is the computer terminal or device that an operator uses to read and/or control the system.

A SCADA system gathers data from instruments throughout the system, inputs it into the CPU, communicates it with other devices, and interfaces with a human on a computer terminal or handheld device.

That data can be used to create reports and analyze trends. A SCADA system can be used to project future demand or create regulatory reports. They can be used to generate maintenance schedules or emergency response procedures.

Because of the complete control available through a SCADA system, it is important to maintain security. SCADA systems should never be connected to public facing internet, default passwords should be changed, and passwords should never be shared.

Additional information on Instrumentation can be found in *American Water Works Association Instrumentation & Control Manual of Water Supply Practices M2, Third Edition.*

Security

Public Water systems are vulnerable to many different types of threats. Natural or environmental disasters can interrupt or contaminate the water supply. Malicious acts like vandalism and terrorism are also threats. The America's Water Infrastructure Act of 2018 (AWIA) requires community water systems serving a population of more than 3,300 people to conduct vulnerability assessments.

Identifying vulnerabilities is the first step in securing and protecting them. Areas to assess include:

- Pipes and constructed conveyances
- Water collection
- Physical barriers
- Treatment and pretreatment
- Storage
- Distribution
- Computer, electronic, and automated systems
- Chemical handling and storage

This is not a comprehensive list. An online threat assessment tool (VSAT2), and a small systems checklist, are available on the EPA's website. AWIA requires that risk assessments be reviewed every five years. Emergency Response Plans (ERP) should be updated based on these assessments. Certification of the review must be submitted to the EPA, but the assessment and ERP should be kept on file at the utility.

Physical Security

Regardless of size, it is important to protect your system from outside threats. Physical security describes methods used to prevent unauthorized entry and the protection of buildings and supplies. Some methods of physically securing your water system include:

- Gates and fences around physical structures throughout the system.
- Locks to secure doors and gates.
- Security cameras at treatment plants, storage tanks, and booster stations.
- Requiring identification from visitors.
- Requiring visitors to sign in and out.
- Running background checks on potential employees.
- Alarms to indicate unauthorized entry.
- Proper storage and use of all chemicals.

In addition to the list above, situational awareness is a critical factor of security. Situational awareness involves being aware of your environment and surroundings and knowing if something or someone is out of place. If you notice something out of place, like an unattended bag, or an unfamiliar vehicle parked outside the utility, it should be reported. Well trained and aware employees are essential to security.

Cybersecurity

Cybersecurity describes the practice of securing your computing resources from attack or unauthorized use. Drinking water systems are increasingly targeted in cyberattacks. Types of attack could include:

- Denial of Service (DoS) – Floods a server with traffic so that it is unavailable to legitimate users.
- Phishing – Attempt to collect secure or personal information by impersonating a legitimate website or entity.
- Spyware – Software that monitors computer activity without the user's knowledge.
- Ransomware - Software that locks authorized users out of a system until a price is paid to the hacker.
- Bad actors using unsecured internet-facing devices to access operational technology and potentially changing or controlling treatment processes.

Employee education is one of the most important parts of an effective cybersecurity program. Ensuring employees are aware of potential threats and using good security practices is critical. Other best practices for cybersecurity are listed below.

- Conduct a cybersecurity assessment.
- Make sure devices that connect to the public internet do not contain sensitive information.
- DO NOT connect SCADA systems to public facing internet.
- Change all default passwords immediately.
- Disable unused computer network ports.
- Secure computer network ports that are in use.
- Require multi-factor authentication (MFA).
- Create an inventory of all Information Technology (IT) and Operational Technology (OT) assets.
- Document critical settings for IT and OT.
- Create a cybersecurity incident response plan.
- Backup critical systems and data regularly.
- Store a backup at a different location and use a different media type.
- Install software and operating system updates and patches in a timely manner.
- Employing a qualified Chief Information Security Officer (CISO).

Emergency Response Plan

An emergency response plan is a document that outlines how the water system will respond in the event of an emergency. A comprehensive emergency response plan can enable a utility to minimize damage, contamination, or loss of service to customers during an emergency. Some examples of emergencies that would require a response plan include:

- Natural disasters, such as earthquakes, tornadoes, floods or fires
- Cyberattacks
- Chemical spills
- Terrorist attacks

The first step in creating an emergency response plan is completing a vulnerability assessment. Once the system vulnerabilities are assessed, a system can better plan for an emergency response. Depending on system size and chemicals used, an emergency response plan may be required by law. Below are some key elements of an emergency response plan.

- Create a list of personnel within the organization and their responsibilities.
- Provide training for employees to carry out the plan (drills and simulations).
- Work with state and local agencies like IDEM, the Department of Health, and fire departments to develop procedures.
- Create a list of contacts and a chain-of-command, including:
  - Plant supervisor
  - Head of the utility
  - Police Department
  - Fire Department
  - Medical professionals
  - Nearby hospitals
- Provide personal protective equipment (PPE) for employees.

Workplace Safety

General Safety

Utilities of all sizes are required to have a workplace safety program by OSHA. Managers are responsible for developing the program, updating it, and ensuring employees receive safety training. The goals of a safety program include:

- Providing a safe workplace.
- Creating a written safety policy.
- Setting attainable safety standards.
- Providing necessary training.

Managers should make sure safety practices are followed, investigate any accidents or injuries, fix any unsafe working conditions, and make sure tools and work areas are properly maintained. They should ensure that all employees have personal protective equipment (PPE) and access to first aid supplies.

Employees are responsible for following safety policies and procedures. They should report any safety hazards to a supervisor immediately. They should regularly inspect their PPE equipment for damage and request replacement for any items that are damaged or not properly working. Some examples of PPE include:

- Hard hats
- Safety vests (reflective, neon)
- Safety shoes (steel-toed, slip-resistant, waterproof, electrical hazard)
- Masks
- Gloves
- Goggles
- Ear plugs
- Coveralls

Even with a comprehensive safety program in place, hazards will still exist. A hazard is a situation that could result in injury, disability, or death. Some of the most common hazards found in the distribution system include confined spaces, heavy equipment, trenches, hand tools, electricity, water, heights, and vehicles. Each hazard has its own safety considerations.

Heavy equipment is used to dig trenches, lift pipes, and move heavy objects like large pipes or valves. Some examples include backhoes, forklifts, and cranes. Some equipment requires special licenses to operate them. While each machine has its own best safety practices, some general safety measures include wearing proper protective equipment, staying out of range of the machine if you're not operating it, and being aware of your surroundings if you are the operator.

Hand tools may be used to repair other equipment. It is important to use the correct tool for the job. Other safety precautions for hand tools include wearing appropriate PPE, inspecting tools for damage before and after use, and avoiding laying them on machines or equipment with moving parts.

Drowning is the main risk when working around water. Water also conducts electricity. Avoid using power tools when in contact with water. Use extra caution when working around water, especially if the depth is unknown, or it is moving.

Falls from high places can cause injury, disability, or death. When working in high places, like elevated storage tanks, use special PPE, like harnesses and connecting devices. OSHA requires training and certification when working at heights of 6 ft. or higher.

Trenches are considered confined spaces. They have the potential to collapse and bury the occupant. If a trench is 5 ft. or more deep, cave-in protection is required. The proper type of shoring depends on many factors, like soil conditions and depth.

When working in the community, vehicles may be a hazard. Distracted or careless drivers may hit workers. PPE, like safety vests and hard hats should be used when working on mains or service lines. Use traffic cones or barrels to block off the work area.

Chemicals are a major hazard in water treatment. Ensure that chemicals are stored properly, and that chemicals that have dangerous reactions with each other are stored separately. Retain the Safety Data Sheet (SDS) for all chemicals used in treatment and distribution.

Electricity

Electricity is a hazard when working on pumps and other system processes that require electrical power. Electric shock can cause burns, cardiac arrest, or death.

When using power tools, ensure that they are in proper condition, and that the power cord is not damaged. If possible, avoid using power tools in standing water. Wearing work boots that protect against electrical hazards is also good practice. Tools and other powered devices can create arc-flash, where the current can jump from the powered device, through the air, to another grounded object.

Ensure extension cords are rated for the tool and job condition. The cord should be rated to carry the proper voltage, should be in good condition, and if used outdoors, should be approved for outdoor use.

The power supply should be disconnected anytime you are performing maintenance on pumps and machinery. The breaker to the machine being worked on should be turned off, and a tag with your name should be attached to the breaker. This process is called lockout/tagout. By tagging the breaker, it alerts other employees that the power supply should remain locked. Only the employee who locked and tagged the breaker should remove the tag once work is completed.

Lockout/tagout should also be used on pipelines and valves when there is potential for high water pressure, air pressure, or steam.

Ground-fault interrupters (GFI), or ground-fault circuit interrupters (GFCI) are devices that can be installed in an electrical system or built into a power cord that will provide some protection from electrical shock. The may also prevent electrical fires. GFIs work by interrupting electrical current when they detect surges.

Confined Spaces

A confined space is defined by OSHA as an area that:

- Has limited or restricted means of entry or exit.
- Is not designed for continuous human occupancy.
- Is large enough for an employee to bodily enter and perform work.

Some examples of confined spaces include:

- Tanks
- Pits
- Trenches
- Manholes
- Tunnels

Some potential dangers of confined spaces are:

- Low oxygen levels
- High oxygen levels
- Toxic gases
- Falling objects
- Electricity
- Water
- Death

Safety precautions before entering a confined space could include:

- Testing and monitoring air quality.
- Using proper equipment for entry and exit.
- Using PPE.
- Using proper lighting.
- Alerting coworkers when you plan to enter or exit the space.

Approximately two thirds, or 67%, of deaths in a confined space are would-be rescuers. Staying aware and alert when working on equipment in the system is important. If an incident occurs, contact emergency personnel. Do not try to rescue a co-worker in distress unless you have emergency response training.

Some confined spaces may require a permit for entry. A permit-required space will have one or more of the following characteristics:

- Has, or may have, a dangerous atmosphere.
- Has, or may have, materials that would engulf the occupant.
- Has, or may have, the ability to trap the occupant.
- Has a known health or safety hazard.

Confined spaces that require a permit for entry must have designated personnel who monitor the space and control entry. Table 5.2 lists those personnel, their functions, and responsibilities.

Table 5.2 – Permit Entry Confined Space Personnel

Title	**Function**	**Responsibilities**
Authorized Entrant	The person(s) entering the confined space.	Be aware of hazards posed in confined space. Properly use all equipment. Communicate with the attendant when needed. Alert the attendant if conditions in the space become dangerous. Exit the space when directed by the entry supervisor or any signs of danger are recognized.

Entry Supervisor	Supervises, or controls, the entry of the confined space.	Know the hazards posed by the confined space. Know the conditions inside of the confined space. Ensure permit is filled out correctly. Ensure tests required by permit have been performed on the space. Terminate entry or cancel permit if conditions in the space become dangerous. Remove unauthorized entrants.
Authorized Attendant	Stays outside of the entrance to the confined space.	Know the hazards posed by the confined space. Know the behavioral effects of exposure to the hazards in the confined space. Maintain an accurate count of authorized entrants into the space and be able to identify them. Stay outside of the space during all operations until relieved by another attendant. Communicate with entrants and monitor activities inside and outside of the space. Summon rescuers, if needed.

Practice Exam

1) What is a cross-connection?
    a. The connection from a main to a service line
    b. An unprotected connection to a water source of unknown quality
    c. The spot where a main connects with a storage tank
    d. The point where the treatment plant connects to the distribution system

2) Which backflow prevention assembly provides the highest level of protection?
    a. Check valve
    b. Atmospheric vacuum breaker
    c. Reduced-pressure principle
    d. Pressure vacuum breaker

3) Which of these is NOT a primary instrument?
    a. Flowmeter
    b. Pressure gauge
    c. Level sensor
    d. Control panel

4) A telemetry system consists of what three parts?
    a. Transmitter, channel, and receiver
    b. Cathode, anode, and wire
    c. Proton, neutron, and electron
    d. Main, corporation stop, and service line

5) Which SCADA component holds the control system programming instructions?
    a. HMI
    b. I/O
    c. Communication interfaces
    d. CPU

6) Which of these is NOT a physical security measure?
    a. Locks to secure doors and gates
    b. Changing default passwords
    c. Requiring visitors to sign in and out
    d. Alarms to indicate unauthorized entry

7) Which of these is NOT a cybersecurity measure?
    a. Not connecting SCADA to the public facing internet
    b. Requiring MFA
    c. Running background checks on potential employees
    d. Disable unused computer network ports

8) Which of these is an example of an emergency that would require a response plan?
    a. Supply chain disruption of treatment chemicals
    b. Pump failure at the source
    c. Main break
    d. Terrorist attack

9) Which of these is NOT an example of PPE?
    a. Hairnet
    b. Masks
    c. Ear plugs
    d. Safety shoes

10) Which of these is NOT a potential hazard of confined spaces?
    a. Toxic gases
    b. Falling objects
    c. Killer bees
    d. Low oxygen levels

Chapter 6 – Pumps

Learning Objectives

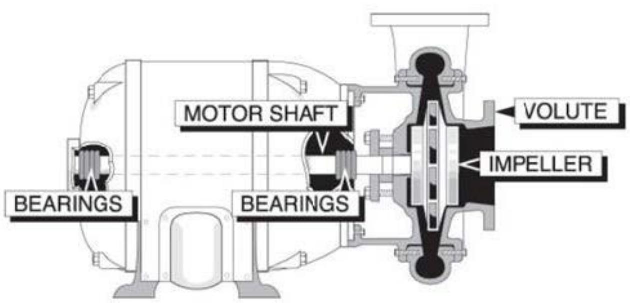
- Explain how the most common types of pumps work
- Identify the parts of a centrifugal pump
- Describe the function of a storage tank and distribution system booster pumps
- List common pump failures and explain the possible causes for each
- Explain the importance of regular inspection and maintenance of pumps

Storage Tank Booster Pumps

Storage tank booster pumps supply water to storage tanks. Recall from Chapter 2 that water will always move from an area of high pressure to an area of lower pressure. Since storage tanks are above the transmission lines, additional pressure is needed to move the water to the higher elevation in the tanks, particularly elevated tanks.

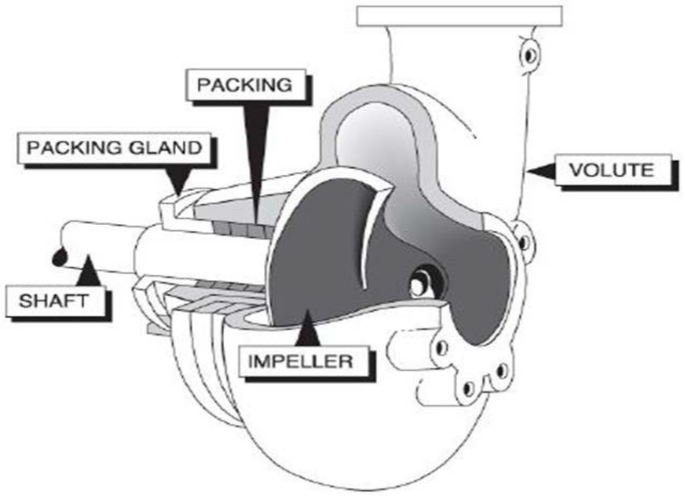
Booster pumps are centrifugal pumps. A motor turns a shaft to power the pump. This causes water to travel through a suction pipe, where it will spin through an impeller, increasing the velocity of the water. The velocity of the water is converted to pressure as it moves through the discharge pipe. Figure 6.1 shows a close-coupled horizontal centrifugal pump. Figure 6.2 is a cutaway of a centrifugal pump.

Figure 6.1 – Centrifugal Pump Horizontal Close-coupled



Courtesy of the EPA

Figure 6.2 – Centrifugal Pump Cutaway



Courtesy of the EPA

The installation and alignment of the pump are critical to its operation. Poorly installed or aligned pumps may not function properly and will require more maintenance. Pumps must be primed, meaning water must be pulled in to fill the suction tube before the motor is started. More information on pump maintenance is in the next section.

Storage tank booster pumps are typically connected with a solenoid switch to an altitude valve on the tank. Once the water level drops to a certain point, the altitude valve will engage the switch, turning the pump on. It will then shut off once the tank is full again.

Most storage tank booster pumps are equipped with a bypass valve. This allows the water to bypass the pump if it is out of service. Table 6.1 lists the components of a centrifugal pump, their purpose, and some troubleshooting tips.

Table 6.1 – Pump components

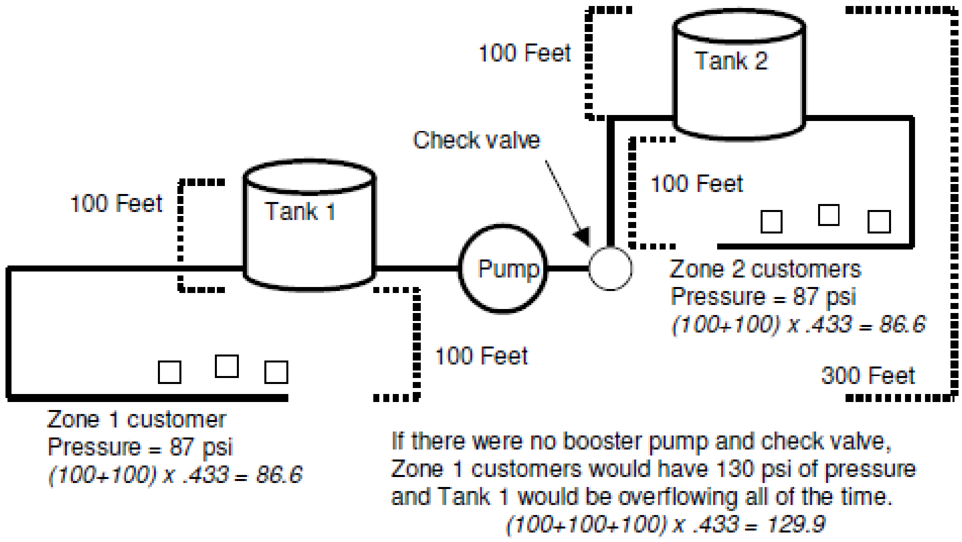
Component	Purpose	Troubleshooting
Suction pipe	Moves water from the source to the pump.	Avoid cavitation by listening for pinging noises. Keep line free of obstacles and clogs. Ensure valves are open.
Impeller	Moves the water, converting kinetic energy into pressure.	Ensure it is free from debris, primed, and turning in the correct direction. Check power supply, voltage, and frequency if it is running at the wrong speed.
Discharge pipe	Moves the water away from the pump.	Flow can be checked with a flowmeter. If flow is restricted, check the impeller.
Motor	Converts electrical energy to mechanical energy to move the pumps parts.	Check the temperature to avoid overheating. Ensure amp draw is within range of ratings on motor nameplate.
Shaft	Transfers torque from the motor to the impeller.	Check the bearings for wear. Open and close valves slowly to avoid water hammer. Ensure proper coupling and alignment.
Water screen	Made of fine mesh material. Prevents debris from entering and damaging the pump.	Screen can get clogged and will require cleaning.

Distribution System Booster Pumps

In large distribution systems with long pipe runs, elevated storage tanks may not provide the required pressure throughout the system. This is especially true for systems that have hills and valleys that impact pressure. Distribution system booster pumps are needed to maintain pressure in these systems.

Figure 6.3 is an example of a water system with two zones using a booster pump and check valve to regulate pressure.

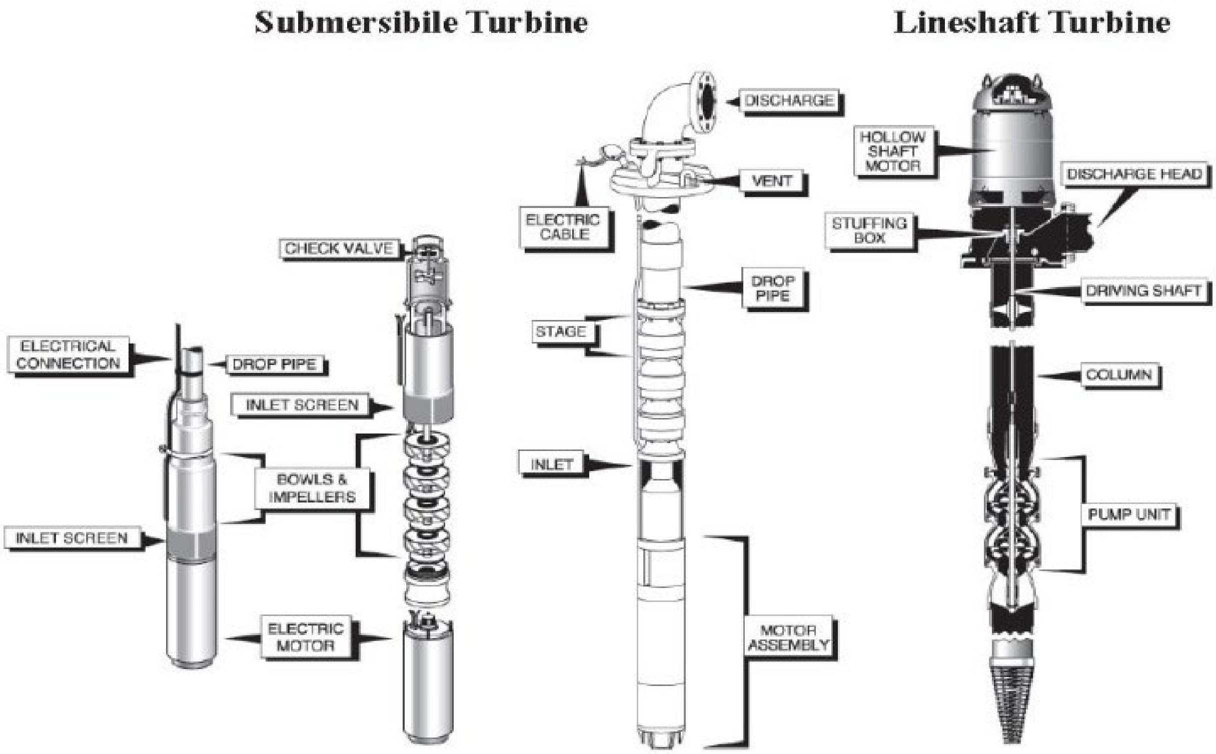
Figure 6.3 – Pressure zones



Like storage tank booster pumps, distribution system booster pumps are typically centrifugal pumps. They may be submersible or line shaft pumps. Vertical turbine pumps are frequently used at booster stations and as in-line booster pumps.

Figures 6.4 shows a cross-section of a submersible and line shaft turbines.

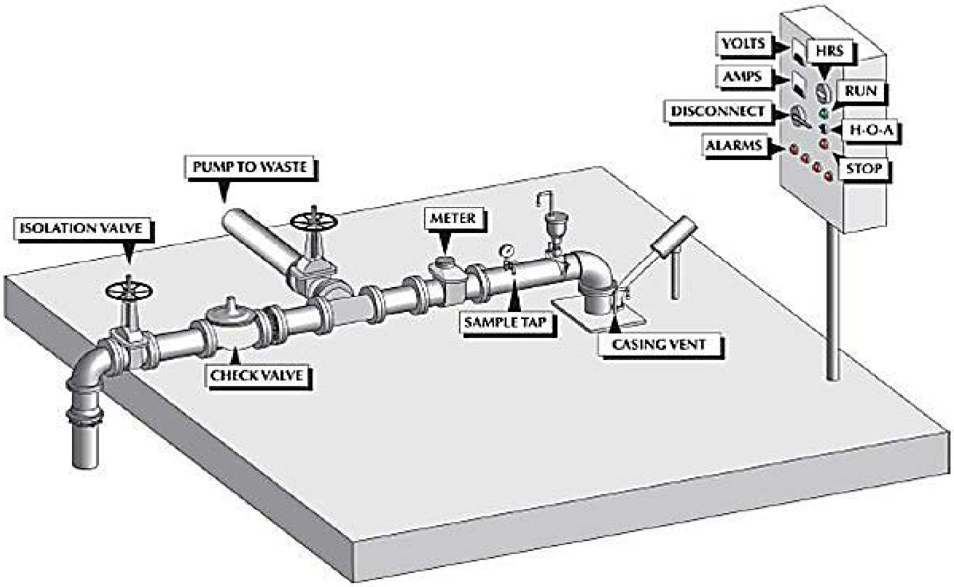
Figure 6.4 – Submersible and line shaft turbines



Courtesy of the EPA

Pumping stations will have a water inlet on the suction side of the pump and an outlet to the distribution system on the discharge side of the pump. They are typically contained within a building or pit, so that access is limited to water system personnel. Figure 6.5 shows a submersible turbine pumping station.

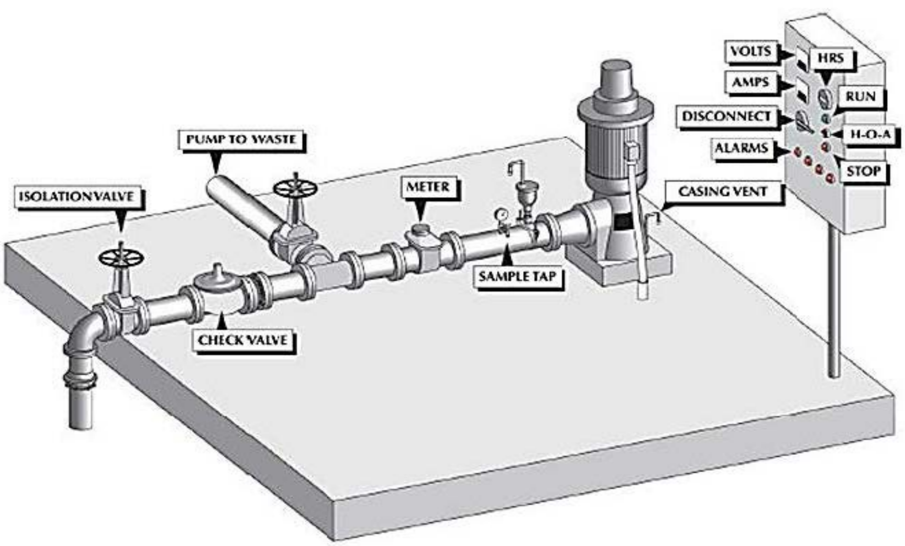
Figure 6.5 – Submersible turbine pumping station



Courtesy of the EPA

Figure 6.6 shows a line shaft turbine pump station.

Figure 6.6 – Line shaft turbine pump station



Courtesy of the EPA

Pump Maintenance

The best resource for operating and maintaining pumps and other equipment is the manufacturer's documentation. Refer to any manuals provided for maintenance schedules and operating instructions.

Packing and bearings should be checked regularly. Ensure that the oil level is in the normal operating range, and change it as directed by the manufacturer. Listen for any unusual noises. These can indicate abnormal operating conditions.

Low pressure at the suction end of a pump can cause some of the water entering the pump to vaporize, creating air bubbles. This condition is called cavitation. The air bubbles make a pinging sound, like gravel or marbles hitting the metal inside the pump or discharge pipes. These air bubbles can cause damage to the pump or the pipes on the discharge side.

Table 6.2 lists common issues with centrifugal pumps and their potential causes.

Table 6.2 – Pump Troubleshooting

Problem	**Possible Cause**
Water is not coming out of the pump.	• Pump is not primed • Debris in the impeller • Malfunctioning valve • Rotating in the wrong direction
Low flow from pump.	• Air pocket or leak in the suction line • Speed is too low • Valve is clogged or malfunctioning • Air is leaking into the pump through the stuffing boxes
Low pressure from pump.	• Rotating in the wrong direction • Impeller is damaged • Wearing rings are worn • Speed is too low
Noise or vibration from pump.	• Bearings are worn • Shaft is bent • Misaligned • Rotor is out of balance

Pump overheats or seizes.	• Pump is not primed • Bearings are worn • Suction lift is too high • Pump is not properly lubricated
Bearings wear too quickly.	• Misaligned • Shaft is bent • Pump is not properly lubricated • Dirt or debris on bearings
Packing wears too quickly.	• Worn bearings • Packing gland is too tight • Incorrect packing is used • Misaligned

Notice that many of the operating problems can be caused by the same issue, such as misalignment and not priming the pump. Table 6.2 is not a comprehensive list of all pump problems and possible causes. The American Water Works Association (AWWA) and California State University Sacramento (CSUS) publish textbooks and manuals with more detailed information.

Practice Exam

1) Which part of the pump spins the water, creating velocity?
    a. Volute
    b. Impeller
    c. Motor shaft
    d. Bearings

2) Which part of the pump is turned by the motor, transferring torque to the impeller?
    a. Shaft
    b. Volute
    c. Discharge pipe
    d. Suction pipe

3) Which part of the pump prevents debris from entering it?
    a. Motor
    b. Shaft
    c. Water screen
    d. Impeller

4) Which type of pump is frequently used at a booster station?
    a. Peristaltic
    b. Pneumatic
    c. Diaphragm
    d. Vertical turbine

5) Which type of valve is commonly used to regulate pressure at booster stations?
    a. Gate
    b. Check
    c. Globe
    d. Needle

6) What is the best resource for operating and maintaining a pump?
    a. The internet
    b. The utility maintenance supervisor
    c. *Pumps for Dummies*
    d. The Manufacturer’s documentation and manuals

7) What is the name for the condition where air bubbles enter the pump?
   a. Cavitation
   b. Air binding
   c. Backsiphonage
   d. Backpressure

8) Which of these is NOT a possible cause, if water is not coming out of the pump?
   a. Pump is not primed
   b. A groundhog built a den at the wellhead
   c. Debris is in the impeller
   d. It is rotating in the wrong direction

9) Which of these is a possible cause for low pressure from the pump?
   a. Open gate valve
   b. Air binding
   c. Impeller is rotating in the wrong direction
   d. Water is too warm

10) Which of these is NOT a possible cause for the pump overheating or seizing?
   a. Bearings are worn
   b. Suction lift is too high
   c. Pump is not primed
   d. Water is too warm

Appendices

Acronyms

AC	Asbestos Cement Pipe
AVB	Atmospheric Vacuum Breaker
AWIA	America's Water Infrastructure Act of 2018
AWWA	American Water Works Association
CCC	Cross Connection Control
CCR	Consumer Confidence Report
CEU	Continuing Education Unit
CIP	Cast Iron Pipe
CISO	Chief Information Security Officer
CORC	Certified Operator in Responsible Charge
CPU	Central Processing Unit
CSUS	California State University, Sacramento
CWS	Community Water System
DBP	Disinfection Byproducts
DC	Double Check Valve Assembly
DCIP	Ductile Cast Iron Pipe
DHHS	Department of Health and Human Services
DIP	Ductile Iron Pipe
DO	Dissolved Oxygen
DoS	Denial of Service
DSL	Distribution System Large
DSM	Distribution System Medium
DSS	Distribution System Small
DWB	Drinking Water Branch
EMF	Electromagnetic Field
EPA, USEPA	Environmental Protection Agency
ERP	Emergency Response Plan
FSO	Facility Specific Operator
ft.	Feet
GAC	Granular Activated Carbon
GPG	Grains Per Gallon
GPM	Gallons per Minute
GWUDI	Groundwater under the direct influence of surface water
HAAs or HAA5	Haloacetic Acids

HDPE	High-density Polyethylene
HMI	Human Machine Interface
HPC	Heterotrophic Plate Count test
I/O	Input/Output
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
IDHS	Indiana Department of Homeland Security
IT	Information Technology
kPa	kilopascal
L	Liter
LCR	Lead and Copper Rule
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MFL	Million Fibers per Liter
mg	milligram
MRDL	Maximum Residual Disinfectant Level
MRDLG	Maximum Residual Disinfectant Level Goal
MRO	Monthly Report of Operations
NEPA	National Environmental Policy Act
NIOSH	National Institute of Occupational Safety and Health
NPDWR	National Primary Drinking Water Regulations
OIT	Operator in Training
OSHA	Occupational Health and Safety Administration
OT	Operational Technology
OWQ	Office of Water Quality
P/A	Presence/Absence test
pH	Potential of Hydrogen
ppb	Parts per Billion
PPE	Personal Protective Equipment
ppm	Parts per Million
psi	pounds per square inch
psig	pounds per square inch gauge
PSM	Process Safety Management
PVB	Pressure Vacuum Breaker
PVC	Polyvinyl Chloride
PWS	Public Water System
PWSID	Public Water System Identification Number
RCPP	Reinforced Concrete Pressure Pipe
RMP	Risk Management Plan
RO	Reverse Osmosis
RP	Reduced Pressure Principle Assembly
RTCR	Revised Total Coliform Rule
RTD	Resistant Temperature Devices

SCADA	Supervisory Control and Data Acquisition
SCBA	Self-contained Breathing Apparatus
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SOC	Synthetic Organic Compounds
TC	Total Coliform
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
THM	Trihalomethanes
VOC	Volatile Organic Compounds

Glossary

Aerobic	To metabolize using oxygen.
Amendment	Change to a legislative policy or act.
Anaerobic	To metabolize without using oxygen.
Anion	Negatively charged ion.
Appurtenance	Equipment or accessories that belong to a larger, more important thing.
Aquifer	Saturated underground formation that will yield usable amounts of water to a well or spring.
Backflow	Unwanted flow of water in the reverse direction.
Backpressure	Resistant pressure exerted against the forward flow.
Backsiphonage	Backflow due to reduced pressure within a water system.
Bacterium	Single celled organism that has a cell wall, but no organization within the cell or nucleus, some of which can cause disease.
Bituminous	Made from bituminous coal, shale, or tar.
Cation	Positively charged ion
Cavitation	Condition where water vaporizes inside of a pump, creating air bubbles which can damage the pump.
Chemical	Substance used in, produced by, or concerned with chemistry.
Coliform	Bacteria that are always present in the digestive tracts of mammals and found in their waste.
Community Water System	Serves the same population year-round.
Compliance	To follow established rules or guidelines.
Condensation	The process of water vapor in the air turning into liquid water.
Confined aquifer	Formation between low permeability layers that restrict movement of water vertically into or out of the saturated formation.
Confined space	Space with limited or restricted entry or exit that is large enough for an employee to bodily enter and perform work, but not designed for continuous human occupancy.
Conservation	To prevent wasteful use of a resource.
Contaminant	Chemical or compound that can cause a negative impact on human or animal health. SDWA defines contaminant as "any physical, chemical, biological, or radiological substance or matter in water."
Corrosion	Breakdown of a substance or material due to interaction with chemicals or its environment.

Cross connection	Any actual or potential connection between a drinking water system and water system of unknown quality. A connection that could contaminate the system.
Deposition	Process of water vapor changing to solid form, skipping the liquid phase.
Disinfection	Process of inactivating or killing pathogenic microorganisms, like bacteria, viruses, and flagellates, typically using a chemical.
Distribution	To spread something out to a group of people or customers.
Drawdown	The lowering of the groundwater surface caused by withdrawal or pumping of water from a well.
Evaporation	The conversion of water from a liquid into a gas.
Evapotranspiration	Water moving from the earth into the atmosphere by evaporation from soil and transpiration from plants.
Filtration	Removing solid particles from water by using a filter that allows liquid to pass while retaining the solid particles.
Galvanic	Producing, causing, or related to an electric current.
Gravity	Force that attracts and object toward the center of the earth.
Groundwater	Water that exists underground in saturated zones.
Head	Body of water kept at a certain height to supply necessary pressure, or the pressure exerted by a body of water kept at a certain height.
Hydraulics	The study of fluid movement or fluid under pressure.
Legislation	Law passed, or adopted, by a governing body
Meter	Device that measures the quantity or rate of something.
Monitor	To observe or keep record of something.
Non-transient non-community	Serves the same population for at least 6 months, but not the entire year.
Operator	Person who operates the facility.
Percolation	The slow seepage of water into and through the ground or the slow passage of water through a filter medium.
Precipitation	Water that falls to the earth.
Pressure	Continuous physical force used on or against an object.
Primacy	Preeminence, or ranking first in importance.
Protozoan	Microscopic single-celled, motile organism that has organization within the cell wall and nucleus, which may cause illness in humans.
Regulation	Rule or law. The process of enforcing a rule or law.
Residual	Quantity that is left after use, remainder.
Responsibility	State of being accountable for something.
Sample	Small part of a whole, often used for analysis.
Soluble	Able to be dissolved, especially in water.

Specific Capacity	A formula for determining if a well can adequately meet the demand of a proposed population or use.
Sublimation	The process where ice and snow (solid) change into water vapor (gas) skipping the liquid phase.
Telemetry	Measurement and transmission of data from remote sources to display equipment in another location.
Transient non-community	Provides water to 25 or more people for at least 60 days/year, but not the same people on a regular basis.
Transmission	The process of transporting something from one location to another.
Transpiration	The process of liquid water evaporating from plants and trees into the environment.
Tubercule	Bump or knob that grows or forms on a surface.
Turbidity	Cloudy, opaque or thick with suspended matter.
Unconfined aquifer	The saturated formation in which the upper surface fluctuates with addition or subtraction of water.
Valve	Mechanical device that controls the movement of a liquid or gas through a pipe or duct.
Violation	Infraction, or rule breaking.
Virus	Submicroscopic infectious agent that replicates inside the cells of living organisms.
Water hammer	Condition where a rapid change in pressure within the pipe generates a sonic wave that oscillates back and forth, causing damage to the pipe or outside structures connected to the pipe.
Water Table	The upper surface of an unconfined aquifer.
Well	A shaft sunk into the ground to obtain water, oil, or gas.
Wellhead	Above ground part of the well structure that controls pressure and connects to the production equipment below ground.

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(NRO)=Northern Regional Office
(NWRO) = Northwest Regional Office
(SWRO)=Southwest Regional Office
(SERO) = Southeast Regional Office

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10/16/2024

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Practice Exam Answer Key

Chapter 1

1) C

2) B

3) D

4) A

5) C

6) A

7) B

8) C

9) B

10) B

Chapter 2

1) C

2) D

3) A

4) B

5) D

6) A

7) B

8) C

9) C

10) A

Chapter 3

1) C

2) D

3) A

4) C

5) A

6) D

7) C

8) D

9) D

10) C

Chapter 4

1) B

2) C

3) D

4) C

5) A

6) B

7) B

8) D

9) A

10) B

Chapter 5

1) B

2) C

3) D

4) A

5) D

6) B

7) C

8) D

9) A

10) C

Chapter 6

1) B

2) A

3) C

4) D

5) B

6) D

7) A

8) B

9) D

10) D

Resources

Office of Water Programs/University Enterprises, Inc. (2018). *Water Distribution System Operation and Maintenance* (7th Edition). Pearson Education, Inc.

American Water Works Association. (2016). *Water Distribution: Grades 1 & 2.*

American Water Works Association. (2001). *Instrumentation and Control: Manual of Water Supply Practices M2.* (3rd Edition).

American Water Works Association. (2015). *Backflow Prevention and Cross-Connection Control Recommended Practices: Manual of Water Supply Practices M14.* (4th Edition).

American Water Works Association. (2016). *Distribution Valves: Selection, Installation, Field Testing, and Maintenance: Manual of Water Supply Practices M44.* (3rd Edition).

Indiana Administration Code Title 327 Water Pollution Control Division. Article 8. Public Water supply. (1987). http://iac.iga.in.gov/iac//iac_title?iact=327

Safe Drinking Water Act. 42 USC Chapter 6A, Subchapter XII: Safety of Public Water Systems (1974). https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title42-chapter6A-subchapter12&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU0Mi1zZWN0aW9uMzAwZg%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim&edition=prelim

EPA 816-R-17-001, Office of Water. *How to Conduct a Sanitary Survey of Drinking Water Systems: A Learner's Guide.* (2019).

Pennsylvania Department of Environmental Management. *Drinking Water Operator Certification Training: Student Manual, Module 8: Distribution Systems.* (2023).