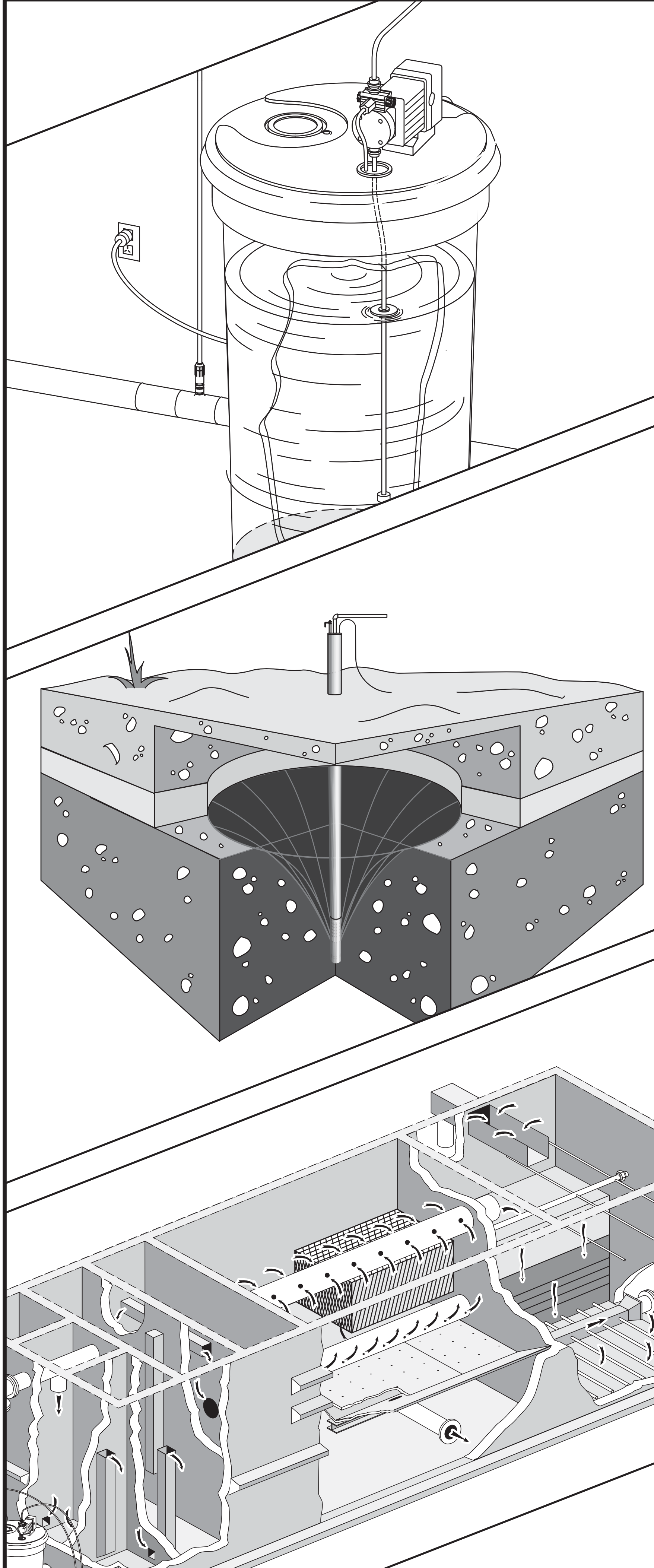

Introduction to Small Water Systems

A Course for Level 1 Operators

Introduction to Small Water Systems: A Course for Level 1 Operators

Original Development

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Albany, Oregon in cooperation with the Alaska Department of Environmental Conservation

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ATTAC welcomes your comments and suggestions for improvements to this manual in the interest of educating water utility professionals for the benefit of their local community.

Printing This Manual

Version

February 2009

Foreword

One of the biggest challenges facing rural Alaskan communities is providing sustainable water services. Having adequately trained and qualified operators is a major part of that challenge. Since 1992 state, federal and private trainers have been delivering entry level water system operator training programs built around this manual. The manual serves as the official text for initial training of water operators, and satisfies the education prerequisite for certification at the Provisional Level. The manual has been critical in the effort to build operational capacity among Alaska's small, rural, public water systems.

This text has been revised to provide owners and operators of small public water systems a basic understanding of the principles and practices involved with collecting, treating, storing and distributing safe drinking water. This course and text material are narrowly focused on communities with a population of less than 3,300. However, we believe that an entry level through Level II operator at any treatment or distribution facility of any size will find the material helpful. Developing an understanding of the concepts discussed in this text should provide the information needed to be successful with the water treatment or the water distribution Provisional Level examination.

The job of water plant operator is an important one and is looked upon by the Alaska Department of Environmental Conservation as a key to the health of the community. Therefore, it is assumed that water plant operators recognize their responsibilities and perform their jobs in a manner that will protect the public health of their community. Failure to perform the responsibilities of the water plant operator can lead to potential health hazards and the loss of the "certified" status.

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Key Words

- Ambient
- Aquatic Life
- Atmosphere
- Celsius
- Community Water System
- Density
- Disinfection
- Evaporation
- Evapotranspiration
- Fahrenheit
- Humidity
- Hydrologic Cycle
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Introduction

Who Is This Manual For?

This training manual and course were developed to provide instruction for water system operators in the State of Alaska. The focus is primarily on small, rural Alaskan **public water systems**[1].

[1] Public Water Systems – Any source of water, intake works, collection system, treatment works, storage facility, or distribution system, including vehicle or vessel used to distribute water, from which water is available for human consumption.

Lesson Content

This manual describes water system components, their functions, and their operation and maintenance techniques and introduces the basic scientific concepts in the field of water system design, operation, monitoring, and management at a level that is addressed on the State of Alaska Provisional Level Water Treatment and Water Distribution System Operator Certification Exams.

The Role of the Water System Operator

Public Health Protection

The water system operator's most important job is that of a guardian of public health. The operator's job performance impacts the health and safety of everyone in the community. The community places its trust in the water system operator to provide a safe, reliable, and aesthetically pleasing source of drinking water. This can be difficult and challenging, but it's an immensely rewarding responsibility.

The Professional Water System Operator

The water system operator assumes a high level of responsibility to maintain the quality, security, and reliability of the community's water supply. The operation, maintenance, and management of public water systems require a working knowledge of water system technology, microbiology, chemistry, hydraulics, electronics, mechanics, and troubleshooting.

The professional water system operator must also understand system regulations and perform necessary monitoring and reporting. The modern professional water system operator is also a public relations specialist, who needs to be able to communicate effectively with the public, the community leaders, and students from schools who may request a tour of water system facilities. The operator should maintain the water system in a clean and orderly condition for reasons of safety, efficiency of operations, and public relations.

To become a water system professional, the operator needs to continually advance in education. The operator needs to develop the skills and knowledge required to pass the certification exams, to invest the time to renew certificates, and be willing to advance in certification levels after acquiring the necessary years of professional experience. This requires a high level of commitment to a career that will involve a lifetime of work, training, and dedication to the protection of public health. It is a profession that can provide excellent employment opportunities and a high level of job satisfaction.

What is Water?

Abundance
Water is one of the most abundant and common materials on earth. It covers 70 percent of the surface of the earth as water and ice.

Lifeblood
Water is the lifeblood of the universe. Without water, there could be no life. Our bodies are 70 percent water. Without drinking water for four to seven days, our blood becomes thick and contains a high concentration of toxic waste materials. We become delirious and unable to function. Death is not far behind.

Other Planets
Even though most other planets have water in some form, the earth is the only planet in the solar system that contains water in all its common forms (gas, liquid, solid). Others have ice, but only the earth has an abundance of this miraculous substance in the proper temperature range to support life.

Universal Solvent
Water is often called the "universal solvent." Given enough time, it will dissolve almost everything that it comes in contact with. Thus, it is effective in carrying food through our bodies to the individual cells and carrying away the cell waste.

Dissolves Minerals
As water flows over and through the ground, it picks up minerals, microorganisms, dirt, and plant material. The water, due to its speed, carries some of these materials along. Others, such as minerals, are dissolved in the water.

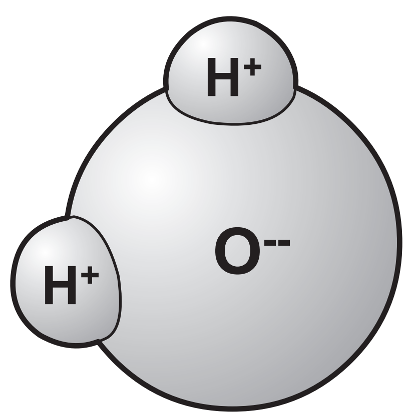
Gases
Water also has the ability to dissolve gases, such as oxygen (O_2) and carbon dioxide (CO_2). Dissolved oxygen in water allows fish and other **aquatic life**[2] to survive. The gills of the fish allow it to filter this dissolved oxygen directly from the water. Without oxygen, fish would die.

[2] Aquatic Life – All forms of plant and animal life that live in water.

The Water Molecule
The water **molecule**[3] has the chemical symbol H_2O (H_2 for two hydrogen atoms and O for one oxygen atom). The chemical symbol is read as "H two O."

[3] Molecule – The smallest division that a substance can be broken down to without separating its individual atoms.

Like a Magnet
The two hydrogen atoms are positioned at one end of the molecule. The hydrogen atoms are positively charged. When they attach themselves to the oxygen atom, the whole molecule becomes polarized with negative and positive poles, like a magnet. Because it has both negative and positive charges, it is much easier for the water molecule to attract other material. This is one of the reasons it is the "universal" solvent.



Water as a Chemical

States of Water

There are three basic states of matter: solid, liquid, and gas. Water is the only material on earth that is found in these basic states at standard temperatures, as ice, liquid water, and water vapor.

Molecules in Motion

The water molecule, like other molecules, is in constant motion. The rate of this motion is directly related to the temperature of the water. It moves slowest when the water is in the form of ice and fastest when it is a vapor.

Density of Water

As the temperature is reduced, the rate of movement slows and the molecules get closer and closer together. At 4°C they are as close together as they are ever going to be. This increases water's **density**[4] to its maximum. The volume that a set amount of water occupies is at a minimum at this point. Below 4°C the molecules are moving so slowly that their electrical charges begin to cause the molecules to line up in a pattern and form crystals.

[4] Density – The weight per unit volume of a substance.

Expands When It Freezes

At 0°C the crystals are fully formed, and the water molecules line up in a way that occupies a greater space than before the temperature reached 0°C. This expansion is what causes water to break a pipe when it is frozen. Water is one of the few compounds that expands when it freezes. This expansion gives ice a lower density than water, which makes it lighter and allows it to float.

Water and Heat

We measure heat by the amount of energy it takes to change the temperature of water. In the English system, the unit of heat measurement is the British Thermal Unit (BTU). One BTU is the amount of heat energy it takes to raise the temperature of one pound of water one degree **Fahrenheit**[5]. In the metric system, heat is measured in calories. One calorie is the amount of heat energy it takes to raise the temperature of one gram of water one degree on the **Celsius**[6] scale.

[5] Fahrenheit – Relating to an English thermometer scale with the boiling point at 212 degrees and the freezing point at 32 degrees.

[6] Celsius – Relating to a metric system thermometer scale with the boiling point at 100 degrees and the freezing point at 0 degrees.

Review

1. The most important job of a water system operator is:

2. List three skills that a professional water system operator should have.

3. Water is called the __________________ solvent.

4. The three states of water are:

5. Water is at its maximum density at ____ °C.

Distribution of Water on Earth

The Study of Water

The study of water is called **hydrology**[7]. This next section briefly discusses the types of water sources, the distribution of water in those sources, and some of the uses of water.

[7] Hydrology – The applied science pertaining to properties, distribution, and behavior of water.

Definition by Sources

The sources of water on the earth are divided into two categories:

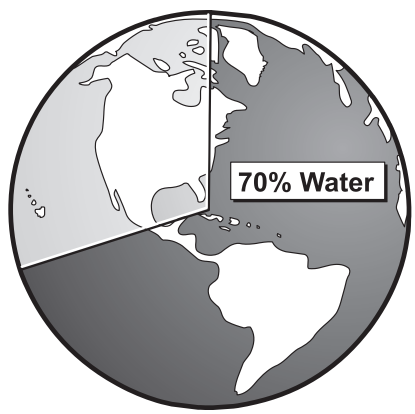
- **Surface Water** – Water that is found in oceans, lakes, streams, springs, and muskeg ponds. Surface water is exposed to the **atmosphere**[8] and is affected by **ambient**[9] conditions. This is the source of drinking water for some of our largest communities.
- **Groundwater** – All the water below the earth's surface. However, we consider only the water down to 2500 feet below the surface to be usable. Water below this depth is too hot and expensive to access. Groundwater may also include springs, which are considered to be either surface water or groundwater.

[8] Atmosphere – The gases that surround the earth.

[9] Ambient – The surrounding atmosphere.

70 Percent of Earth Is Water

Seventy percent of the earth's surface is covered with water. The total volume of water on the earth is approximately 305.79 million cubic miles. Of this total supply, 296 million cubic miles are in the oceans, leaving only 9.79 million cubic miles of fresh water.



Hydrologic Cycle

Introduction

The **hydrologic cycle**[10] is the key to our supply of fresh water. It is made up of four components:

1. The **atmosphere**
2. The **lithosphere**[11] – the crust of the earth
3. The **hydrosphere**[12] – the water on the earth
4. The **sun** – the energy source which drives the hydrologic cycle

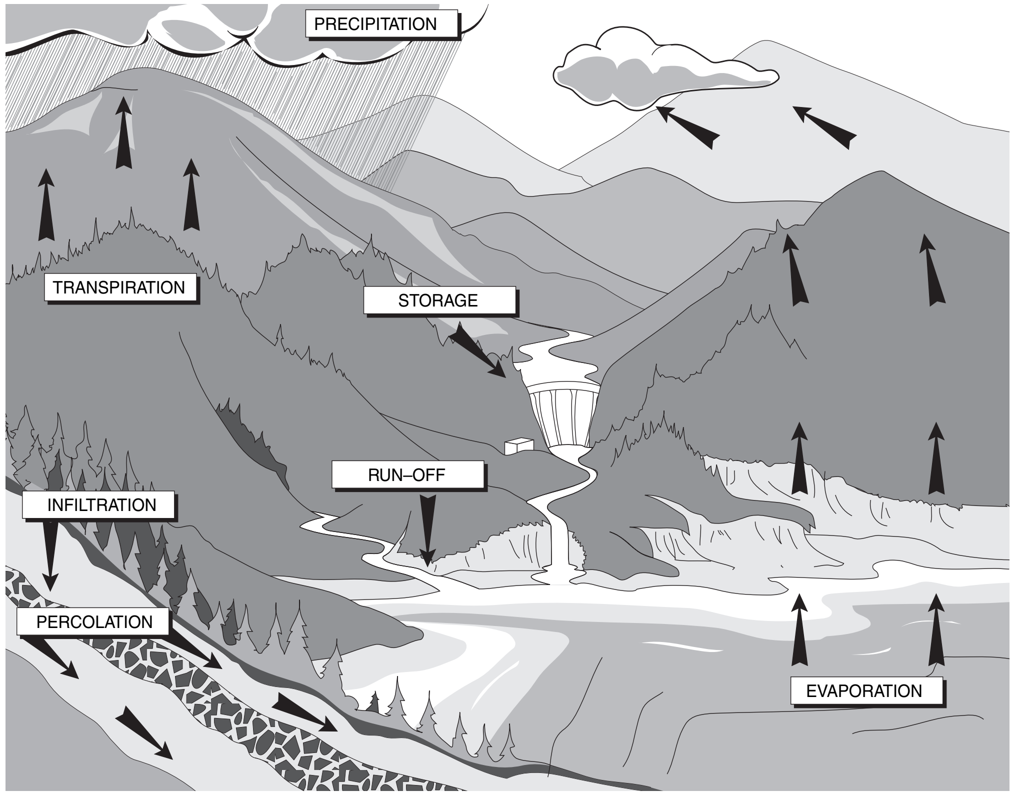
[10] Hydrologic Cycle – Nature's method of continuously recycling the earth's renewable water supply, between the earth and atmosphere, makes it possible to use this water over and over again.

[11] Lithosphere – The solid crust of the earth. It consists of the thin, loose layer known as soil and the mass of hard rock, several miles in thickness, upon which soil lies.

[12] Hydrosphere – All of the water on the earth.

Available Water Supply

The amount of water available in the atmosphere, lithosphere, and hydrosphere remains constant. This water is continually recycled by the action of plants and the sun. To understand this process, let's follow the hydrologic cycle.



Precipitation

You could start the cycle anywhere because it is continuous. So let's pick-up a droplet of precipitation and follow it through the cycle. **Precipitation**[13] in the form of rain, snow, or sleet falls towards the earth.

[13] Precipitation – The process by which atmospheric moisture is discharged onto the earth's crust. Precipitation takes the form of rain, snow, hail, and sleet.

As the precipitation falls toward the earth, it can pick up contamination from industrial air pollution and natural pollution such as volcanic ash. As it falls toward the earth, some of the precipitation **evaporates**[14].

[14] Evaporate – The process of conversion of liquid water to water vapor.

Evaporation

The amount of evaporation depends on several factors. Among them are the ambient **humidity**[15], air temperature, and the amount of wind. There is a significant amount of precipitation that is recycled back to the atmosphere before ever striking the ground. Some of the precipitation hits the forest canopy, brush, and grass. Some of the precipitation evaporates directly from the leaves of the canopy.

[15] Humidity – The amount of water vapor in the air.

Some water flows down the outside of the trees onto the ground, and some strikes the ground directly. As water accumulates on the ground, it runs downhill. This movement is called **overland flow**[16].

[16] Overland flow – The movement of water on and just under the earth's surface.

Flows Along the Surface

As the water moves along the surface, it picks up contamination in the form of **organic**[17] material, such as bits of leaves; microorganisms such as bacteria, viruses, and protozoa; and **inorganic**[18] matter such as silt, clay, minerals, and volcanic ash.

[17] Organic – Chemical substances of animal or vegetable origin, usually containing carbon.

[18] Inorganic – Chemical substances of mineral origin, not usually containing carbon.

Surface Water

The overland flow accumulates in lakes, streams, muskeg ponds, and rivers. These sources are referred to as surface water. A large quantity of surface water evaporates back into the atmosphere. In most of the world, this is the largest single loss of surface water.

Groundwater

Some of the water that runs along the earth's surface seeps into the soil. This process is called **infiltration**[19]. As the water infiltrates the soil and moves downward, some is taken up by the roots of trees and other plants. The water that is taken in by plants moves upward and is given off into the atmosphere through the leaves of the plants in a process called **transpiration**[20].

[19] Infiltration – The initial movement of water from the earth surface into the soil.

[20] Transpiration – The process by which water vapor is lost to the atmosphere from living plants.

Evaporation and Transpiration

This moisture mixes with the moisture that is evaporated from surface waters and from the plants. This combined process is referred to as **evapotranspiration**[21].

[21] Evapotranspiration – The combined vaporization of water from water surfaces and plants.

Groundwater Movement

The water not taken up by plants continues to move downward in a process called **percolation**[22]. This water continues to move downward until it collects in gravels and sands called aquifers. From there the water continues to move slowly towards adjacent lakes, streams, and the ocean, where it collects with the surface water and is evaporated back into the atmosphere.

[22] Percolation – Movement of water into and through the ground.

Springs

Sometime in the past, changes in the earth's crust left the edge of an aquifer exposed to the surface. This allows the groundwater supply to exit the hillside or mountain in what is referred to as a spring. From there it runs along the surface and mixes with surface water.

Back to the Atmosphere

As you can see, both the groundwater and the surface water eventually mix and are evaporated back into the atmosphere and form water vapor. This vapor is condensed by atmospheric conditions and forms precipitation, which falls to the ground and continues the cycle, providing us with clean fresh water for our water systems.

Review

1. The movement of water from the surface of the earth to the atmosphere and back to the surface is called the:

2. The term used to describe the movement of water from the surface of the earth to the atmosphere is called:

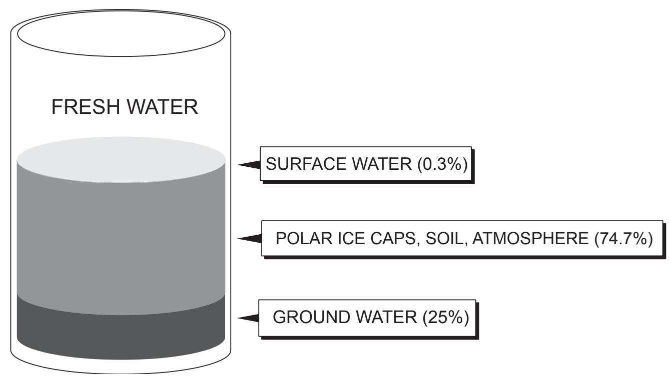
Distribution of Water

Total Supply

The total supply of all water in the world is approximately 305.79 million cubic miles. Of this total supply, 296 million cubic miles are in the world's oceans. This leaves 9.79 million cubic miles or 3.2 percent of all water in the world as fresh water.

Distribution of Fresh Water

Of the 9.79 million cubic miles of fresh water, 74.7 percent is tied up in the polar ice caps, soil moisture, and the atmosphere. Twenty-five percent of this fresh water is in the groundwater supply, leaving 0.3 percent of the fresh water in the lakes and streams.



Fresh water distribution 3.2% of all water

Percent of World's Fresh Water	Location	Million Cubic Miles
74.60	Polar ice caps	7.33
0.06	Soil moisture	0.00587
0.035	Atmosphere	0.00342
14.00	Groundwater between 2500 and 12,500 feet	1.36
11.00	Groundwater between 0 and 2500 feet	1.06
0.30	Lakes	0.029
0.03	Rivers	0.00293

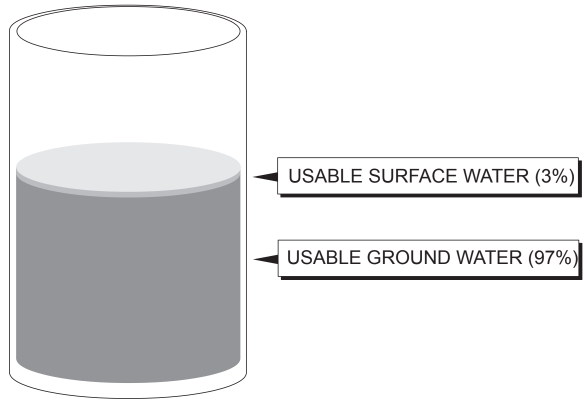
Usable Fresh Water

The total groundwater supply is estimated at 2.42 million cubic miles. Only 44 percent of this, or 1.06 million cubic miles, is usable since it is less than 2500 feet below the surface. Lakes and rivers represent 0.03 million cubic miles of water. This gives a total usable fresh water supply of 1.09 million cubic miles.

Division of Fresh Water

Of the usable fresh water, 97 percent or 1.06 million cubic miles is in the groundwater supply and 0.3 percent is in the surface water supply.

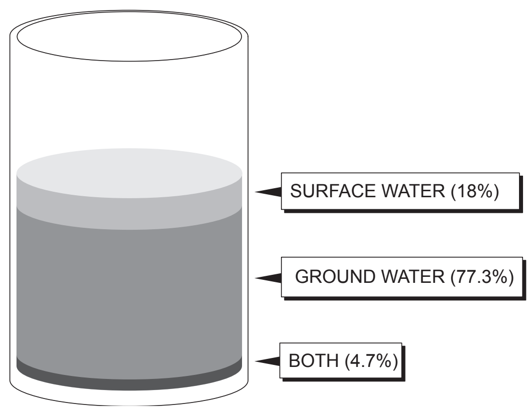
Usable fresh water
1.09 million cubic miles



Distribution by System Type

Within the continental United States, 77.3 percent of all public water systems use groundwater, 18 percent use surface water, and 4.7 percent use a combination of groundwater and surface water.

Water distribution by system type (US)

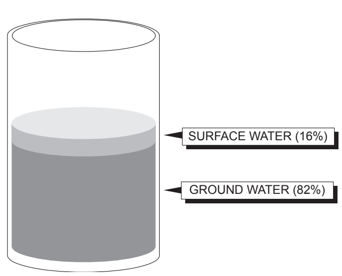


Distribution in Alaska

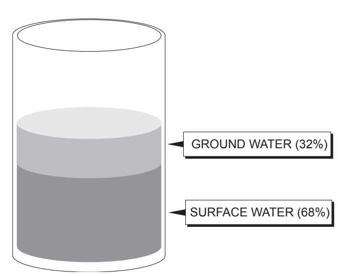
In the State of Alaska, 82 percent of the community water systems (CWS), non-transient non-community water systems (NTNCWS) and transient non-community water systems (TNCWS) use groundwater; 16 percent use surface water; and two percent use groundwater under the direct influence of surface water. There are approximately 1,600 CWS, NTNCW and TNCWS in Alaska (2008).

Distribution by Population

Within the continental United States, 68 percent of the population is served by surface water suppliers, while only 32 percent of the population relies on groundwater supplies.



Water distribution by system type (AK



Water distribution by population (US)

Why the Difference?

In the Continental United States

There are several reasons for the difference between the number of surface water suppliers and the number of people obtaining their drinking water from surface water suppliers. First, in the continental United States, 37 of the 100 largest communities use surface water. This is because the majority of these communities are built next to surface water sources, including 10 that are built next to the Great Lakes. In the West, communities such as Los Angeles, San Francisco, Portland, and Seattle all use surface water.

Water Availability

Although a large portion of this country is without any surface water source, there are few groundwater supplies that can provide sufficient water for a large community.

Alaska Differences

Alaska has distribution conditions similar to the rest of the U.S. First, although there is a significant amount of usable groundwater in the state, most of this water needs some kind of treatment. Second, the North Slope and many Southeast Alaska and Aleutian Island communities primarily use surface water; Fairbanks and many other Interior Alaska and Yukon Kuskokwim Delta communities use groundwater supplies; and Anchorage and Juneau use a combination of groundwater and surface water. This means that except in Southeast Alaska and the North Slope, the majority of smaller Alaskan communities use groundwater supplies.

Review

1. In the United States, water systems serving larger communities usually use ____________________ water as their source.

2. The most common type of water system in Alaska is __________________ water.

Uses of Water

Categories

Water consumption is often categorized based on its intended use:

- Industrial use
- Agricultural use
- Public water supply use
- Domestic use

Industrial Use

Industry in the United States uses an average of 150 billion gallons of water each day to produce the products that Americans use. Typical uses include 270 tons of water to make one ton of steel, 250 tons of water to make one ton of paper, and 10 gallons of water to produce each gallon of gasoline. The processing of seafood requires large volumes of high-quality water, and gold mining in Alaska would have been nearly impossible without the use of water. Water is also used on the North Slope to force oil from the ground. As you can see, water plays an important role in industry.

Agricultural Use

Even the food we eat requires water to grow and process. Each loaf of bread requires 115 gallons of water to produce, and a ton of milk requires 4000 gallons for processing and clean up. These figures do not include the water required to grow the wheat, feed and water the cow, and clean up the dairy. In fact, water for irrigation of farms in the U.S. is one of the largest uses of water, consuming approximately 137 billion gallons per day (gpd).

Public Water Supply Use

Public water systems are designed to deliver **potable water**[23]. Public water systems in the U.S. deliver approximately 39 billion gpd, for a combination of domestic, public and light industrial use. In Alaska, usage varies widely from a few gallons per day for self-haul systems to large volumes where water is allowed to run to prevent freezing. The average domestic consumption in all of the U.S. is 105 gallons per capita (or person) per day (gpcd) and 28 gpcd for commercial (offices, stores, etc.) use.

[23] Potable Water – Water satisfactory safe for drinking purposes from the standpoint of its chemical, physical, and biological characteristics..

Domestic Use

Within the United States, this average of 105 gallons per day per capita (gpdpc) is used for laundry, 20 to 45 gallons per load; showers, 20 to 30 gallons each; baths, 30 to 40 gallon each; flushing toilets, 1.5 to 5 gallons per flush. Most important, each of us drinks one to two quarts of water a day. The amount of water consumed per person per day in the U.S. has declined over the past 20 years with the introduction of more water-conserving fixtures such as reduced-flow shower heads and low-flow toilets.

Demands Are System-Specific

Average Day

The average daily demand for your utility should be determined for each month and recorded as part of the routine records for the water system. Minimizing the average daily demand can reduce the cost of upgrading the system.

Peak Day

Normally a peak day ranges from 1.5 to 3 times the average day. The peak day for each month and the peak day for each year should be identified and recorded as part of normal operating procedure. The average and peak days for each year should be reviewed and changes explained.

Peak Hour

The peak hour of water use is often ten times the average hourly use. This peak hour is important to the operator and design engineer. The water system's pumps, storage, and treatment must be designed so that the system can meet peak hour demands without stressing the system. The peak hourly demand is best determined from a chart recorder. If one is not available, an important piece of data will be missing and could cause difficulties in future design of the facility.

The highest peak hourly flow that water systems will usually encounter is during fire suppression. Fire flow demand thus is the primary design factor for sizing many water systems.

What is a Water System?

Definition

A water system includes all of the means for collecting, treating, storing, distributing, operating, maintaining, and managing the mechanical components in such a way as to provide potable water service to meet the customers' needs.

Adequate and Reliable

Meeting the needs means that the system must be adequate and reliable. The water must be safe to drink at all times and meet the quantity and quality requirements of the customer. This means that not only must the water be potable, but it must also be **palatable**[24] and aesthetically pleasing.

[24] Palatable – In relation to drinking water, it is water that does not give off an unpleasant taste and odors, is cool in temperature, has low color and low turbidity, and is pleasant to drink.

Collection Components

The collection portion of the water system consists of methods of collecting surface water, such as dams, rainwater catchments, intake structures, screens, pumps, and piping. Groundwater is collected using a pump in a well.

Treatment Process

The treatment process varies from community to community. Typical treatment processes include the reduction of color and turbidity as well as the removal of microorganisms and harmful and nuisance chemicals. These treatment processes are accomplished through the addition of chemicals and the use of filtration systems.

Fluoride is added to many water supplies as a means of reducing tooth decay.

In many Alaskan communities, heat is added to the water as a treatment process to keep it from freezing and/or to help in the chemical treatment process.

Disinfection

Nearly all water systems use the process of **disinfection**[25] of their water as a primary means of controlling disease-causing microorganisms. This disinfection process is commonly done with the addition of a small amount of chlorine. Other chemicals and processes, such as the addition of ozone and ultraviolet light, are also used to disinfect drinking water.

[25] Disinfection – The process used to control pathogenic organisms.

Distribution System Types

Like the treatment process, the distribution system varies widely based on community needs and environmental conditions. Typical distribution systems include the following:

- Piped systems
- Circulating loop systems
- Watering points
- Haul systems

Distribution Components

Most distribution systems include pipes, valves, fire hydrants, tanks, pumps, and house service connections.

Review

1. The average water consumption in the U.S. is _________ gpcd.
2. The highest peak hourly flow in most water distribution systems is for what use?
3. Describe four conditions that consumers expect of their water service:

A Brief History of Drinking Water Systems

Ancient History

We have no record of when water systems, as we know them, were first used. However, we know that systems of bamboo pipes and channels were in use as long ago as 3000 BC.

Indus Valley

Somewhere between 1500 and 2000 BC in the Indus Valley of Pakistan, clay pipes were used to form a water distribution system in many of the communities.

Pumps

The screw pump, one of the first pumps ever developed, was designed by Archimedes (287 – 212 BC).

Romans

The Roman Empire existed from 700 BC to 500 AD. During their existence, they built many water-collecting and distribution systems. The most famous of these are the 300 miles of aqueducts that brought water from its sources into the city. The longest of these aqueducts was 20 miles in length. During the height of the empire, these aqueducts moved as much of 84 million gallons a day to the city. The Romans' great concern over the quality of water caused them to enact penalties equivalent to $800 to $1000 of today's money for polluting a water source.

Wells

While there are recordings of hand-dug wells from the beginning of recorded history, it was not until 1126 AD that the first well was drilled in Artois, France.

Public Water System

The first recorded public water system in the United States was established in Boston in 1652. By 1850 there were 83 such systems in the United States. These systems both reduced **waterborne disease**[26] and caused it to spread because once a system was polluted, a large population could be infected.

[26] Waterborne Disease – A disease caused by organisms or toxic substances that are carried by water. The most common waterborne diseases are typhoid fever, cholera, dysentery, giardiasis, and other intestinal disturbances.

Waterborne Disease

In 1880 in the United States, cholera and typhoid fever, both waterborne diseases, killed 75 to 100 people for each 100,000 population. At this time, there were very few systems providing treatment of any type, and there was no disinfection in any system.

Treatment

The first recorded use of a water filtration system was in Europe in the early 1700s. In 1835 the first slow sand filter was installed in the United States in Richmond, Virginia. The first rapid sand filter in the United States was installed in Summerville, New Jersey, in 1885. While it is widely believed that chlorine was used in some systems in the late 1800s, it was not until 1908 in Jersey City, New Jersey, that we have the first recorded use of chlorine for disinfection in a water system in the United States.

Fire Hydrants

Fire hydrants similar to those we use today, called dry barrel hydrants, were first developed in Philadelphia in 1803. This style of fire hydrant allowed access to the water in the system without shutting down the system or losing excessive amounts of water. In addition, the design allowed the hydrant to remain permanently installed with little possibility of freezing.

Piping

Significant strides in piping systems were not developed until the coke-fired furnace was developed in the early 1700s and a method of welding was developed in the early 1800s. The first cast iron pipe was installed in Europe in 1785 and in the United States in 1816. Today there are over 200 utilities in the United States with cast iron pipe over 100 years of age. Ductile cast iron pipe, a material stronger than cast iron, was developed in 1948. Steel pipe was first introduced in 1825. PVC was developed in the 1930s, but not widely used until after the Second World War.

Reasons for Drinking Water Systems

Public Health

The primary reason for having a public water system is to protect public health. The water system serves as a line of defense between disease and the public.

Properly operated systems protect public health by:

- Removing or inactivating **pathogenic microorganisms**[27], including bacteria, viruses and protozoa.
- Reducing and removing chemicals that can be detrimental to health, such as arsenic, nitrates, lead, and copper.
- Providing quality water and discouraging customers from seeking better-tasting or better-looking water (which may be from contaminated sources).

[27] Pathogenic Microorganisms – Bacteria, virus, and protozoa that can cause disease.

Alternative Supplies

When the water produced by a system is objectionable because of odor, taste, or appearance, customers will often seek other sources for their drinking water. These alternative sources, while looking, tasting, and smelling good, could contain harmful microorganisms or chemicals.

Waterborne Diseases
Diseases that are carried by the water are called waterborne diseases. The organisms that cause these diseases do not normally live in the water, but are transported by the water. Examples of typical waterborne diseases include cholera, typhoid, dysentery, polio, hepatitis, and giardiasis. All of these diseases can be prevented from spreading through a water system with proper treatment and disinfection.

Effectiveness of Treatment
At the turn of the century, there were 36 typhoid fever deaths for each 100,000 population. With the installation of water treatment plants and disinfection, this was reduced to 0.1 deaths per 100,000 population. This reduction was enhanced by improvements in personal hygiene.

Worldwide
In the United States, we are fortunate when it comes to waterborne disease. Worldwide, one infant dies every nine minutes from a waterborne disease.

Classification of Systems

Reason for Classification
Water systems are classified by using various methods and criteria:

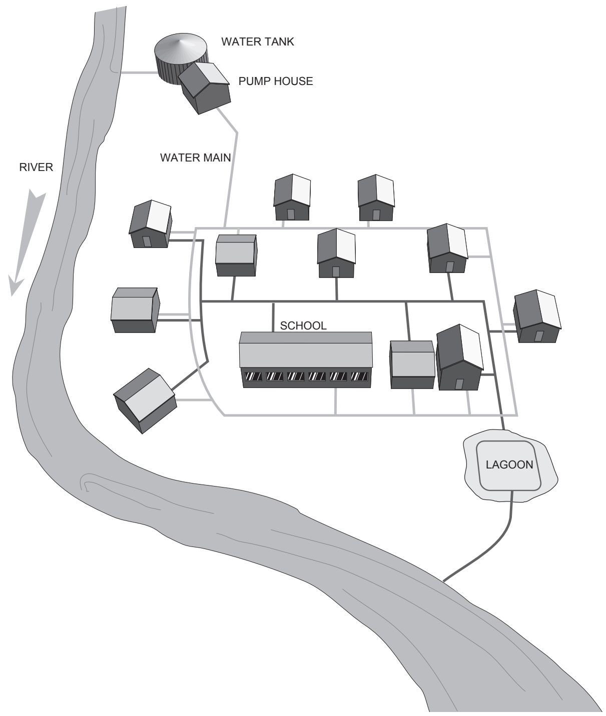
- Type of source
- Population
- Size and population
- Complexity

The following discussion is a review of each of these systems.

Classification by Source
One of the most common methods of classification is by source. The common classifications are surface water, groundwater and groundwater under the influence of surface water. This last type of system is discussed in detail in the lesson on sources.

Classification by Population
The U.S. Environmental Protection Agency (EPA) has classified systems according to population. These classifications are used to determine when a specific regulation must be applied. This classification was developed to allow the EPA to phase in regulations so that systems serving the largest segments of the population were addressed first. The typical classifications are populations below 3300, 3300 to 10,000, and above 10,000.

Alaska Classification System
Background
Because of the uniqueness of Alaska, a system that fit the State's needs was developed in 1978. The nomenclature system divided the "public water system" into three categories based on population served (at least 25 residents or individuals per day) and duration (in the normal order of events or at least 60 days per year) for Class A and Class B systems, and for Class C (neither a Class A nor Class B system).



This system, using the state nomenclature for Alaska public water systems rather than using the federal nomenclature, has become too complicated to continue in regards to compliance monitoring requirements. Because the State has adopted federal drinking water rules by reference since 1999, and these rules reference the federal water system nomenclature, the State of Alaska is revising the public water system classification nomenclature throughout Title 18, Chapter 80 of the Alaska Administrative Code, dealing with Drinking Water to conform with the nomenclature used in 40 CFR Parts 141, 142, and 143. These changes replace "Class A" with "community" and "non-transient non-community" water systems, and "Class B" with "transient non-community" water systems. The Class C water systems (state regulated systems) will remain in the regulations.

EPA Classification for Regulations

Background

To apply drinking water regulations uniformly across the United States, the EPA classified systems into three categories. All of these systems fall into the general category of a public water system.

Public Water System

For the purposes of the EPA regulations, a public water system is a system that supplies drinking water to the public where there are 15 or more service connections or that regularly serves at least 25 individuals 60 or more days each year.

Community Water System

A community water system is a public water system that has 15 or more service connections and is used by year-round residents or serves 25 or more residents year-round. In Alaska, these were referred to as Class A systems.

Non-Community Water System

Non-community water system means a public water system that is not a community water system. A non-community water system is either a transient non-community water system or a non-transient non-community water system. Generally these are systems with 15 or more connections used by travelers or intermittent users at least 60 days of a year or serves a daily average of at least 25 persons at least 60 days a year. In Alaska, these were referred to as Class B systems.

Non-Transient Non-Community Water System (NTNCWS)

Non-transient non-community water system or NTNCWS means a public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. In Alaska, these were referred to as Class A systems.

Transient Non-Community Water System (TNCWS)

Transient non-community water system means a non-community water system that does not regularly serve at least 25 of the same persons over six months per year. In Alaska, these were referred to as Class B systems.

Classification by System Type and Complexity

Background

For the purposes of application of treatment techniques, operator certification and training, and technical assistance and engineering, systems in Alaska are also classified by system type and/or complexity:

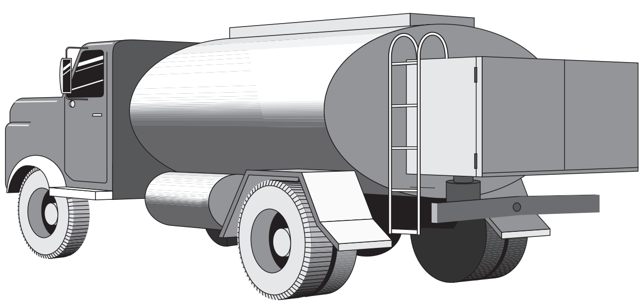
- Haul Systems
- Watering Point
- Fill and Draw
- Piped Systems

The collection and treatment of water is not directly included in this system.

Haul Systems

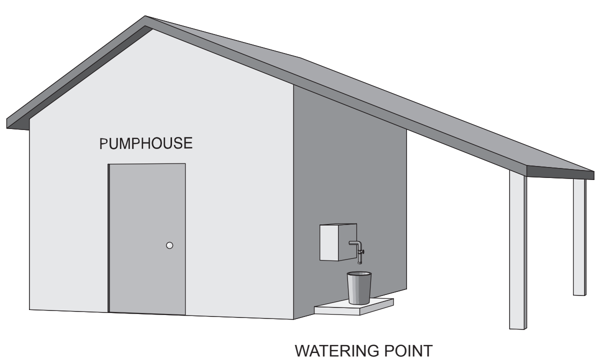
In a haul system the **purveyor**[28], transports the water from the treatment plant or storage to the customer, using a truck, trailer, or a track snow machine. Each customer has a storage tank that is filled by the purveyor personnel. Water is delivered on an order-basis in the same way that furnace oil is delivered in much of the country.

[28] Purveyor – An agency or person that supplies potable water.



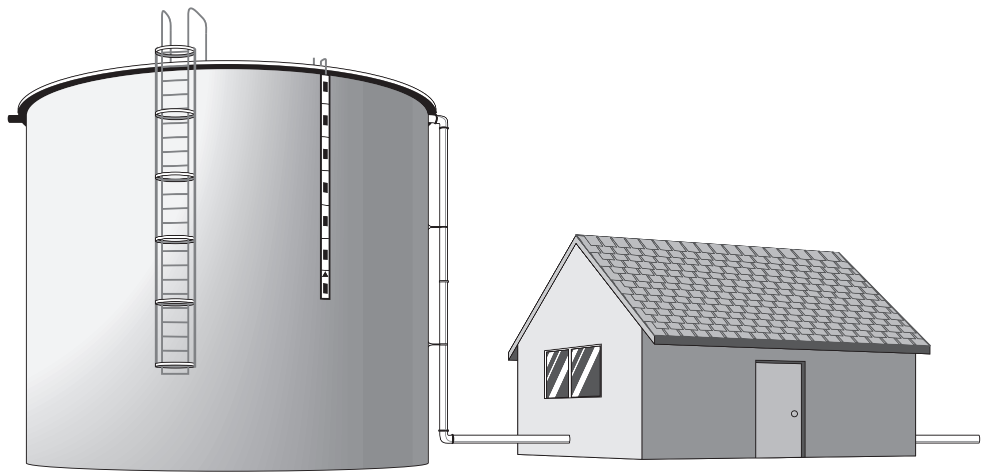
Watering Point

A common village distribution system is the watering point. This is a hosed connection to a storage or treatment facility. This connection may be inside or outside of a building, which is commonly called the pump house or washeteria. Customers bring their container to the watering point, put money in a coin box, and receive a measured amount of water.



Fill and Draw

Another common village system is the fill and draw system. A typical fill and draw system consists of a large tank that is filled with treated water one or more times during the year. The village draws water from the tank during the rest of the year.



Piped Systems

Piped Systems Configurations

A piped system refers to a system where the water is piped directly to the individual houses. There are several variations on this type of system.

Standard System

The simplest variation is the standard system where a large pipeline leads from the storage to the housing area. Individual homes are connected directly to the piped system.

Circulating System

In some locations, it is necessary to heat and circulate the water in the system to prevent it freezing during the winter. These systems require a loop from the treatment facility or storage to the customers and back. The circulating system normally requires a boiler and a circulating pump.

Utilidors

One popular technique to prevent water from freezing in the arctic is to use a utilidor. Utilidors protect and insulate the pipes, so the community can use a traditional piped water system. Utilidors may be above or below ground and are made of insulated wood or insulation covered with a protective material such as corrugated steel or aluminum.

Transient Non-Community Water Systems (TNCWS)

It is common for TNCWSs (lodges, restaurants, etc.) not to have a classic distribution system found in the community water system or non-transient non-community water system.

Introduction to Drinking Water Quiz

1. What is the most important job of the water system operator?
   A. Operate and maintain the water system equipment at the lowest cost.
   B. Keep the water plant clean and orderly.
   C. Protect the public health.
   D. Maintain good public relations with the community.

2. Water is at its maximum density at ___ °C.
   A. 0
   B. 4
   C. 20
   D. 100

3. _______________ is the term used to describe the movement of water from the surface of the earth to the atmosphere.
   A. Hydrologic cycle
   B. Precipitation
   C. Percolation
   D. Evapotranspiration

4. The majority of water systems in Alaska and the rest of the US use surface water supplies.
   A. True
   B. False

5. The average domestic potable water use in the US is _________ gpcd.
   A. 20
   B. 50
   C. 100
   D. 200

6. What causes the highest demand in most US public water systems?
   A. Fire suppression
   B. Half time on Super Bowl Sunday
   C. Morning use by a typical community
   D. Commercial use

7. The term used to describe water that is safe to drink is:
   A. Adequate
   B. Reliable
   C. Potable
   D. Palatable

8. The most common treatment method used to control disease-causing microorganisms is which of the following?
   A. Filtration
   B. Disinfection
   C. Fluoridation
   D. Chemical addition